Postpartum hemorrhage: Medical and minimally invasive management

AUTHOR: Michael A Belfort, MBBCH, MD, PhD, D.A. (SA), FRCSC, FRCOG, FACOG
SECTION EDITORS: Lynne Uhl, MD, Dena Goffman, MD
DEPUTY EDITOR: Vanessa A Barss, MD, FACOG

All topics are updated as new evidence becomes available and our peer review process is complete.

Literature review current through: **Apr 2025.**
This topic last updated: **Feb 25, 2025.**

INTRODUCTION

Postpartum hemorrhage (PPH) is an obstetric emergency that can be managed by a variety of potentially effective medical and surgical interventions (table 1). The keys to management are to recognize excessive bleeding before it becomes life-threatening, identify the cause, and initiate appropriate interventions based on the clinical setting (eg, cause of bleeding, severity of bleeding, whether the abdomen is open or not).

This topic will discuss medical and minimally invasive management of patients with PPH. An overview of issues related to PPH (terminology, definition/diagnosis, incidence, causes, risk factors, general principles of planning and management, morbidity and mortality, recurrence) is available separately. (See "Overview of postpartum hemorrhage".)

Treatment approaches to PPH that are performed at laparotomy are also reviewed separately. (See "Postpartum hemorrhage: Management approaches requiring laparotomy".)

INITIAL PATIENT ASSESSMENT

Postvaginal birth — Patients with persistent excessive vaginal bleeding after a vaginal birth despite active management of the third stage of labor should be assessed immediately by a provider capable of appropriately evaluating the clinical situation and initiating necessary medical and surgical emergency care (eg, identifying and repairing lacerations, adding another uterotonic medication, examining the placenta for evidence of retained fragments). (See "Prophylactic pharmacotherapy to reduce the risk of postpartum hemorrhage" and 'Treat the cause of bleeding' below.)

- **Assessment includes:**

  - **Vital signs/examination** – Evaluate blood pressure, heart rate (HR), respiratory rate, peripheral oxygen saturation, and urine output. In patients with excessive bleeding, signs of hypovolemia correlate with the volume of blood loss (table 2) and include tachypnea, tachycardia, hypotension, low oxygen saturation, and air hunger.

    Trends in vital signs over time should also be evaluated to identify and address patterns suspicious for ongoing bleeding or inadequately replaced blood loss. Assume progressively increasing HR and decreasing blood pressure are due to blood loss/hypovolemia until these causes have been definitely excluded. Deterioration of maternal vital signs out of proportion to vaginal bleeding suggests intraperitoneal or retroperitoneal bleeding (eg, ruptured uterus, expanding vaginal hematoma, liver rupture [eg, preeclampsia, HELLP]).

    Abdominal examination may reveal atony, peritoneal signs, and/or distention. Pelvic examination may reveal a vaginal hematoma. Ultrasound examination may reveal retained products of conception or concealed hemorrhage.

    Findings from several maternal mortality review committees have shown that a delayed response to abnormal vital signs is a common factor in preventable mortality [1,2]. Limited evidence suggests that maternal early warning systems that target specific vital sign criteria (eg, tachycardia, hypotension) and mandate an immediate response may reduce maternal morbidity [3,4]; however, a disadvantage of such systems is a high false-positive rate and "alarm fatigue." (See "Overview of postpartum hemorrhage", section on 'PPH management protocols'.)

  - **Shock index (SI)** – The SI, which is calculated by dividing the HR by the systolic blood pressure (HR/SBP), is an indicator of hemodynamic instability and hypovolemia in trauma and sepsis patients. The normal range for healthy, nonpregnant adults is 0.5 to 0.7 [5], and an SI of >0.9 has been associated with increased mortality [6]. An SI ≥1.4 has been used as a trigger to activate a massive transfusion protocol [7].

- In one study, the SI performed as well or better (even after adjusting for confounding) than any individual standard vital sign (HR, SBP or diastolic BP, mean arterial pressure, pulse pressure) in predicting which recently pregnant patients with PPH would need intensive care unit admission [8]. In this study, an SI <0.9 was reassuring, while an SI ≥1.7 required urgent attention.

- Another study concluded that in postpartum patients, the peak SI and delta-SI (peak SI – baseline SI) may be superior to both HR and SBP alone in predicting PPH and need for intervention (eg, transfusion, surgery) [9]. An SI ≥1.143 was a good initial threshold, and an SI ≥1.412 was the "critical" threshold for accurate prediction. In this study, in contrast to nonpregnant patients, an SI as high as 1.1 could be normal in peripartum patients.

- **Blood loss** – Quantify the amount of blood loss by collecting blood in graduated volumetric containers, using visual aids that correlate the size and appearance of blood on specific surfaces (eg, maternity pad, emesis basin, bed sheet, lap sponge) with the volume of blood absorbed by that surface (picture 1), or measuring the difference in the total weight of bloody materials and the known weight of the same materials when dry (the difference in weight between wet and dry in grams approximates the volume of blood in milliliters). (See "Overview of postpartum hemorrhage", section on 'Quantify blood loss'.)

- **Coagulation** – Coagulopathy should prompt blood and blood product replacement (see 'Transfuse blood products' below). Thromboelastography (TEG), where available, is a quick and accurate means of identifying an acute coagulopathy. (See 'Viscoelastic testing' below.)

  In the absence of on-unit TEG, check for nonclotting blood or very anemic-appearing vaginal bleeding while waiting for results from the first set of laboratory studies. One method is to draw 5 mL of blood from an arm vein, place it in clean dry red top glass tube, and note the clotting time (ie, time until the blood no longer flows when the tube is inverted). The clotting time is 5 to 8 minutes when the patient likely has adequate fibrinogen stores: If the blood in the tube does not clot within 8 minutes or the initial clot dissolves, then it is likely they are markedly deficient in key clotting factors.

  Over a dozen methods for testing whole blood clotting time have been described and vary in number of syringes used to draw the blood, whether some of the blood is discarded, the degree and frequency of tilting the tube(s), the diameter of the tube(s), the number of tubes, the volume of blood, whether tubes are prerinsed with saline, the temperature at which the test

is performed (room temperature versus 37°C), etc [10,11]. All of these variables affect the time to clotting, which make this an insensitive test.

- **Medication review** – The patient may have received medications that have unanticipated hemodynamic side effects and may confound the situation. For example, beta blockade for treatment of hypertension may prevent a normal HR response in a bleeding patient; histamine release due to an analgesic (morphine) may lead to peripheral vasodilation and destabilized compensated shock with resultant sudden hemodynamic collapse.

Postcesarean birth

- **Abdomen open** – If the abdomen is still open, the presence and cause of excessive bleeding are usually readily apparent (eg, atony, uterine laceration, retained placental fragments). However, in patients with vital signs that are normal or near normal and have no oozing from wounds, the clinician may not recognize when blood is accumulating in the retroperitoneum, confined to the uterine cavity after closure of the hysterotomy, or hidden under surgical drapes. When compensated shock is present (normal blood pressure with increasing HR) at cesarean birth, these sites should be actively evaluated.

- **Abdomen closed** – If the abdomen has been closed, persistent excessive vaginal bleeding despite active management of the third stage of labor is evaluated as described above for vaginal birth, and treatment is initiated (eg, add another uterotonic medication). Another laparotomy may be required to perform surgical techniques to control bleeding (eg, uterine compression sutures). (See 'Postvaginal birth' above and "Postpartum hemorrhage: Management approaches requiring laparotomy", section on 'Etiology-based management'.)

  Signs of compensated or uncompensated shock without vaginal bleeding should prompt consideration of internal bleeding related to birth. A modified focused assessment with sonography for trauma (FAST) examination in the recovery room may show fluid in the upper abdomen suggestive of intraabdominal bleeding, but sensitivity is low [12] and an equivocal scan or logistic issues have the potential to delay emergency and life-saving interventions. In all cases, clinical signs suggestive of ongoing bleeding (tachycardia, falling blood pressure, expanding abdomen, change in level of consciousness) should overrule a negative ultrasound scan in determining further management.

BLOOD LOSS >500 mL AT VAGINAL DELIVERY OR >1000 mL AT CESAREAN DELIVERY BUT <1500 mL WITH ONGOING EXCESSIVE BLEEDING

These patients are generally hemodynamically stable, but may have mild tachycardia (heart rate ≥110 beats/min), mild hypotension (systolic blood pressure 80 to 85 mmHg), fall in oxygen saturation (O_2 sat <95 percent), and/or lightheadedness, before initiation of therapy.

Continue to monitor vital signs and quantify blood loss.

Assistance and location of care

- Obtain assistance, if not already assembled. Team may include obstetricians, nurses, anesthesiologists, hematologists/blood bank personnel, laboratory medicine, surgical subspecialists (eg, vascular, urology), and interventional vascular specialists.

- If not already in an operating room, move unstable and potentially unstable patients to an operating room expeditiously since this is the safest place to initiate and maintain definitive treatment. In those facilities where the labor and delivery operating room may not be equipped and/or staffed for emergency major abdominal surgery, the patient should be stabilized and moved to a main operating room suite (or other appropriately equipped unit [eg, hybrid operating room on labor unit]) for further management.

Establish adequate intravenous access — Adequate intravenous access should be provided with two lines, at least one should be a large bore catheter (at least 18 gauge, preferably 14 or 16 gauge), for administration of fluids and blood and medications. (See 'Resuscitate with crystalloid and blood' below and 'Increase oxytocin infusion' below and 'Administer tranexamic acid' below.)

Resuscitate with crystalloid and blood

- **Crystalloid** – The approach to fluid therapy is similar to that in trauma patients. Traditionally, isotonic crystalloid has been liberally infused to prevent hypotension (target systolic blood pressure 90 mmHg) and to maintain urine output at >30 mL/hour [13]. One guideline suggested twice the lost volume and up to 3.5 L of fast fluid infusion in patients with more than 1000 mL blood loss or clinical shock [14]. Closely monitoring hematocrit, coagulation status, core temperature, and electrolytes (calcium

and potassium especially) is essential when large volumes of crystalloid (eg, >3 to 4 L) are rapidly infused since this may promote dilutional coagulopathy, electrolyte imbalances, and hypothermia.

No large multicenter randomized trials have evaluated optimal fluid resuscitation in patients with PPH. Emerging research in nonobstetric settings (eg, trauma, surgery) suggests that limited fluid replacement to maintain minimally adequate organ perfusion rather than liberal fluid resuscitation may be advantageous for some patients. One small randomized trial in patients with early mild PPH showed neither benefit nor harm of a restrictive policy (crystalloid infusion of 0.75 to 1 times the volume of blood lost) [15]. (See "Intraoperative management of shock in adults" and "Initial management of moderate to severe hemorrhage in the adult trauma patient", section on 'Intravenous fluid resuscitation'.)

- **Blood and blood products** – We advise early recourse to blood and blood product replacement when hemorrhage is heavy to rapidly replace lost red blood cells (RBCs), platelets, and coagulation factors and minimize the risk for dilutional coagulopathy, electrolyte imbalances, and hypothermia. As a general rule, progressively increasing heart rate and dropping blood pressure in any obstetric patient indicate ongoing bleeding and should be treated with aggressive blood and blood product transfusion, regardless of whether or not abdominal examination or ultrasound suggest intraabdominal bleeding (which may be concealed). This clinical scenario may also be the result of inadequate replacement of sustained blood loss (which may not be ongoing) in patients in whom blood loss was underestimated. Regardless, when a recently pregnant patient becomes progressively unstable, the safest approach is to start transfusing blood and blood products empirically and to continue efforts to isolate the cause. (See 'Transfuse blood products' below.)

Provide adequate anesthesia — In the nonanesthetized patient, local anesthesia rarely provides sufficient pain relief for thorough examination and treatment. Gentle digital exploration of the lower segment of the uterus may be performed without anesthesia; however, if a thorough manual examination is required, it should be performed in an operating room with immediate recourse to anesthesia, surgical therapy, and laparotomy, if needed. The choice of a regional or general anesthetic depends upon the planned interventions and the patient's hemodynamic status. (See "Anesthesia for the patient with peripartum hemorrhage".)

Examine the lower genital tract and uterus to determine the cause of bleeding

- **Perform thorough vaginal, abdominal, and rectal examinations** – It is not sufficient to look only for obvious vaginal or incisional bleeding when determining the source of PPH because significant hemorrhage can occur into the retroperitoneum or

into a vaginal/vulval hematoma without visible external blood loss.

After a completed birth, we examine the genital tract with the patient in stirrups (dorsal lithotomy position) in a room with facilities for general anesthesia and both vaginal and abdominal surgery. Lower genital sources of bleeding not previously detected can usually be readily identified by assessing the birth canal with adequate assistance, exposure, lighting, instruments, and anesthesia, which allow performance of a thorough examination.

The entire vagina from perineum to cervix should be inspected for significant lacerations. This examination should be performed in all patients with PPH who gave birth vaginally, as well as those who attained significant cervical dilation and descent of the presenting fetal part before a cesarean birth. Even if inspection for lacerations has already been performed at the birth (or after the birth but without adequate analgesia), a thorough examination should be repeated, as a bleeding site may have been missed. Risk factors for significant cervical lacerations (ie, associated with excessive bleeding or requiring repair) include precipitous labor, assisted vaginal birth, and cerclage [16]. However, absence of such risk factors should not preclude re-examination of the birth canal.

Intense anal pain may be a warning sign of an enlarging vaginal or vulvar hematoma and should prompt examination and repeat examination, as necessary, to exclude this source of potentially life-threatening blood loss. (See "Management of hematomas incurred as a result of obstetric delivery".)

- **Rapidly assess uterine tone** – Atony is a common cause of hemorrhage. Be aware that the lower uterine segment can be poorly contracted despite adequate good upper segment contraction (discussed in the following bullet).

- **Examine the uterine cavity for rupture or retained products of conception** – Retained products are more common after vaginal than cesarean birth, unless the cesarean was performed for placenta accreta spectrum.

  Even when a retained placenta is removed manually (either after vaginal birth or at the time of cesarean birth), it is possible that the remaining uterine tissue in the placental bed is thinned and functionally abnormal. If the placenta was difficult to remove in a patient who has recently had a cesarean birth for placenta previa, the lower segment may become atonic even though the upper segment is well-contracted. Lower segment atony may be difficult to diagnose, and even more difficult to treat. This is because the atony may be intermittent (or even segmental with only a part of the lower segment affected). Partial, intermittent, or segmental myometrial contraction may lead to difficulty in adequately positioning an intrauterine tamponade balloon. In the

event of intermittent periods of myometrial contraction with light and heavy bleeding the clinician may unwittingly delay definitive management in the belief that uterine massage or medical therapy is working.

- **Assess for uterine inversion** – If the uterus is inverted, vaginal examination may reveal a smooth round mass protruding from the cervix or vagina and abdominal examination may reveal absence of a normally positioned fundus. (See "Puerperal uterine inversion".)

- **Consider the possibility of uterine rupture** – Although uterine rupture is infrequent, it is important to consider and exclude this diagnosis in patients with signs of PPH who have undergone a trial of labor after a previous cesarean birth. Rupture of the unscarred uterus is rare, but can occur if labor was induced or augmented and, even more rarely, after an assisted vaginal birth. Palpation of the uterine cavity may reveal the site of rupture, which can be anterior, fundal, posterior, or lateral. Ultrasound examination may show signs of blood in the abdomen and/or a broad ligament hematoma.

  Uterine rupture is often characterized by pain and persistent vaginal bleeding despite use of uterotonic medications. Even mild hemodynamic instability in any postpartum patient should prompt consideration of uterine rupture and intraabdominal bleeding, even if vaginal bleeding is not excessive. Hematuria may occur if the rupture extends into the bladder. Maternal symptoms of hypovolemia that appear to be out of proportion to the observed blood loss and abdominal distention should also prompt consideration of intraabdominal hemorrhage. (See 'Postcesarean birth' above.)

  Posterior rupture is more common in the unscarred uterus than the scarred uterus. When laparotomy is performed, a posterior rupture is not readily observed upon entering the abdomen so the entire uterus needs to be inspected carefully. (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".)

Administer tranexamic acid — Tranexamic acid, an antifibrinolytic medication, is given as soon as possible after the onset of hemorrhage and concomitantly with other medications and procedures for control of bleeding.

- Dose: One gram (10 mL of a 100 mg/mL solution) intravenously over 10 to 20 minutes, as infusion >1 mL/minute can cause hypotension. If bleeding persists after 30 minutes, a second 1 g dose can be administered.

The antifibrinolytic effect lasts up to seven to eight hours in serum. The concentration in breast milk is approximately one hundredth of the serum peak concentration, so it is unlikely to have antifibrinolytic effects in the neonate.

An antifibrinolytic medication is useful because markedly enhanced fibrinolytic activity and fibrinogen depletion are common in the early stages of major postpartum and traumatic bleeding. Delay in treatment, even if short, reduces the benefit.

The World Maternal Antifibrinolytic Trial (WOMAN) found that tranexamic acid reduced death due to bleeding in patients with PPH by 20 to 30 percent, and was not associated with an increase in adverse effects [17]. This pragmatic, randomized, double-blind, placebo-controlled trial involved 193 hospitals in 21 countries and evaluated the effect of early administration of tranexamic acid (1 g by intravenous injection) on mortality, hysterectomy, and other morbidities in over 20,000 patients with clinically diagnosed PPH. Individuals were eligible for randomization if blood loss was >500 mL at vaginal birth, >1000 mL at cesarean, or associated with hemodynamic instability and the provider was uncertain whether to use the medication. All other aspects of management of PPH were per usual standards and determined by the provider. Approximately 70 percent of the births were vaginal and 30 percent cesarean. Compared with placebo, tranexamic acid:

- Reduced death due to bleeding by 19 percent overall (1.5 versus 1.9 percent, relative risk [RR] 0.81, 95% CI 0.65-1.00).
    - The reduction in death due to bleeding was observed after both vaginal and cesarean births. Death due to bleeding was reduced by 31 percent when treatment was initiated within three hours of the birth (1.2 versus 1.7 percent, RR 0.69, 95% CI 0.52-0.91) and by 26 percent for bleeding due to atony (1.2 versus 1.6 percent, RR 0.74, 95% CI 0.55-0.99). In contrast, the reduction was not significant when the time after the birth was more than three hours and in patients with other or unknown causes of bleeding.
- Reduced the incidence of laparotomy to control bleeding by 36 percent (0.8 versus 1.3 percent, RR 0.64, 95% CI 0.49-0.85).
- Did not reduce hysterectomy; however, the decision to perform hysterectomy was sometimes made at the same time as randomization, so some hysterectomies were performed before or concurrently with administration of tranexamic acid. (For this reason, the trial was extended and the sample size was increased).
- Did not reduce all-cause mortality, which included death from sepsis, organ failure, eclampsia, pulmonary embolism, etc and accounted for over 25 percent of the deaths. There was no significant increase or decrease in any specific cause of death, other

than death from bleeding.

- Did not increase the risk of thromboembolic events (lack of an association between tranexamic acid and thromboembolic events was confirmed in a subsequent meta-analysis [18]).

Meta-analyses of randomized trials have concluded that tranexamic acid reduces mortality due to bleeding in patients with primary PPH, irrespective of mode of birth [19,20]. As an example, in a meta-analysis using individual level data from patients with acute severe bleeding (traumatic and PPH), tranexamic acid increased overall survival from bleeding (odds ratio [OR] 1.20, 95% CI 1.08-1.33), and immediate treatment improved survival by more than 70 percent (OR 1.72, 95% CI 1.42-2.10). The survival benefit decreased by 10 percent for every 15 minutes of treatment delay until 3 hours, after which there was no benefit [19]. Based on these data, the World Health Organization recommended not initiating tranexamic acid for PPH treatment more than three hours after birth [21].

Prophylactic use (before PPH) in the third stage of labor may decrease risk of PPH. It is generally not administered before birth since it freely crosses the placenta, but limited evidence has not shown fetal harm. Prophylactic use is reviewed separately. (See "Prophylactic pharmacotherapy to reduce the risk of postpartum hemorrhage", section on 'Tranexamic acid'.)

A study in the anesthesia literature has raised the question of whether PPH leads to markedly enhanced fibrinolytic activity, as measured by thromboelastography (TEG) [22]. The authors did not identify elevated fibrinolytic activity using TEG in their 13 patients with PPH and hypothesized that the elevations in clot lysis on TEG may have been secondary to platelet-mediated clot retraction. They state that the risk/benefit ratio of tranexamic acid in a high-resource setting may differ from that studied in the WOMAN trial where many patients were in low-resource settings and suggest that, if further studies confirm their findings, providers in high-resource settings may need to reconsider the use of tranexamic acid. In particular, they are concerned about the potential for adverse side effects, even though there was no increase in side effects from tranexamic acid in the WOMAN trial and no data suggest significant side effects as a result of its use in either low- or high-resource settings. Given that the sensitivity of TEG/rotational thromboelastography (ROTEM) for hyperfibrinolysis is relatively low, the author of this topic believes that, until more data are available, tranexamic acid should be given empirically to any patient with severe PPH in whom there is rapid and persistent bleeding (especially when an underlying cause [eg, abruption or disseminated intravascular coagulation] is a consideration). Once the results of coagulation laboratory tests (which may include a TEG/ROTEM evaluation) are available, more goal-directed management can be instituted, and if there is no evidence of fibrinolysis by the best available testing, the additional

dose of tranexamic acid may be omitted. World Health Organization (WHO) guidelines recommend not using tranexamic acid in patients with a known contraindication, including a known thromboembolic event in pregnancy, history of coagulopathy, active intravascular clotting, or known hypersensitivity to the medication.

Treat the cause of bleeding — This may involve one or more of the following actions.

- Repair bleeding lacerations. (See 'Repair genital tract lacerations' below.)
- Manage atony. (See 'Manage atony' below.)
- Remove any retained placental fragments or fetal membranes manually, if possible, or with ring forceps. Ultrasound examination can be helpful for diagnosis of retained tissue and to guide removal [23]. Curettage with a 16 mm suction catheter or (preferably) a large blunt curette (banjo curette) is performed if manual or forceps removal is unsuccessful in controlling hemorrhage. (See "Retained placenta after vaginal birth".)

  Management of placenta accreta spectrum is reviewed separately. (See "Placenta accreta spectrum: Management".)
- Manually replace an inverted uterus, if present. (See "Puerperal uterine inversion".)
- If uterine rupture is diagnosed, definitive surgical management involves hysterectomy, but uterine repair may be possible, depending on the patient's plans for future pregnancies, extent of uterine damage, hemodynamic stability, and the surgeon's skills. (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".)

  Repair genital tract lacerations — We repair heavily bleeding vaginal and cervical lacerations with a running locked #0 absorbable suture. Exposure is facilitated by using a Gelpi retractor (figure 1) to spread the distal vaginal sidewalls and Heaney (figure 2) or Breisky (figure 3) retractors to access the upper vagina. If available, use of several assistants with Deaver retractors placed laterally is also effective. Adequate lighting and exposure are crucial in such repairs, often necessitating that repairs are performed in the operating room with appropriate anesthesia, patient positioning, retraction, and suction apparatus.

It is often difficult to begin a suture line at the apex of the laceration because of problems exposing and thus identifying the apex. In such cases, one can begin the suture line at the distal end of the laceration and sew toward the apex, while using the suture to pull the lacerated tissue toward the surgeon. Alternatively, these patients are good candidates for angiographic embolization, if stable. (See 'Consider uterine or hypogastric artery embolization' below.)

In cases where bladder injury is an issue or where lateral vaginal sutures may be placed, cystoscopy with or without ureteral stent placement may be advisable. When there is retroperitoneal hemorrhage and ongoing bleeding requiring control, having stents in the ureters helps locate them and, if necessary, allows the operator to retract them as sutures are placed and thus help avoid inadvertent ureteral damage.

Three pitfalls to avoid:

- Sutures should not be placed cephalad to the fornix, as this can result in ureteral ligation. A laparotomy (or angiographic embolization) may be needed when a vaginal laceration has extended above the fornix and appears to be expanding (either on imaging or because of persistent hemodynamic instability). The patient's thighs are abducted in stirrups (modified lithotomy position) to allow surgery to proceed simultaneously via the abdominal and vaginal routes, as needed, for optimal exposure and access. This facilitates identification of the bladder and ureters, minimizing the chance of inadvertently damaging these structures. If appropriately skilled surgeons and equipment are available, the abdominal portion may be possible with a laparoscopic approach.

- Vaginal hematomas should not be drained unless expanding. Attempts at operative drainage can result in significant additional blood loss because it is often difficult to identify and ligate bleeding vessels in a fresh vaginal sulcus (ie upper third of the vagina) hematoma. A stable hematoma may be drained later if it becomes infected or pain is not relieved adequately with analgesics. Continuous expansion of a hematoma leading to hypovolemia may necessitate drainage and packing. Alternatively, embolization may be the best approach. Management of vaginal hematomas is discussed in more detail separately. (See "Evaluation and management of female lower genital tract trauma".)

- Arterial or heavy active vaginal bleeding should not be treated with packing, as this has the potential to divert blood into the retroperitoneum. A vaginal balloon or packing can be useful to tamponade venous oozing, before or after repair of the vaginal laceration. A balloon with a drainage channel can compress lacerated sidewalls while the drainage channel allows

monitoring of any ongoing significant bleeding. Such patients should be closely monitored for ongoing concealed bleeding, which would necessitate active intervention.

If uterine artery laceration is suspected, diagnosis and management will require interventional radiology if the patient is hemodynamically stable, or surgical exploration and ligation if they are not. (See 'Consider uterine or hypogastric artery embolization' below and "Postpartum hemorrhage: Management approaches requiring laparotomy".)

Manage atony — Administration of uterotonic medications is the key intervention for treatment of atony. Uterine massage and compression are also useful.

Perform uterine massage and compression — Fundal massage stimulates the atonic uterus to contract. Bimanual uterine massage, which manually compresses the corpus between the clinician's two hands, is another effective technique: One hand is made into a fist and placed vaginally in the anterior fornix, while the other massages the fundus abdominally while firmly compressing it against the vaginal hand.

Massage should be maintained while other interventions are being initiated, and continued until the uterus remains firm and bleeding has abated. If the fundus is well contracted but bleeding continues unabated, then further massage is not likely to be effective and progression to other methods of hemorrhage control should occur promptly.

Increase oxytocin infusion — Oxytocin is routinely initiated just before or after placental separation to reduce postpartum bleeding and risk of hemorrhage. If given intravenously, the rate can usually be increased if bleeding is greater than normal.

We administer oxytocin 40 units in 1 L of normal saline intravenously at a rate sufficient to control uterine atony. The CMQCC suggests 10 to 30 units in 500 mL normal saline or 20 to 60 units in 1 L normal saline with a time-limited bolus over 10 to 15 minutes followed by a maintenance infusion at a lower rate; suggested maximum infusion: 40 units/hour [24]. While higher doses of oxytocin have been used intravenously for a short duration to manage atony (eg, up to 80 units in 500 mL over 30 minutes) [25], this is not advisable since lower doses appear to be just as effective. Moreover, rapid infusion of high-dose oxytocin, as may occur in an emergency situation, can cause significant hypotension and cardiovascular collapse. Therefore, if a high-dose oxytocin regimen is used, we advise preparing smaller volumes (ie, 15 units in 250 mL) to limit the total dose infused over a short period of time and being aware that vital sign deterioration might be related to high-dose oxytocin if atony and bleeding have been controlled.

If oxytocin prophylaxis against PPH was given intramuscularly (10 units intramuscularly, including directly into the myometrium), the dose is not repeated in patients who develop PPH soon after giving birth, given the long duration of action with intramuscular administration (at least one hour versus three to five minutes with intravenous administration). These issues and dosing are discussed in more detail separately. (See "Prophylactic pharmacotherapy to reduce the risk of postpartum hemorrhage", section on 'Oxytocin'.)

Administer additional uterotonic medications — Since uterine atony is the most common cause of PPH, uterotonic medications are administered for presumed atony until a therapeutic effect is observed or until it is obvious that these medications are ineffective. The important point is not the sequence of medications, but the prompt initiation of uterotonic therapy and the prompt assessment of its effect. It should be possible to determine within 30 minutes whether pharmacologic treatment (eg, oxytocin, tranexamic acid, and a prostaglandin or methylergonovine) is reversing uterine atony. If it does not, prompt invasive intervention (interventional endovascular procedure, laparotomy) is usually warranted.

If bleeding persists after administering oxytocin, we promptly administer carboprost tromethamine and/or methylergonovine. These medications have similar efficacy [26].

- **Carboprost tromethamine** (15 methyl-PGF2alpha, Hemabate; contraindication: asthma)
  - 0.25 mg intramuscularly every 15 to 90 minutes, as needed, to a total cumulative dose of 2 mg (eight doses). Approximately 75 percent of patients respond to a single dose; move on to a different uterotonic agent if no response after one or two doses.

    Carboprost tromethamine may be injected directly into the myometrium either transabdominally (with or without ultrasound guidance) or vaginally. The author prefers to use a dilute solution of 0.25 mg in 20 mL normal saline for injection via a six-inch spinal needle. Prior to the blind injection of this solution into the myometrium, aspiration should be performed to prevent intravenous administration.
- **Methylergonovine** (contraindications: hypertension, coronary or cerebral artery disease, Raynaud's syndrome)
  - 0.2 mg intramuscularly or directly into the myometrium (never intravenously). May repeat at two- to four-hour intervals, as needed. If the first dose does not reduce bleeding, quickly move on to a different uterotonic agent.

Other uterotonic medications:

- **Misoprostol** (PGE1) is most useful for reducing blood loss in settings where injectable uterotonics are unavailable or contraindicated (eg, hypertension, asthma). A meta-analysis found no clear evidence that misoprostol is more effective than other uterotonics either for primary therapy of PPH or as an adjunctive treatment to oxytocin infusion [27]. In addition, the side effect of hyperthermia is a significant disadvantage because it is uncomfortable, triggers a work up for sepsis, and may lead to unnecessary empiric antibiotic therapy.

  The optimum dose and route for misoprostol administration are unclear [28-34]. If used, the author of this topic suggests 400 mcg sublingually. Sublingual misoprostol is rapidly absorbed, achieving a peak concentration within 30 minutes. The peak concentration is higher and sustained longer (approximately three hours) than with oral administration due to avoidance of first-pass hepatic metabolism; thus, sublingual administration is probably the optimal route of administration for PPH. He uses 400 mcg because of the increasing potential for hyperthermia with larger doses [35-37]. A systematic review concluded that a dose of 400 mcg sublingually appeared to be as effective as 600 mcg sublingually and had fewer side effects, but available data on optimal dose were limited [38]. The World Health Organization (WHO) suggests a single dose of 800 mcg sublingually [39]. The California Maternal Quality Care Collaborative also suggests 800 mcg sublingually or 600 mcg orally [24].

  Oral misoprostol is also rapidly and almost completely absorbed, reaching a peak concentration within 30 minutes, but the level is lower than with sublingual administration and declines rapidly over two hours due to liver metabolism.

  Rectal administration takes longer to reach peak concentration compared with oral or sublingual administration (up to an hour versus within 30 minutes), which is disadvantageous in the hemorrhaging patient [40,41]. The most commonly used rectal doses are 800 and 1000 mcg [29,30,42,43]. Rectally administered misoprostol has a longer duration of action than oral/sublingual routes (four hours versus two to three hours), which is advantageous in PPH and may be necessary in semi-conscious or unconscious patients.

  Vaginal administration is **not** recommended because the medication will be washed away by heavy bleeding, thus impairing absorption.

Maternal temperature should be monitored closely, as pyrexia ≥40°C (104°F) can occur at these doses and should be treated (eg, acetaminophen). The frequency of pyrexia increases with increasing misoprostol dose. High fever may be accompanied by adverse autonomic and central nervous system effects. In one randomized trial of patients with PPH, those who received misoprostol 600 mcg sublingually plus standard uterotonics (oxytocin in 98 percent) had a threefold higher rate of temperature ≥38°C than those who received standard uterotonics alone (58 versus 19 percent); for temperature ≥40°C, the rates were 7 and <1 percent, respectively [44].

- **Carbetocin**, a long-acting analog of oxytocin, is used in many countries (not available in the United States) for preventing uterine atony and hemorrhage. In this capacity, it appears to be as effective as oxytocin [45]. Carbetocin 100 mcg is given by a single slow intravenous injection (ie, over one minute), although lower doses may be effective [46]. The toxicity spectrum is similar to that of oxytocin. It seems reasonable to use this medication as an alternative to oxytocin in countries where it is available, as it is easy to administer and has a long duration of action, but its efficacy in treating rather than preventing uterine atony is not well documented.

- **Sulprostone**, a PGE2 analog, is used in some countries (not available in the United States) for managing persistent PPH despite oxytocin treatment [47]. It is administered intravenously as a continuous infusion. The initial dose is 100 mcg/hour, which may be increased up to 500 mcg in the first hour to control bleeding, after which it is reduced to a maintenance dose of 100 mcg/hour. The cumulative total dose should not exceed 1500 mcg in 24 hours.

  Common side effects include nausea, vomiting, diarrhea, abdominal pain and the other characteristic side effects associated with prostaglandins. Serious cardiovascular events have been reported but are rare. The drug should be avoided or used with caution in patients with a history of asthma, glaucoma, or severe hepatic or renal impairment.

Use an intrauterine postpartum hemorrhage control device in patients with atony or lower segment bleeding — If administration of oxytocin and tranexamic acid are ineffective or only partially effective, or if there is any delay in getting these uterotonic medications, we expeditiously move on to placing a tamponade balloon or a device for vacuum-induced tamponade to decrease bleeding and plan for interventional radiology or surgical options. Uterotonic medications are continued until bleeding is controlled. (See "Postpartum hemorrhage: Use of an intrauterine hemorrhage-control device".)

Regardless of the method employed (table 3), continued blood loss, hemoglobin, and urine output should be closely monitored. Blood and blood product replacement should be aggressively pursued as well to stabilize the patient as much as possible in case emergency surgery is needed. Continued excessive bleeding indicates that the device is not effective and surgery or embolization should be performed. (See 'Consider uterine or hypogastric artery embolization' below and 'Consider laparotomy' below.)

BLOOD LOSS >1500 mL WITH ONGOING EXCESSIVE BLEEDING

These patients may be hemodynamically unstable.

As a general rule, progressively increasing heart rate and dropping blood pressure in any obstetric patient indicate ongoing bleeding and should be treated as such. This means aggressive blood and blood product transfusion, regardless of whether or not abdominal examination or ultrasound suggests intraabdominal bleeding (which may be concealed). This clinical scenario may also be the result of inadequate replacement of sustained blood loss (which may not be ongoing) in patients in whom blood loss was underestimated. Regardless, when a recently pregnant patient becomes progressively unstable, the safest approach is to start blood and blood product transfusion empirically and to continue efforts to isolate the cause.

Basic interventions

- Do all of the above (figure 4). (See 'Initial patient assessment' above and 'Blood loss >500 mL at vaginal delivery or >1000 mL at cesarean delivery but <1500 mL with ongoing excessive bleeding' above.)
- Any unstable patient who is not already in an operating room should be moved to an operating room as soon as practically possible, since this is the safest place to initiate and maintain definitive treatment.
- In addition to large bore IVs for fluid resuscitation, central venous access should be considered early (while the patient is still in compensated shock) as it is often very difficult to gain such access in a shocked and hemodynamically unstable patient. In addition, it may take time to assemble appropriate personnel (anesthesia team, vascular access team) to place the line. A central venous pressure line enables rapid volume infusion and provides supplemental data regarding intravascular volume status, but these parameters are inaccurate surrogates to determine cardiac preload, are poor predictors of fluid

responsiveness, and do not detect or predict impending pulmonary edema indicative of hypervolemia. (See "Central venous access in adults: General principles of placement" and "Intraoperative management of shock in adults".)

- A bladder catheter with urometer should be used to monitor urine output.

In addition to these basic interventions, we do the following. Although the interventions described below are often successful, in the setting of cardiovascular instability, it is important to avoid prolonged, futile attempts at conservative therapy before proceeding to laparotomy (or re-laparotomy if a cesarean birth was performed) and, if necessary, hysterectomy. One-third of postpartum patients in shock will need to undergo hysterectomy to control hemorrhage [48]. (See 'Consider laparotomy' below.)

Laboratory evaluation

Routine — Routine laboratory evaluation should include [49]:

- **Complete blood count**, including platelet count – For every 500 mL of blood loss, hemoglobin levels will fall by approximately one gram/dL; however, the initial hemoglobin/hematocrit value does not accurately reflect the amount of acute blood loss.
- **Type and crossmatch** for at least four units of red blood cells (RBCs), if not already done.
- **Coagulation studies**, including fibrinogen concentration, prothrombin time, and activated partial thromboplastin time. The coagulation panel should be repeated every 30 to 60 minutes to observe trends until PPH is controlled. Coagulation studies are usually normal in the early stages of hemorrhage, but may be abnormal when comorbidities are present, such as abruption, liver disease, fetal demise, sepsis, or amniotic fluid embolism. Eventually, significant hemorrhage without adequate replacement of coagulation factors will result in coagulation abnormalities.
  - **Fibrinogen** – Fibrinogen falls to critically low levels earlier than other coagulation factors during PPH, thus the fibrinogen level is a more sensitive indicator of ongoing major blood loss than the prothrombin time, activated partial thromboplastin time, or platelet count [50,51]. The fall is likely related to loss of fibrinogen through bleeding, increased fibrinolytic activity, and hemodilution from fluids given to support blood pressure, and the contribution of each of these factors may be affected by the cause of PPH [52].

The fibrinogen level at the time of diagnosis of PPH has been called the "canary in the coal mine" for coagulopathy because fibrinogen depletion is an early predictor of hemorrhage severity and can be used to guide the approach to clinical resuscitation [53-56]. The normal fibrinogen level in a term pregnancy is 350 to 650 mg/dL, which is nearly double that of nonpregnant adults (200 to 400 mg/dL) [57]. In multiple studies of patients with PPH, a low fibrinogen level (less than 200 mg/dL) was predictive of severe PPH, defined as need for transfusion of multiple units of blood and blood products, need for angiographic embolization or surgical management of hemorrhage, or maternal death [53-55,58]. The positive predictive value for progression to severe PPH has been reported to be 100 percent at this level, with a 79 percent negative predictive value for progression at fibrinogen values >400 mg/dL [53]. In one study, compared with patients with fibrinogen >300 mg/dL at diagnosis of PPH, the odds of severe PPH (hemoglobin decrease ≥4 g/dL, RBC transfusion, arterial embolization or emergency surgery, admission to intensive care, or death) for patients with fibrinogen between 200 and 300 mg/dL were almost doubled (odds ratio [OR] 1.90, 95% CI 1.16-3.09) and increased 12-fold for fibrinogen less than 200 mg/dL (OR 11.99, 95% CI 2.56-56.06) [54].

A target fibrinogen level >200 mg/dL is commonly recommended for patients with obstetric hemorrhage. The author of this topic increases the fibrinogen level to >300 mg/dL in patients with active bleeding who are being resuscitated, given the higher normal baseline fibrinogen level in pregnancy and the desire to maintain the fibrinogen level well above the danger zone in these patients. (See 'Transfusion targets' below.)

- **Other** – Where expeditious measurement is available, measuring the factor XIII activity level also may be informative because it can become critically low in patients with acute obstetric coagulopathy, and if low early replacement with factor XIII concentrate could be beneficial [59]. Further study is needed, particularly on the level of activity that should prompt replacement and the appropriate dose in patients with PPH.

Viscoelastic testing — Thromboelastography (TEG) and rotational thromboelastometry (ROTEM), where available, can be useful for guiding plasma and coagulation product therapy in PPH [60,61]. The devices rotate a pin (ROTEM) or cup (TEG) through a small sample of whole blood. Measurement of the resistance to rotation provides a global assessment of whole blood hemostasis (time to clot development, clot stabilization/strength, and clot dissolution (figure 5 and table 4)) and can be performed at the bedside, so results are available within minutes [62]. TEG and ROTEM results can be useful for choosing only the specific blood components for transfusion that the patient requires and assessing the efficacy of interventions [63-69]. Detailed information about these tests is available separately. (See "Point-of-care hemostasis testing (viscoelastic tests)".)

Formal reference ranges from small and varied patient groups are available across pregnancy, during labor, and during the postpartum period, including patients undergoing cesarean birth [70]. In pregnancy, which is a hypercoagulable state, mean clot firmness and alpha angle (TEG) are larger and clot time (ROTEM) and reaction time (TEG) are shorter compared with nonpregnant patients [71]. In the only large study of healthy pregnant patients in labor at term (n = 122), baseline median and interquartile ranges (IQR) for selected ROTEM parameters were FIBTEM amplitude at 5 minutes (A5), 21 mm (IQR 18 to 23 mm); EXTEM A5, 55 mm (52 to 58 mm); and EXTEM coagulation time (CT), 52 seconds (48 to 56 seconds) [72]. However, these data may not be generalizable to patients earlier in gestation or postpartum.

TEG/ROTEM-based transfusion algorithms have been developed to enable goal-directed transfusion therapy in patients with postpartum and other major pregnancy-related hemorrhage, but have not been formally validated [70]. (See 'Initial approach' below.)

Transfuse blood products

Initial approach — Replacement of blood components is more important than crystalloid infusion if massive hemorrhage has occurred or is likely [73]. In a postsurgical patient who repeatedly drops their blood pressure and/or urine output despite reasonable volume replacement, the clinician should assume ongoing hemorrhage. In such patients volume replacement should be with blood products and fibrinogen as necessary, rather than crystalloid, which may result in a dilutional coagulopathy and worsen bleeding.

There are no universally accepted guidelines for replacement of blood components in patients with PPH [74,75]. Recommendations are usually based upon expert opinion since there is no strong evidence from randomized trials, and these opinions are often extrapolated from data from studies in trauma patients.

Before laboratory studies are available, we suggest transfusing 2 units of RBCs if hemodynamics do not improve after the administration of 2 to 3 liters of normal saline, estimated blood loss is under 1500 mL, and continued bleeding is likely. Most patients with PPH will maintain adequate hemostasis until they have sustained a very large volume of blood loss (often in excess of 3000 mL) in the absence of abruption or amniotic fluid embolism, as impaired hemostasis is more likely in these settings. There is no consensus on the optimal ratio of empiric blood product replacement; recommendations for RBC to fresh frozen plasma (FFP) ratios vary widely (eg, RBC:FFP: 1:1, 2:1, 3:2, 6:4) [74,76,77]. If no laboratory results are available, bleeding is

ongoing, and bleeding is due to atony or trauma, a reasonable approach is 4 units RBCs followed by 4 units FFP; the 1:1 RBC:FFP ratio is maintained until tests of hemostasis are available to guide goal-directed replacement [71]. FFP transfusion is begun sooner in patients with abruption or amniotic fluid embolism. In addition, one platelet apheresis pack is transfused for each 4 to 6 units of RBCs transfused [24].

Hemodilution, hyperfibrinolysis, acidosis, and hypothermia all significantly deplete fibrinogen levels and are often present (separately or in combination) during PPH. Acidosis increases fibrinogen breakdown whereas hypothermia impairs its synthesis [78]. Hypofibrinogenemia has been reported to occur in 5.4 percent of severe PPH (>1500 mL) and 17 percent of massive PPH [79]. Early targeted fibrinogen therapy in severe PPH can prevent worsening of coagulopathy and halt the progression from severe PPH to massive PPH [79,80]. In observational studies of patients with PPH >1000 mL blood, use of viscoelastometric hemostatic assay (VHA) to guide fibrinogen concentrate administration was associated with reduced rates of all of the following: blood loss ≥2500 mL, ≥4 units RBC transfusion, FFP transfusion, and ≥8 units of any blood product transfusion [80]. Importantly, among patients with a fibrinogen level <200 mg/mL, the proportion of patients needing >4 units RBC transfusion fell from 67 to 0 percent with early fibrinogen replacement. However, empiric use of fibrinogen concentrate without coagulation test guidance should be avoided as it has no benefit. In a randomized trial, administering 3 g of fibrinogen concentrate to patients with PPH and an initial fibrinogen level over 300 mg/mL did not reduce blood loss, transfusion needs, or postpartum anemia compared with placebo [81].

Of note, a small subgroup of patients with PPH demonstrate a distinct, severe coagulopathy characterized by hyperfibrinolysis and dysfibrinogenemia [82]. The authors of this paper termed this rare (1:1000) coagulopathy acute obstetric coagulopathy and compared it to that seen in amniotic fluid embolism, where there is an acquired dysfibrinogenemia due to both decreased absolute fibrinogen levels and impaired function. The mechanism for the dysfibrinogenemia is unknown, but may be due to high levels of fibrin degradation products that interfere with fibrin polymerization [83]. Patients with very low fibrinogen levels and very high fibrin degradation products are at increased risk for further dilution of whatever fibrinogen remains if they receive large volumes of RBCs, FFP/cryoprecipitate, and platelets since these products do not contain sufficient fibrinogen to replace that being lost to fibrinolysis, blood loss, and dilutional coagulopathy. Therefore, in patients in whom acute obstetric coagulopathy is a possibility (eg, massive abruption, amniotic fluid embolism) and immediate assessment of fibrinogen and fibrin degradation product levels are not available, we suggest early administration of highly concentrated lyophilized

fibrinogen (RiaStap, FIBRYGA) along with tranexamic acid or using a different ratio of blood products combined with fibrinogen concentrate, to ensure the fibrinogen level is at least 200 mg/dL.

Laboratory monitoring — Blood loss should be quantitated or at least estimated every 15 to 30 minutes and laboratory studies drawn every 30 to 60 minutes to guide blood product replacement. In the massively transfused patient, assumptions about possible dilutional coagulopathy secondary to crystalloid infusion or RBC transfusion should be confirmed by measurement of the following laboratory tests after the administration of every five to seven units of red blood cells; results of viscoelastic testing are informative if available (see 'Viscoelastic testing' above). After the initial set of blood components are transfused, further replacement therapy should be based on these parameters rather than on any formula. (See "Massive blood transfusion".)

- Hemoglobin
- Prothrombin time/International normalized ratio [INR]
- Activated partial thromboplastin time
- Fibrinogen
- Platelet count

In any massive transfusion situation where multiple units of blood are rapidly transfused, calcium and potassium should also be monitored, with prompt treatment of abnormalities. The most common electrolyte abnormalities are low ionized calcium levels and hyperkalemia. Both disturbances, if severe, can lead to cardiac arrest or significantly depressed cardiac function that precludes optimal resuscitation. Calcium is often necessary in severe PPH due to the citrate used for anticoagulation in blood products [84].

- Ionized calcium – Ionized calcium should be measured at baseline and then every 15 to 30 minutes during a massive transfusion, and then hourly for the next few hours after transfusions have been stopped because of potential rebound hypercalcemia and hypokalemia. During a massive transfusion, the obstetric anesthesiologist will often check ionized calcium in arterial blood gas specimens and will replete as necessary.

  An ionized calcium level <1 mmol/L (normal 1.1 to 1.3 mmol/L) impairs coagulation and places the patient at risk of cardiac arrest. Emergency replacement may be accomplished by infusing 1 gram of calcium chloride over two to five minutes via a

central line for every four units of RBCs transfused. Alternatively, 1 to 2 grams of calcium gluconate can be infused intravenously over two to three minutes empirically for every four units of RBCs transfused [85]. Hypocalcemia has a linear, concentration-dependent relationship more important in predicting hospital mortality than the lowest fibrinogen concentration, the development of acidosis, or the lowest platelet count [86].

- Potassium – Hyperkalemia may result from the rapid transfusion of multiple units of RBCs, especially if they are older units. The potassium ion (K^+) concentration in the supernatant increases from 2 to approximately 45 mEq/L as a unit of blood ages from 2 to 42 days. In an older unit of RBCs (300 mL), there may be as much as 5 mEq of K^+. When a massive transfusion protocol is instituted and large numbers of RBCs are given at a high rate of infusion (eg, >500 mL/minute using a rapid transfusion device), dangerously high (>6 mEq/dL) K^+ levels may result.

  Patients undergoing massive transfusion should have electrolyte levels evaluated serially to detect hyperkalemia. When urgent reduction of K^+ is needed, one commonly used regimen for administering insulin and glucose is 10 to 20 units of regular insulin in 500 mL of 10 percent dextrose, given intravenously over 60 minutes. (See "Treatment and prevention of hyperkalemia in adults", section on 'Insulin with glucose'.)

Transfusion targets — Continue to transfuse RBCs, platelets, cryoprecipitate, and FFP in patients with ongoing bleeding to achieve the following minimum targets:

- Hemoglobin greater than 7.5 g/dL
- Platelet count greater than 50,000/mm^3
- Fibrinogen greater than 200 mg/dL
- Prothrombin time less than 1.5 times the control value
- Activated partial thromboplastin time less than 1.5 times the control value

As an example, 4 units of FFP are given if the prothrombin time is more than 1.5 times the control value, one apheresis platelet pack is given if the platelet count is less than 50,000/mm^3, and 10 bags of cryoprecipitate (usually supplied in one or two pools) are given if the fibrinogen is less than 100 mg/dL (table 5).

Most providers continue to transfuse patients with hemoglobin values less than 7.5 to 8 g/dL [87]. A hemoglobin level of at least 8 g/dL after transfusion has been recommended since values below this level can be associated with impaired hemostasis from

lower platelet adhesion and high blood velocity [88], as well as myocardial ischemia [13]. Transfusion is rarely indicated when the hemoglobin is greater than 10 g/dL [89]. In other critical care settings, a restrictive transfusion policy (ie, hemoglobin threshold for initiating transfusion 7 g/dL) has been advocated and widely adopted, based on data from randomized trials [90].

A fibrinogen level >200 mg/dL in a pregnant patient is considered the minimum level necessary for adequate coagulation. As discussed in the section on coagulation studies above, this author attempts to elevate the fibrinogen level to >300 mg/dL in patients with active bleeding who are being resuscitated, given the higher normal baseline fibrinogen level in pregnancy and the desire to maintain the fibrinogen level well above the danger zone in these patients. (See 'Routine' above.)

Once hemostasis and hemodynamic stability are achieved, it is important to stop aggressive transfusion of blood and blood components (ie, red blood cells, plasma, platelets, cryoprecipitate). When bleeding is controlled and the patient is stable, the infusion of further blood and blood products is likely to only add risk (eg, fluid overload and transfusion complications) without clear benefit.

The following UpToDate topic reviews discuss blood transfusion therapy in detail:

- (See "Indications and hemoglobin thresholds for RBC transfusion in adults".)
- (See "Approach to shock in the adult trauma patient".)
- (See "Practical aspects of red blood cell transfusion in adults: Storage, processing, modifications, and infusion".)
- (See "Massive blood transfusion".)

Issues relating to patients who are unwilling to accept transfusions (eg, Jehovah's Witnesses) are addressed in a separate topic review. (See "Approach to the patient who declines blood transfusion".)

Blood salvage and infusion has been used for management of massive hemorrhage at cesarean birth (see "Surgical blood conservation: Intraoperative blood salvage"). Its use is under investigation as an option for management of massive hemorrhage at vaginal birth [91-95].

Types of blood products

Blood — Few studies have evaluated the use of whole blood versus RBCs for obstetric hemorrhage [96,97]. Whole blood units are not widely available but are used for initial resuscitation of some trauma patients [98]. (See 'Transfusion targets' above

and "Practical aspects of red blood cell transfusion in adults: Storage, processing, modifications, and infusion", section on 'Whole blood'.)

The blood bank should have compatible blood available for massive transfusion in obstetric emergencies, and eliminate barriers to rapid access of O-negative and O-positive uncrossmatched blood when needed [77,99]. (See "Massive blood transfusion".)

Institutions should adopt an obstetric hemorrhage massive transfusion protocol for obstetric patients with massive hemorrhage and continued bleeding; several such protocols exist, including the California Maternal Quality Care Collaborative OB Hemorrhage Protocol [24].

Fresh frozen plasma — The typical dose of FFP is approximately 10 to 15 mL/kg (ie, approximately three to five units) in most adults. This dose will raise the level of any factor, including fibrinogen, by close to 30 percent. Because the volume of standard units of FFP is approximately 200 to 250 mL, therapeutic dosing in PPH represents a significant volume challenge. (See "Clinical use of plasma components", section on 'Plasma products'.)

Clotting factors — Critically low fibrinogen levels cannot be returned to normal using only FFP without the use of cryoprecipitate; in some cases of established coagulopathy, fibrinogen concentrate is also essential (see 'Fibrinogen concentrate' below). These substances should be given together in patients undergoing massive transfusion who have severe coagulopathy. TEG and ROTEM, where available, can be useful for guiding plasma and coagulation product therapy. (See 'Viscoelastic testing' above.)

Standard approach: Cryoprecipitate — Cryoprecipitate is primarily used for correcting fibrinogen deficiency, but also contains other clotting factors (table 5). The dose depends on the measured and target fibrinogen levels. A reasonable approach is 30 units for fibrinogen <50, 20 units for fibrinogen <100, and 10 units for fibrinogen 100 to 200 [24]. If no laboratory results are available and 8 units of RBCs and 8 units of FFP have been transfused, one guideline advises infusion of two pools of cryoprecipitate (one pool contains 5 units) [71]. In the average adult, each unit raises the plasma fibrinogen concentration by at least 7 to 10 mg/dL; thus, 10 units (or two 5-unit pools) will raise the fibrinogen by approximately 70 to 100 mg/dL in a 70 kg recipient (see "Cryoprecipitate and fibrinogen concentrate").In a trial that randomly assigned 199 patients with severe PPH to early treatment with cryoprecipitate (within 90 minutes of the first RBC transfusion) or standard

of care (cryoprecipitate administered later or not at all), early use resulted in fewer RBC transfusions and a trend towards fewer surgical procedures and intensive care unit admissions, with no difference in thrombotic events or serious adverse events between the two groups [100].

Advantages of cryoprecipitate are that large amounts of fibrinogen can be administered in a low-volume product (table 6) and it is less costly than the commercial products described below. Disadvantages are that it takes time to thaw and prepare for transfusion, and it carries a risk of transmissible infections since it is a pooled blood product that has not undergone any pathogen inactivation procedures.

The following specific clotting factor therapies can be useful instead of or in addition to cryoprecipitate in cases of intractable hemorrhage and coagulopathy. Further research is required before use of any of these products becomes routine.

Fibrinogen concentrate — Fibrinogen concentrate (RiaSTAP, FIBRYGA [formerly Fibryna]), a heat-treated, lyophilized fibrinogen (Factor I) powder made from pooled human plasma, may be available in some institutions. Each 50 mL vial contains approximately 1000 mg fibrinogen. It is usually administered alone but can be used in combination with cryoprecipitate (table 6). The initial dose calculation for the dose in mg/kg body weight is based on the formula: Dose = [Target fibrinogen level - measured fibrinogen level] ÷ correction factor. The fibrinogen level is expressed in mg/dL. The correction factor is in mg/dL or mg/kg. The correction factor is 1.7 for RiaSTAP and Haemocomplettan and 1.8 for FIBRYGA. Thus, the dose in mg is calculated as follows (see "Cryoprecipitate and fibrinogen concentrate"):

RiaSTAP and Haemocomplettan: Dose (in mg) = [weight (in kg) x desired increase (in mg/dL)] ÷ 1.7.

FIBRYGA: Dose (in mg) = weight (in kg) x desired increase (in mg/dL) ÷ 1.8. For FIBRYGA in children, divide by 1.4 instead of 1.8.

Fibrinogen concentrate may be used when fibrinogen levels are critically low (ie, <100 mg/dL), and FFP and cryoprecipitate are not available. It must be reconstituted but can be administered sooner than cryoprecipitate since thawing is not required. It is effective, but there are few data that it improves outcome compared with cryoprecipitate [101].

When rapid evaluation and treatment are essential, the combination of intraoperative dynamic monitoring of clotting abnormalities using TEG or ROTEM (where available) and administration of fibrinogen concentrate may be the optimum

approach. As an example, one study reported ROTEM-guided fibrinogen concentrate administration in major obstetric hemorrhage reduced requirements for blood component therapy (trigger for administration: Fibtem A5 <7 mm or fibrinogen ≤150 mg/dL) [102]. (See 'Viscoelastic testing' above and "Disorders of fibrinogen", section on 'Fibrinogen concentrate: Dosing and monitoring'.)

Prothrombin complex concentrate — Three-factor (II, IX, X) and four-factor (II, VII, IX, X) prothrombin complex concentrates (PCCs) (table 7) are available and have been suggested as an alternative to FFP. The perceived advantages are a reduced risk of volume overload, no need for thawing or blood group typing, and a reduced risk for transfusion-related acute lung injury and allergic reactions. Disadvantages include very high cost and increased risk of thrombosis.

The US Food and Drug Administration-approved indication for four-factor PCCs is for urgent reversal of acquired coagulation factor deficiency induced by vitamin K antagonist therapy in adult patients with acute major bleeding or need for an urgent surgery/invasive procedure. We caution those using PCC off-label in patients with PPH to have evidence (or strong suspicion) of a specific factor deficiency that would be alleviated by PCC because of the risk of thrombosis, the lack of data of efficacy in this population, and the concern that deficiencies in factors II, VII, IX, and X are not common in this setting [71]. The most likely scenario where PCC might be of benefit is in a massive transfusion situation with ongoing disseminated intravascular coagulation (DIC) unresponsive to all of the usual therapies or a patient on warfarin with life-threatening bleeding and elevated International Normalized Ratio (INR).

The dose of a PCC product is tailored to the individual patient's needs based on clinical indications and laboratory testing, but typically 1000 to 2000 units is administered. (See "Plasma derivatives and recombinant DNA-produced coagulation factors", section on 'PCCs'.)

Recombinant factor VIIa — Recombinant human-activated factor VII (rFVIIa) is used for treatment of individuals with bleeding related to hemophilia A and B inhibitors, acquired inhibitors, and congenital factor VII deficiency. It has also been used successfully off-label for control of bleeding in other situations, such as intractable bleeding associated with postpartum uterine atony, placenta accreta, or uterine rupture [103-105]. Although this therapy appears to be promising for patients with hemorrhage refractory to standard therapy, the medication is very expensive and some studies have reported failure in 50 percent of patients and a possible increase in thrombotic events [103-106]; therefore, we suggest

reserving its use for patients with PPH and coagulopathy unresponsive to standard therapies. (See "Recombinant factor VIIa: Administration and adverse effects".)

The optimal dose is unclear. Doses of 16.7 to 120 mcg/kg as a single bolus injection over a few minutes every two hours until hemostasis is achieved have been effective, and usually control bleeding within 10 to 40 minutes of the first dose [103,107]. It is preferable to start with a low dose (40 or 60 mcg/kg) to reduce the risk of thromboembolic events; doses of 40 mcg/kg [108] to 90 mcg/kg [109] have been suggested for obstetric hemorrhage. The dose may be repeated once in 15 to 30 minutes if there is no response. Additional doses are unlikely to be effective.

The efficacy of rFVIIa depends on the levels of other coagulation factors present. For maximal effectiveness, major sources of bleeding should be controlled and blood products should be administered to correct major deficiencies before administering rFVIIa [110]. In addition, patient temperature, pH, and calcium levels should be adequate. At a minimum, we attempt to achieve:

- Platelet count >50,000/mm^3
- Fibrinogen level >50 to 100 mg/dL
- pH ≥7.2
- Absence of hypothermia
- Absence of hypocalcemia

In a trial that randomly assigned patients with severe PPH unresponsive to oxytocin and sulprostone to treatment with rFVIIa (60 mcg/kg) or standard care, use of rFVIIa resulted in a 41 percent reduction in the primary outcome measure (arterial embolization, arterial ligation, or hysterectomy; 22/42 [52 percent] versus 39/42 [93 percent], relative risk 0.56, 95% CI 0.42-0.76), independent of the mode of birth [105]. The proportion of patients requiring transfusion was lower in the intervention group, although the absolute number of blood products administered was similar for both groups. Eight of the 42 patients in the standard care group received late rFVIIa as a compassionate treatment in an attempt to avoid hysterectomy and peripartum hysterectomy was avoided in two cases. One patient developed postpartum ovarian vein thrombosis and one developed deep vein thrombosis and pulmonary embolus; both had received thromboprophylaxis and rFVIIa after a cesarean birth.

Maintain oxygenation — Maintain oxygen saturation >95 percent by administering oxygen (10 to 15 L/minute) by face mask and also transfuse to improve oxygen-carrying capacity and delivery. An anesthesiologist should assess the patient's airway and breathing, and intubate if indicated. A high-flow mask with the correct flow rate is important since a low oxygen flow rate may result in CO_2 retention and worsen the situation.

Avoid hypothermia and acidosis — Fluids and blood components should be normothermic to avoid hypothermia, which has been linked to coagulopathy in trauma patients [111,112]. Warming devices (blankets, devices for warming all IV fluids, insulation water mattresses, and/or upper- and lower-body forced-air warming devices) are employed to maintain normothermia (temperature ≥35.5°C).

Hypothermia results in sympathetic stimulation with increased myocardial oxygen consumption, particularly if shivering occurs, which may lead to myocardial ischemia. Other adverse consequences of hypothermia include sepsis, coagulopathy, decreased platelet function, and increased mortality. The combination of hypothermia and acidosis increases the risk of clinically significant bleeding despite adequate blood, plasma, and platelet replacement [111], so acidosis should be corrected, using bicarbonate for pH <7.1 if necessary. In many cases improving tissue perfusion and correcting coagulopathy will improve pH without use of bicarbonate. (See "Bicarbonate therapy in lactic acidosis".)

Consider uterine or hypogastric artery embolization

Candidates — Where personnel and facilities are readily available, uterine or hypogastric artery embolization by an interventional vascular specialist is an option for appropriate candidates: Patients with persistent slow but excessive bleeding, who are hemodynamically and hemostatically stable, and who have failed less invasive therapies.

Consultation with an interventional vascular specialist should be obtained early in the patient's course. This facilitates decision making about the possible need for, and timing of, a procedure. Decision-making and mobilization of personnel and appropriate equipment take time and, in some cases, a significant delay is likely before the uterine vessels can be occluded. Embolization procedures can take one to three hours to complete and fail to control bleeding in 10 percent of cases; furthermore, personnel in a typical interventional suite may not be able to monitor PPH during the procedure. Thus, laparotomy should be performed if the patient is not sufficiently stable to wait for the embolization procedure. However, performing the embolization in an operating room with a full surgical team in attendance is a reasonable option for

hemodynamically unstable patients if the facility has an operating room that allows simultaneous surgery and embolization (eg, hybrid operating room, or an appropriately sensitive portable C-arm and carbon fiber table).

If coagulopathy is present, it should be corrected before the procedure, if possible, although some interventional vascular specialists will proceed while a coagulopathy is being treated since the hemorrhage is generally the cause of the coagulopathy. Others consider coagulopathy a relative contraindication to nonemergency interventional procedures; however, under emergency situations, it can be performed as a lifesaving measure even with coagulopathy. In two series, disseminated intravascular coagulation was a risk factor for failure of embolization to control hemorrhage [113,114].

Procedure — The technique of uterine or hypogastric artery embolization is basically the same as with other embolization procedures. Diagnostic angiography is initially performed to identify a bleeding site or abnormal vascular findings, such as extravasation, abnormal arteriovenous communication, pseudoaneurysm, spasm, or truncation (image 1A-B).

Gelfoam, an absorbable gelatin sponge, is the preferred agent for embolization of the uterine or hypogastric arteries since the duration of occlusion is temporary (two to six weeks), but sufficient to reduce hemorrhage. Slow development of collateral arterial flow occurs a few hours after embolization and serves to prevent ischemia [115,116]. DIC is a risk factor for failure of embolization to control hemorrhage.

N-butyl cyanoacrylate (NBCA) is a liquid glue that instantly solidifies (polymerizes) when in contact with blood. It has the advantage that it does not depend on maternal clotting factors to plug the bleeding site. In a retrospective cohort study, uterine artery embolization with NBCA was highly effective for hemostasis in patients with PPH and as effective in patients with and without DIC [117]. Disadvantages of NBCA include higher costs compared with Gelfoam, the possibility of systemic embolization, minimal information about subsequent pregnancies, and it is permanent [118,119].

The patient's clinician should monitor their status in the angiography suite at the time of the procedure and be ready to proceed to surgical intervention if the patient becomes hemodynamically unstable. Frequent communication about the patient's status between the interventional vascular specialist and the clinician is important. A prolonged embolization procedure should be avoided if there appears to be little chance of therapeutic success because the patient's condition may deteriorate and increase the risk when surgical intervention is performed.

If the uterine or hypogastric artery procedure is unsuccessful and time permits, angiographic occlusion balloon catheters can be placed to temporarily occlude the hypogastric or common iliac arteries (or even in the aorta) while en route to the operating room or during the surgery for control of hemorrhage. Prolonged (48 hours) balloon catheter occlusion of the hypogastric arteries alone, without embolization, was reported to successfully control hemorrhage in two hemodynamically unstable patients [120].

Outcome — Arterial embolization for controlling pelvic hemorrhage unrelated to malignancy has a 90 to 97 percent success rate [116,121,122]. Studies of this technique have used a variety of embolization materials in a variety of arteries (but usually the uterine artery) and employed a variety of interventions prior to and concomitantly with embolization, which explains the spectrum of reported success rates [123]. Data are also limited by the small number of published studies and the small number of participants.

Serious complications are unusual, and the procedure-related morbidity of 3 to 6 percent is much less than with laparotomy [121,122,124,125]. Postembolization fever is the most common complication; other less common complications include buttock ischemia, vascular perforation, uterine ischemia and necrosis, leg ischemia, and infection. Ovulation and menses generally resume when the uterus and ovaries are intact. However, the author is aware of one patient who died after embolization resulted in peripheral pulmonary vascular occlusion (personal communication).

Menstrual function and fertility generally return to baseline after arterial embolization for PPH [126], and subsequent pregnancies experience no or minimal increase in adverse outcome [127-137]. A case report of uterine artery embolization for treatment of a cervical ectopic pregnancy described regionally decreased blood supply in the mid-posterior wall of the uterine fundus on magnetic resonance imaging on days 5 and 25 postprocedure; this patient had a spontaneous uterine rupture at the mid-posterior wall of the uterus at 32 weeks during a subsequent pregnancy four years later [138]. Some authors have reported placenta accreta spectrum in 12 to 39 percent of subsequent pregnancies, but there was a small number of subsequent pregnancies and events in these series [139].

This generally favorable experience appears to contradict the reports describing increased pregnancy loss after uterine artery embolization for treatment of leiomyomas. Possible reasons for this discordance include the typically younger age of pregnant patients, the vastly increased vascularization of the gravid uterus (possibly permitting formation of more adequate alternative blood supply), and the absence of leiomyomas in the gravid patients. It is also possible that arterial embolization of the gravid

uterus is associated with an increased incidence of subsequent pregnancy loss above baseline, but literature supporting this theory is lacking.

BLOOD LOSS >1500 mL WITH ONGOING EXCESSIVE BLEEDING REFRACTORY TO MEDICAL AND MINIMALLY INVASIVE INTERVENTIONS

Basic interventions — Patients who fail to respond to the medical and minimally invasive therapies described above are at high risk of hemodynamic instability. (See 'Blood loss >1500 mL with ongoing excessive bleeding' above.)

It is important to quickly move on to more aggressive treatment. Laparotomy is generally required for control of bleeding, which may involve uterine sparing surgical procedures and/or hysterectomy.

Consider external aortic compression — Aortic compression is a temporizing measure to reduce blood flow to the uterus and thus provide time to initiate and continue the measures described above to stabilize the patient [140,141]. The person applying compression should position himself/herself above the epigastric area with arms extended. One hand is made into a closed fist and covered by the other hand, then both hands are used to apply firm downward pressure above and slightly to the left of the patient's umbilicus to compress the abdominal aorta against the vertebrae just above the sacral promontory. This can be readily accomplished since the postpartum abdominal wall tends to be flaccid.

Consider laparotomy — Laparotomy is indicated in patients with massive bleeding and those who are unstable after the initial interventions described above since it is unlikely that ongoing replacement of blood products will match blood loss in these patients. Ideally, the clinician should correct hemostatic defects prior to laparotomy, but surgery should not be delayed if bleeding cannot be controlled promptly.

In patients with atony who have had a vaginal birth, laparotomy is generally a last resort when less invasive interventions have failed. The need for laparotomy is rare in this setting, as the combination of uterotonic therapy, uterine tamponade, and uterine artery embolization can be used to control bleeding in virtually all cases. (See 'Consider uterine or hypogastric artery embolization' above.)

Because the abdomen is already open in patients with atony at cesarean birth, surgical procedures for controlling hemorrhage are performed sooner and are successful in 85 to 90 percent of cases [142]. In postcesarean birth patients with ongoing bleeding, the author has found that reopening the patient and washing out any collected blood and blood breakdown products and inspecting pedicles is best done earlier rather than later. The lax abdomen of a postpartum patient will not tamponade bleeding until very late in the process, and a large volume of blood can be lost without any increase in girth. In addition, the accumulation of clotted and unclotted blood in the abdominal cavity may activate the fibrinolytic system, with increased release of tissue-type plasminogen activator and possibly fibrinolytic shutdown with increased plasminogen activator inhibitor-1. This may potentiate any coagulopathy and interfere with efforts to reverse disseminated intravascular coagulation [143,144]. (See "Postpartum hemorrhage: Management approaches requiring laparotomy".)

Consider resuscitative endovascular balloon occlusion of the aorta — Resuscitative endovascular balloon occlusion of the aorta (REBOA) is increasingly used to control or reduce catastrophic or potentially catastrophic obstetric hemorrhage [145]. An endovascular balloon catheter is placed in the aorta via the deep femoral artery and maneuvered to just below the renal arteries. The balloon can be fully or partially inflated to reduce perfusion pressure and thus enable emergency bleeding control. Complete aortic occlusion at the distal thoracic aorta should be limited to 15 minutes and more distal occlusion limited to less than 30 to 60 minutes [146]. It has been used in patients with severe postpartum bleeding and collapse as well as prophylactically (eg, in patients with placenta accreta spectrum) [147-152]. (See "Endovascular methods for aortic control in trauma", section on 'REBOA technique'.)

While use of REBOA was associated with some severe complications (eg, ruptured aorta, intra- and postoperative ischemia and bleeding, and deep venous thrombosis) when first introduced clinically, the devices have since been reduced in size and the technique modified, which have improved safety. These modifications include: (i) partial balloon inflation to allow continued blood flow at a much reduced pressure rather than complete aortic occlusion (this has reduced ischemic injury but still reestablishes or maintains hemodynamic stability); (ii) placement of the balloon catheter using ultrasound alone without the need for fluoroscopy; (iii) use of a smaller catheter (4F instead of 7F, which decreases the need for postremoval compression and decreases the risk of bleeding from the insertion site); and (iv) prophylactic placement in patients at high risk for bleeding rather than placement at the time of massive hemorrhage [152].

Clinicians caring for patients at risk for massive hemorrhage may benefit from REBOA training, including its potential uses, proper placement and intraoperative management, and risks and complications. Appropriate training, credentialling, and ongoing

experience are necessary for optimal outcomes.

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".)

INFORMATION FOR PATIENTS

UpToDate offers two types of patient education materials, "The Basics" and "Beyond the Basics." The Basics patient education pieces are written in plain language, at the 5th to 6th grade reading level, and they answer the four or five key questions a patient might have about a given condition. These articles are best for patients who want a general overview and who prefer short, easy-to-read materials. Beyond the Basics patient education pieces are longer, more sophisticated, and more detailed. These articles are written at the 10th to 12th grade reading level and are best for patients who want in-depth information and are comfortable with some medical jargon.

Here are the patient education articles that are relevant to this topic. We encourage you to print or e-mail these topics to your patients. (You can also locate patient education articles on a variety of subjects by searching on "patient info" and the keyword(s) of interest.)

- Basics topic (see "Patient education: Postpartum hemorrhage (The Basics)")

SUMMARY AND RECOMMENDATIONS

- **Basic interventions** – The key to management of postpartum hemorrhage (PPH) is to recognize excessive bleeding before it becomes life-threatening, identify the cause, and initiate appropriate interventions (table 1), which are based on the severity of hemorrhage. (See 'Introduction' above.)

Initial basic interventions include:

- Obtain assistance, monitor vital signs and quantify blood loss, move unstable patients to an operating room, and perform a clot observation test. (See 'Assistance and location of care' above.)
- Establish adequate intravenous access. (See 'Establish adequate intravenous access' above.)
- Resuscitate with controlled amounts of crystalloid while making arrangements to get blood and blood products (table 5), and keep track of how much crystalloid is being given. (See 'Resuscitate with crystalloid and blood' above.)
- The shock index (SI; calculated by dividing the heart rate by the systolic blood pressure) is an indicator of hemodynamic instability and hypovolemia; SI >0.9 has been associated with increased mortality and ≥1.4 has been used as a trigger to activate a massive transfusion protocol. (See 'Initial patient assessment' above and 'Transfuse blood products' above.)
- Provide adequate analgesia. (See 'Provide adequate anesthesia' above.)
- Examine for lacerations, atony, uterine inversion, retained products of conception, and uterine rupture. (See 'Examine the lower genital tract and uterus to determine the cause of bleeding' above.)
- Consider placenta accreta spectrum with abnormal myometrial contraction in persistently bleeding patients even if the placenta has been removed and is reportedly complete. A persistently relaxing or dilated lower uterine segment, despite good upper segment contraction, is a sign of this. (See 'Examine the lower genital tract and uterus to determine the cause of bleeding' above.)
- Treat the cause of bleeding. (See 'Treat the cause of bleeding' above.)

- **Approach to patients with atony** – Atony is the most common cause of PPH. Treatment involves:
  - Perform fundal massage and manual uterine compression. (See 'Perform uterine massage and compression' above.)
  - Increase oxytocin dose. (See 'Increase oxytocin infusion' above.)

- Administer tranexamic acid. When PPH is diagnosed within three hours of start of bleeding after delivery, we suggest administration of tranexamic acid (**Grade 2B**). When more than three hours have elapsed since start of bleeding after delivery, there is no clear evidence of benefit. (See 'Administer tranexamic acid' above.)

- If hemorrhage is not controlled, add either carboprost tromethamine or methylergonovine. Misoprostol (PGE1) is useful for reducing blood loss in settings where injectable uterotonics are unavailable or contraindicated, but is less effective and has bothersome side effects. (See 'Administer additional uterotonic medications' above.)

- If pharmacologic interventions are ineffective or only partially effective, an intrauterine hemorrhage-control device can be useful (table 3). (See 'Use an intrauterine postpartum hemorrhage control device in patients with atony or lower segment bleeding' above and "Postpartum hemorrhage: Use of an intrauterine hemorrhage-control device", section on 'Types and efficacy'.)

- **Approach to patients with blood loss >1500 mL with ongoing excessive bleeding** – Patients with blood loss >1500 mL with ongoing excessive bleeding require all of the above, and:

  - Laboratory tests to evaluate blood loss and coagulopathy. (See 'Laboratory evaluation' above.)

  - Transfuse red blood cells and correct coagulopathy (table 5). Cryoprecipitate is primarily used for correcting fibrinogen deficiency, but also contains other clotting factors. The dose depends on the measured and target fibrinogen levels. (See 'Transfuse blood products' above and 'Clotting factors' above.)

  - Maintain oxygen saturation >95 percent. (See 'Maintain oxygenation' above.)

  - Infuse normothermic fluids and blood to avoid hypothermia. (See 'Avoid hypothermia and acidosis' above.)

  - Consider selective arterial embolization if less invasive measures fail, the patient is hemodynamically stable, and volume and blood product replacement can compensate for the rate of blood loss. (See 'Consider uterine or hypogastric artery embolization' above.)

- **Approach to patients with blood loss >1500 mL with ongoing excessive bleeding refractory to medical and minimally invasive interventions** – Patients with blood loss >1500 mL and ongoing excessive bleeding refractory to medical and

minimally invasive interventions are at high risk of hemodynamic instability. It is important to quickly move on to more aggressive treatment.

- Laparotomy is generally required for control of bleeding, which may involve uterine sparing surgical procedures and/or hysterectomy. Laparotomy is indicated in patients with massive bleeding and those who are hemodynamically unstable after the initial interventions described above since it is unlikely that ongoing replacement of blood products will match blood loss in these patients. Ideally, the clinician should correct hemostatic defects prior to laparotomy, but surgery, including definitive therapy with hysterectomy, should not be delayed if bleeding cannot be controlled promptly. (See 'Consider laparotomy' above.)

- Aortic compression is a temporizing measure to reduce blood flow to the uterus and thus provide time to initiate and continue other measures. Resuscitative endovascular balloon occlusion of the aorta by appropriately trained personnel can decrease the amount of bleeding distal to the occluded site and provide a window of opportunity for resuscitation and definitive hemorrhage control. (See 'Consider external aortic compression' above and 'Consider resuscitative endovascular balloon occlusion of the aorta' above.)

- **Role of intraaortic balloon occlusion in patients with severe obstetric hemorrhage** – Resuscitative endovascular balloon occlusion of the aorta (REBOA) is an increasingly used method to control, or reduce, catastrophic or potentially catastrophic obstetric hemorrhage.

  - Used in management of PPH, placenta accreta spectrum disorder, and cardiopulmonary resuscitation (CPR) of pregnant and recently pregnant patients
  - Prophylactic use as well as emergency use
  - Use profile has recently significantly improved
  - Those managing severe hemorrhage may wish to become more familiar in the use of REBOA

ACKNOWLEDGMENT

The UpToDate editorial staff acknowledges Dr. Allan J Jacobs, who contributed to earlier versions of this topic review.

REFERENCES

1. Main EK, McCain CL, Morton CH, et al. Pregnancy-related mortality in California: causes, characteristics, and improvement opportunities. Obstet Gynecol 2015; 125:938.
2. Saving Lives, Improving Mothers' Care - Surveillance of maternal deaths in the UK 2012-14 and lessons learned to inform mat ernity care from the UK and Ireland Confidential Enquiries into Maternal Deaths and Morbidity 2009-14 https://www.npeu.ox. ac.uk/downloads/files/mbrrace-uk/reports/MBRRACE-UK%20Maternal%20Report%202016%20-%20website.pdf (Accessed on October 23, 2019).
3. Shields LE, Wiesner S, Klein C, et al. Use of Maternal Early Warning Trigger tool reduces maternal morbidity. Am J Obstet Gynecol 2016; 214:527.e1.
4. Mhyre JM, D'Oria R, Hameed AB, et al. The maternal early warning criteria: A proposal from the national partnership for maternal safety. Obstet Gynecol 2014; 124:782.
5. Rady MY, Nightingale P, Little RA, Edwards JD. Shock index: a re-evaluation in acute circulatory failure. Resuscitation 1992; 23:227.
6. Vandromme MJ, Griffin RL, Kerby JD, et al. Identifying risk for massive transfusion in the relatively normotensive patient: utility of the prehospital shock index. J Trauma 2011; 70:384.
7. Callum J, Evans CCD, Barkun A, Karkouti K. Nonsurgical management of major hemorrhage. CMAJ 2023; 195:E773.
8. Nathan HL, El Ayadi A, Hezelgrave NL, et al. Shock index: an effective predictor of outcome in postpartum haemorrhage? BJOG 2015; 122:268.
9. Kohn JR, Dildy GA, Eppes CS. Shock index and delta-shock index are superior to existing maternal early warning criteria to identify postpartum hemorrhage and need for intervention. J Matern Fetal Neonatal Med 2019; 32:1238.
10. Sussman LN. The clotting time--an enigma. Am J Clin Pathol 1973; 60:651.
11. Didisheim P. Tests of blood coagulation and hemostasis. II. The coagulation (clotting) time. JAMA 1966; 198:1299.

12. Hoppenot C, Tankou J, Stair S, Gossett DR. Sonographic evaluation for intra-abdominal hemorrhage after cesarean delivery. J Clin Ultrasound 2016; 44:240.
13. Karpati PC, Rossignol M, Pirot M, et al. High incidence of myocardial ischemia during postpartum hemorrhage. Anesthesiology 2004; 100:30.
14. Prevention and Management of Postpartum Haemorrhage: Green-top Guideline No. 52. BJOG 2017; 124:e106.
15. Schol PBB, de Lange NM, Woiski MD, et al. Restrictive versus liberal fluid resuscitation strategy, influence on blood loss and hemostatic parameters in mild obstetric hemorrhage: An open-label randomized controlled trial. (REFILL study). PLoS One 2021; 16:e0253765.
16. Melamed N, Ben-Haroush A, Chen R, et al. Intrapartum cervical lacerations: characteristics, risk factors, and effects on subsequent pregnancies. Am J Obstet Gynecol 2009; 200:388.e1.
17. 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.
18. Taeuber I, Weibel S, Herrmann E, et al. Association of Intravenous Tranexamic Acid With Thromboembolic Events and Mortality: A Systematic Review, Meta-analysis, and Meta-regression. JAMA Surg 2021; 156:e210884.
19. Gayet-Ageron A, Prieto-Merino D, Ker K, et al. Effect of treatment delay on the effectiveness and safety of antifibrinolytics in acute severe haemorrhage: a meta-analysis of individual patient-level data from 40 138 bleeding patients. Lancet 2018; 391:125.
20. Shakur H, Beaumont D, Pavord S, et al. Antifibrinolytic drugs for treating primary postpartum haemorrhage. Cochrane Database Syst Rev 2018; 2:CD012964.
21. World Health Organization (WHO). Updated WHO Recommendation on Tranexamic Acid for the Treatment of Postpartum Ha emorrhage. Geneva, Switzerland: WHO; 2017. Licence: CC BY-NC-SA 3.0 IGO. WHO/RHR/17.21.
22. Arnolds DE, Scavone BM. Thromboelastographic Assessment of Fibrinolytic Activity in Postpartum Hemorrhage: A Retrospective Single-Center Observational Study. Anesth Analg 2020; 131:1373.
23. Lousquy R, Morel O, Soyer P, et al. Routine use of abdominopelvic ultrasonography in severe postpartum hemorrhage: retrospective evaluation in 125 patients. Am J Obstet Gynecol 2011; 204:232.e1.

24. Lagrew D, McNulty J, Sakowski C, Cape V, McCormick E, Morton CH. Improving Health Care Response to Obstetric Hemorrhage, a California Maternal Quality Care Collaborative Toolkit, 2022.
25. Munn MB, Owen J, Vincent R, et al. Comparison of two oxytocin regimens to prevent uterine atony at cesarean delivery: a randomized controlled trial. Obstet Gynecol 2001; 98:386.
26. Cole NM, Kim JJ, Lumbreras-Marquez MI, et al. Second-Line Uterotonics for Uterine Atony: A Randomized Controlled Trial. Obstet Gynecol 2024; 144:832.
27. Parry Smith WR, Papadopoulou A, Thomas E, et al. Uterotonic agents for first-line treatment of postpartum haemorrhage: a network meta-analysis. Cochrane Database Syst Rev 2020; 11:CD012754.
28. Hofmeyr GJ, Walraven G, Gülmezoglu AM, et al. Misoprostol to treat postpartum haemorrhage: a systematic review. BJOG 2005; 112:547.
29. O'Brien P, El-Refaey H, Gordon A, et al. Rectally administered misoprostol for the treatment of postpartum hemorrhage unresponsive to oxytocin and ergometrine: a descriptive study. Obstet Gynecol 1998; 92:212.
30. Lokugamage AU, Sullivan KR, Niculescu I, et al. A randomized study comparing rectally administered misoprostol versus Syntometrine combined with an oxytocin infusion for the cessation of primary post partum hemorrhage. Acta Obstet Gynecol Scand 2001; 80:835.
31. Walraven G, Dampha Y, Bittaye B, et al. Misoprostol in the treatment of postpartum haemorrhage in addition to routine management: a placebo randomised controlled trial. BJOG 2004; 111:1014.
32. Hofmeyr GJ, Ferreira S, Nikodem VC, et al. Misoprostol for treating postpartum haemorrhage: a randomized controlled trial [ISRCTN72263357]. BMC Pregnancy Childbirth 2004; 4:16.
33. Blum J, Winikoff B, Raghavan S, et al. Treatment of post-partum haemorrhage with sublingual misoprostol versus oxytocin in women receiving prophylactic oxytocin: a double-blind, randomised, non-inferiority trial. Lancet 2010; 375:217.
34. Winikoff B, Dabash R, Durocher J, et al. Treatment of post-partum haemorrhage with sublingual misoprostol versus oxytocin in women not exposed to oxytocin during labour: a double-blind, randomised, non-inferiority trial. Lancet 2010; 375:210.
35. Kaiser J, Royer PA. Profound Hyperthermia After Postpartum Rectal Misoprostol Administration. Obstet Gynecol 2016; 127:1067.

36. Fong YF, Singh K, Prasad RN. Severe hyperthermia following use of vaginal misoprostol for pre-operative cervical priming. Int J Gynaecol Obstet 1999; 64:73.
37. Chong YS, Chua S, Arulkumaran S. Severe hyperthermia following oral misoprostol in the immediate postpartum period. Obstet Gynecol 1997; 90:703.
38. Hofmeyr GJ, Gülmezoglu AM, Novikova N, et al. Misoprostol to prevent and treat postpartum haemorrhage: a systematic review and meta-analysis of maternal deaths and dose-related effects. Bull World Health Organ 2009; 87:666.
39. WHO recommendations for the prevention and treatment of postpartum haemorrhage. 2012 https://apps.who.int/iris/bitstream/handle/10665/75411/9789241548502_eng.pdf;sequence=1 (Accessed on March 26, 2019).
40. Tang OS, Schweer H, Seyberth HW, et al. Pharmacokinetics of different routes of administration of misoprostol. Hum Reprod 2002; 17:332.
41. Tang OS, Gemzell-Danielsson K, Ho PC. Misoprostol: pharmacokinetic profiles, effects on the uterus and side-effects. Int J Gynaecol Obstet 2007; 99 Suppl 2:S160.
42. Shojai R, Desbrière R, Dhifallah S, et al. [Rectal misoprostol for postpartum hemorrhage]. Gynecol Obstet Fertil 2004; 32:703.
43. Nasr A, Shahin AY, Elsamman AM, et al. Rectal misoprostol versus intravenous oxytocin for prevention of postpartum hemorrhage. Int J Gynaecol Obstet 2009; 105:244.
44. Widmer M, Blum J, Hofmeyr GJ, et al. Misoprostol as an adjunct to standard uterotonics for treatment of post-partum haemorrhage: a multicentre, double-blind randomised trial. Lancet 2010; 375:1808.
45. Su LL, Chong YS, Samuel M. Oxytocin agonists for preventing postpartum haemorrhage. Cochrane Database Syst Rev 2007; :CD005457.
46. Anandakrishnan S, Balki M, Farine D, et al. Carbetocin at elective Cesarean delivery: a randomized controlled trial to determine the effective dose, part 2. Can J Anaesth 2013; 60:1054.
47. Sentilhes L, Vayssière C, Deneux-Tharaux C, et al. Postpartum hemorrhage: guidelines for clinical practice from the French College of Gynaecologists and Obstetricians (CNGOF): in collaboration with the French Society of Anesthesiology and Intensive Care (SFAR). Eur J Obstet Gynecol Reprod Biol 2016; 198:12.

48. Fingar KR, Hambrick MM, Heslin KC, Moore JE https://www.hcup-us.ahrq.gov/reports/statbriefs/sb243-Severe-Maternal-Morbidity-Delivery-Trends-Disparities.jsp (Accessed on October 31, 2018).
49. Chandler WL, Ferrell C, Trimble S, Moody S. Development of a rapid emergency hemorrhage panel. Transfusion 2010; 50:2547.
50. de Lloyd L, Bovington R, Kaye A, et al. Standard haemostatic tests following major obstetric haemorrhage. Int J Obstet Anesth 2011; 20:135.
51. Hiippala ST, Myllylä GJ, Vahtera EM. Hemostatic factors and replacement of major blood loss with plasma-poor red cell concentrates. Anesth Analg 1995; 81:360.
52. McDonnell NJ, Browning R. How to replace fibrinogen in postpartum haemorrhage situations? (Hint: Don't use FFP!). Int J Obstet Anesth 2018; 33:4.
53. 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.
54. 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.
55. 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.
56. van der Bom JG. Viscoelastometric testing, fibrinogen and transfusion during post-partum haemorrhage. Br J Anaesth 2017; 119:352.
57. Szecsi PB, Jørgensen M, Klajnbard A, et al. Haemostatic reference intervals in pregnancy. Thromb Haemost 2010; 103:718.
58. 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.
59. Duque P, Korte W. Factor XIII in the Acute Care Setting and Its Relevance in Obstetric Bleeding. Transfus Med Hemother 2023; 50:10.
60. Amgalan A, Allen T, Othman M, Ahmadzia HK. Systematic review of viscoelastic testing (TEG/ROTEM) in obstetrics and recommendations from the women's SSC of the ISTH. J Thromb Haemost 2020; 18:1813.

61. Nelson DB, Ogunkua O, Cunningham FG. Point-of-Care Viscoelastic Tests in the Management of Obstetric Hemorrhage. Obstet Gynecol 2022; 139:463.
62. Whiting D, DiNardo JA. TEG and ROTEM: technology and clinical applications. Am J Hematol 2014; 89:228.
63. Afshari A, Wikkelsø A, Brok J, et al. Thrombelastography (TEG) or thromboelastometry (ROTEM) to monitor haemotherapy versus usual care in patients with massive transfusion. Cochrane Database Syst Rev 2011; :CD007871.
64. de Lange NM, Lancé MD, de Groot R, et al. Obstetric hemorrhage and coagulation: an update. Thromboelastography, thromboelastometry, and conventional coagulation tests in the diagnosis and prediction of postpartum hemorrhage. Obstet Gynecol Surv 2012; 67:426.
65. Della Rocca G, Dogareschi T, Cecconet T, et al. Coagulation assessment in normal pregnancy: thrombelastography with citrated non activated samples. Minerva Anestesiol 2012; 78:1357.
66. Karlsson O, Sporrong T, Hillarp A, et al. Prospective longitudinal study of thromboelastography and standard hemostatic laboratory tests in healthy women during normal pregnancy. Anesth Analg 2012; 115:890.
67. Karlsson O, Jeppsson A, Hellgren M. Major obstetric haemorrhage: monitoring with thromboelastography, laboratory analyses or both? Int J Obstet Anesth 2014; 23:10.
68. Armstrong S, Fernando R, Ashpole K, et al. Assessment of coagulation in the obstetric population using ROTEM® thromboelastometry. Int J Obstet Anesth 2011; 20:293.
69. 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.
70. Othman M, Han K, Elbatarny M, Abdul-Kadir R. The use of viscoelastic hemostatic tests in pregnancy and puerperium: review of the current evidence - communication from the Women's Health SSC of the ISTH. J Thromb Haemost 2019; 17:1184.
71. Collins P, Abdul-Kadir R, Thachil J, Subcommittees on Women' s Health Issues in Thrombosis and Haemostasis and on Disseminated Intravascular Coagulation. Management of coagulopathy associated with postpartum hemorrhage: guidance from the SSC of the ISTH. J Thromb Haemost 2016; 14:205.
72. Lee J, Eley VA, Wyssusek KH, et al. Baseline parameters for rotational thromboelastometry in healthy labouring women: a prospective observational study. BJOG 2020; 127:820.

73. Holcomb JB, Jenkins D, Rhee P, et al. Damage control resuscitation: directly addressing the early coagulopathy of trauma. J Trauma 2007; 62:307.
74. Spahn DR, Rossaint R. Coagulopathy and blood component transfusion in trauma. Br J Anaesth 2005; 95:130.
75. Fuller AJ, Bucklin B. Blood component therapy in obstetrics. Obstet Gynecol Clin North Am 2007; 34:443.
76. Gonzalez EA, Moore FA, Holcomb JB, et al. Fresh frozen plasma should be given earlier to patients requiring massive transfusion. J Trauma 2007; 62:112.
77. Burtelow M, Riley E, Druzin M, et al. How we treat: management of life-threatening primary postpartum hemorrhage with a standardized massive transfusion protocol. Transfusion 2007; 47:1564.
78. De Robertis E, Kozek-Langenecker SA, Tufano R, et al. Coagulopathy induced by acidosis, hypothermia and hypocalcaemia in severe bleeding. Minerva Anestesiol 2015; 81:65.
79. Bell SF, Collis RE, Collins PW. Comparison of haematological indices and transfusion management in severe and massive postpartum haemorrhage: analysis of a two-year national prospective observational study. Int J Obstet Anesth 2022; 50:103547.
80. de Lloyd LJ, Bell SF, Roberts T, et al. Early viscoelastometric guided fibrinogen replacement combined with escalation of clinical care reduces progression in postpartum haemorrhage: a comparison of outcomes from two prospective observational studies. Int J Obstet Anesth 2024; 59:104209.
81. Ducloy-Bouthors AS, Mercier FJ, Grouin JM, et al. Early and systematic administration of fibrinogen concentrate in postpartum haemorrhage following vaginal delivery: the FIDEL randomised controlled trial. BJOG 2021; 128:1814.
82. de Lloyd L, Jenkins PV, Bell SF, et al. Acute obstetric coagulopathy during postpartum hemorrhage is caused by hyperfibrinolysis and dysfibrinogenemia: an observational cohort study. J Thromb Haemost 2023; 21:862.
83. LATALLO ZS, BUDZYNSKI AZ, LIPINSKI B, KOWALSKI E. INHIBITION OF THROMBIN AND OF FIBRIN POLYMERIZATION, TWO ACTIVITIES DERIVED FROM PLASMIN-DIGESTED FIBRINOGEN. Nature 1964; 203:1184.
84. Erfani H, Fox KA, Belfort MA, Shamshirsaz AA. Preventing severe hypocalcemia during surgery for placenta accreta spectrum. Acta Obstet Gynecol Scand 2019; 98:1358.
85. Elmer J, Wilcox SR, Raja AS. Massive transfusion in traumatic shock. J Emerg Med 2013; 44:829.

86. Ho KM, Leonard AD. Concentration-dependent effect of hypocalcaemia on mortality of patients with critical bleeding requiring massive transfusion: a cohort study. Anaesth Intensive Care 2011; 39:46.
87. Matot I, Einav S, Goodman S, et al. A survey of physicians' attitudes toward blood transfusion in patients undergoing cesarean section. Am J Obstet Gynecol 2004; 190:462.
88. Jansen AJ, van Rhenen DJ, Steegers EA, Duvekot JJ. Postpartum hemorrhage and transfusion of blood and blood components. Obstet Gynecol Surv 2005; 60:663.
89. American Society of Anesthesiologists Task Force on Perioperative Blood Transfusion and Adjuvant Therapies. Practice guidelines for perioperative blood transfusion and adjuvant therapies: an updated report by the American Society of Anesthesiologists Task Force on Perioperative Blood Transfusion and Adjuvant Therapies. Anesthesiology 2006; 105:198.
90. Hébert PC, Carson JL. Transfusion threshold of 7 g per deciliter--the new normal. N Engl J Med 2014; 371:1459.
91. Teare KM, Sullivan IJ, Ralph CJ. Is cell salvaged vaginal blood loss suitable for re-infusion? Int J Obstet Anesth 2015; 24:103.
92. Yost G, Collofello B, Goba G, et al. A novel obstetric medical device designed for autotransfusion of blood in life threatening postpartum haemorrhage. J Med Eng Technol 2017; 41:515.
93. Lim G, Kotsis E, Zorn JM, et al. Cell salvage for postpartum haemorrhage during vaginal delivery: a case series. Blood Transfus 2018; 16:498.
94. Weingarten M, Rao S, Toop K, et al. Use of the cell salvage for re-infusion of autologous blood retrieved vaginally in a case of major postpartum haemorrhage. Eur J Obstet Gynecol Reprod Biol 2017; 211:215.
95. Wilson MJ, Wrench IJ. Cell salvage for vaginal delivery - is it time we considered it? Int J Obstet Anesth 2015; 24:97.
96. Alexander JM, Sarode R, McIntire DD, et al. Whole blood in the management of hypovolemia due to obstetric hemorrhage. Obstet Gynecol 2009; 113:1320.
97. Kohli N, Bhaumik S, Jagadesh S, et al. Packed red cells versus whole blood transfusion for severe paediatric anaemia, pregnancy-related anaemia and obstetric bleeding: an analysis of clinical practice guidelines from sub-Saharan Africa and evidence underpinning recommendations. Trop Med Int Health 2019; 24:11.
98. Black JA, Pierce VS, Kerby JD, Holcomb JB. The Evolution of Blood Transfusion in the Trauma Patient: Whole Blood Has Come Full Circle. Semin Thromb Hemost 2020; 46:215.

99. Novello A, King JC. Health Advisory: Prevention of Maternal Deaths Through Improved Management of Hemorrhage. www.acog.org/acog_districts/dist_notice.cfm?recno=1&bulletin=1517 (Accessed on May 02, 2006).
100. Green L, Daru J, Gonzalez Carreras FJ, et al. Early cryoprecipitate transfusion versus standard care in severe postpartum haemorrhage: a pilot cluster-randomised trial. Anaesthesia 2022; 77:175.
101. Ahmed S, Harrity C, Johnson S, et al. The efficacy of fibrinogen concentrate compared with cryoprecipitate in major obstetric haemorrhage--an observational study. Transfus Med 2012; 22:344.
102. Mallaiah S, Barclay P, Harrod I, et al. Introduction of an algorithm for ROTEM-guided fibrinogen concentrate administration in major obstetric haemorrhage. Anaesthesia 2015; 70:166.
103. Franchini M, Lippi G, Franchi M. The use of recombinant activated factor VII in obstetric and gynaecological haemorrhage. BJOG 2007; 114:8.
104. Phillips LE, McLintock C, Pollock W, et al. Recombinant activated factor VII in obstetric hemorrhage: experiences from the Australian and New Zealand Haemostasis Registry. Anesth Analg 2009; 109:1908.
105. Lavigne-Lissalde G, Aya AG, Mercier FJ, et al. Recombinant human FVIIa for reducing the need for invasive second-line therapies in severe refractory postpartum hemorrhage: a multicenter, randomized, open controlled trial. J Thromb Haemost 2015; 13:520.
106. Levi M, Levy JH, Andersen HF, Truloff D. Safety of recombinant activated factor VII in randomized clinical trials. N Engl J Med 2010; 363:1791.
107. Alfirevic Z, Elbourne D, Pavord S, et al. Use of recombinant activated factor VII in primary postpartum hemorrhage: the Northern European registry 2000-2004. Obstet Gynecol 2007; 110:1270.
108. Pacheco LD, Saade GR, Gei AF, Hankins GD. Cutting-edge advances in the medical management of obstetrical hemorrhage. Am J Obstet Gynecol 2011; 205:526.
109. Abdul-Kadir R, McLintock C, Ducloy AS, et al. Evaluation and management of postpartum hemorrhage: consensus from an international expert panel. Transfusion 2014; 54:1756.
110. Rossaint R, Bouillon B, Cerny V, et al. Management of bleeding following major trauma: an updated European guideline. Crit Care 2010; 14:R52.

111. Ferrara A, MacArthur JD, Wright HK, et al. Hypothermia and acidosis worsen coagulopathy in the patient requiring massive transfusion. Am J Surg 1990; 160:515.

112. Watts DD, Trask A, Soeken K, et al. Hypothermic coagulopathy in trauma: effect of varying levels of hypothermia on enzyme speed, platelet function, and fibrinolytic activity. J Trauma 1998; 44:846.

113. Kim YJ, Yoon CJ, Seong NJ, et al. Failed pelvic arterial embolization for postpartum hemorrhage: clinical outcomes and predictive factors. J Vasc Interv Radiol 2013; 24:703.

114. Lee HY, Shin JH, Kim J, et al. Primary postpartum hemorrhage: outcome of pelvic arterial embolization in 251 patients at a single institution. Radiology 2012; 264:903.

115. Hansch E, Chitkara U, McAlpine J, et al. Pelvic arterial embolization for control of obstetric hemorrhage: a five-year experience. Am J Obstet Gynecol 1999; 180:1454.

116. Badawy SZ, Etman A, Singh M, et al. Uterine artery embolization: the role in obstetrics and gynecology. Clin Imaging 2001; 25:288.

117. Obata S, Kasai M, Kasai J, et al. Emergent Uterine Arterial Embolization Using N-Butyl Cyanoacrylate in Postpartum Hemorrhage with Disseminated Intravascular Coagulation. Biomed Res Int 2017; 2017:1562432.

118. Nakamura Y, Aoki S, Takebayashi S, Hirahara F. Effect of transarterial embolization for post-partum hemorrhage on subsequent pregnancy. J Obstet Gynaecol Res 2016; 42:1186.

119. McCormick CC, Kim HS. Successful pregnancy with a full-term vaginal delivery one year after n-butyl cyanoacrylate embolization of a uterine arteriovenous malformation. Cardiovasc Intervent Radiol 2006; 29:699.

120. Oei SG, Kho SN, ten Broeke ED, Brölmann HA. Arterial balloon occlusion of the hypogastric arteries: a life-saving procedure for severe obstetric hemorrhage. Am J Obstet Gynecol 2001; 185:1255.

121. Vedantham S, Goodwin SC, McLucas B, Mohr G. Uterine artery embolization: an underused method of controlling pelvic hemorrhage. Am J Obstet Gynecol 1997; 176:938.

122. Sentilhes L, Gromez A, Clavier E, et al. Predictors of failed pelvic arterial embolization for severe postpartum hemorrhage. Obstet Gynecol 2009; 113:992.

123. Management of Postpartum Hemorrhage, Likis FE, Sathe NA, Morgans AK, Hartmann KE, Young JL, Carlson-Bremer D, Schorn M, Surawicz T, Andrews J. (Eds), Agency for Healthcare Research and Quality (US), Rockville (MD) 2015.

124. Alvarez M, Lockwood CJ, Ghidini A, et al. Prophylactic and emergent arterial catheterization for selective embolization in obstetric hemorrhage. Am J Perinatol 1992; 9:441.

125. Tseng JJ, Ho JY, Wen MC, Hwang JI. Uterine necrosis associated with acute suppurative myometritis after angiographic selective embolization for refractory postpartum hemorrhage. Am J Obstet Gynecol 2011; 204:e4.

126. Doumouchtsis SK, Nikolopoulos K, Talaulikar V, et al. Menstrual and fertility outcomes following the surgical management of postpartum haemorrhage: a systematic review. BJOG 2014; 121:382.

127. Picone O, Salomon LJ, Ville Y, et al. Fetal growth and Doppler assessment in patients with a history of bilateral internal iliac artery embolization. J Matern Fetal Neonatal Med 2003; 13:305.

128. Ornan D, White R, Pollak J, Tal M. Pelvic embolization for intractable postpartum hemorrhage: long-term follow-up and implications for fertility. Obstet Gynecol 2003; 102:904.

129. Descargues G, Mauger Tinlot F, Douvrin F, et al. Menses, fertility and pregnancy after arterial embolization for the control of postpartum haemorrhage. Hum Reprod 2004; 19:339.

130. Wang H, Garmel S. Successful term pregnancy after bilateral uterine artery embolization for postpartum hemorrhage. Obstet Gynecol 2003; 102:603.

131. Eriksson LG, Mulic-Lutvica A, Jangland L, Nyman R. Massive postpartum hemorrhage treated with transcatheter arterial embolization: technical aspects and long-term effects on fertility and menstrual cycle. Acta Radiol 2007; 48:635.

132. Chauleur C, Fanget C, Tourne G, et al. Serious primary post-partum hemorrhage, arterial embolization and future fertility: a retrospective study of 46 cases. Hum Reprod 2008; 23:1553.

133. Shim JY, Yoon HK, Won HS, et al. Angiographic embolization for obstetrical hemorrhage: effectiveness and follow-up outcome of fertility. Acta Obstet Gynecol Scand 2006; 85:815.

134. Fiori O, Deux JF, Kambale JC, et al. Impact of pelvic arterial embolization for intractable postpartum hemorrhage on fertility. Am J Obstet Gynecol 2009; 200:384.e1.

135. Alanis M, Hurst BS, Marshburn PB, Matthews ML. Conservative management of placenta increta with selective arterial embolization preserves future fertility and results in a favorable outcome in subsequent pregnancies. Fertil Steril 2006; 86:1514.e3.

136. Sentilhes L, Gromez A, Clavier E, et al. Fertility and pregnancy following pelvic arterial embolisation for postpartum haemorrhage. BJOG 2010; 117:84.

137. Hardeman S, Decroisette E, Marin B, et al. Fertility after embolization of the uterine arteries to treat obstetrical hemorrhage: a review of 53 cases. Fertil Steril 2010; 94:2574.

138. Takeda J, Makino S, Ota A, et al. Spontaneous uterine rupture at 32 weeks of gestation after previous uterine artery embolization. J Obstet Gynaecol Res 2014; 40:243.

139. Poggi SH, Yaeger A, Wahdan Y, Ghidini A. Outcome of pregnancies after pelvic artery embolization for postpartum hemorrhage: retrospective cohort study. Am J Obstet Gynecol 2015; 213:576.e1.

140. Riley DP, Burgess RW. External abdominal aortic compression: a study of a resuscitation manoeuvre for postpartum haemorrhage. Anaesth Intensive Care 1994; 22:571.

141. Soltan MH, Sadek RR. Experience managing postpartum hemorrhage at Minia University Maternity Hospital, Egypt: no mortality using external aortic compression. J Obstet Gynaecol Res 2011; 37:1557.

142. Doumouchtsis SK, Papageorghiou AT, Arulkumaran S. Systematic review of conservative management of postpartum hemorrhage: what to do when medical treatment fails. Obstet Gynecol Surv 2007; 62:540.

143. Olsson E, Svartling N, Asko-Seljavaara S. Massive intra-abdominal bleeding due to injury in the mesenteric artery during late breast reconstruction with a free TRAM flap: a case report. Microsurgery 2005; 25:57.

144. Yamamoto Y, Wakabayashi G, Ando N, et al. Increased fibrinolytic activity and body cavity coagula. Surg Today 2000; 30:778.

145. Webster LA, Little O, Villalobos A, et al. REBOA: Expanding Applications From Traumatic Hemorrhage to Obstetrics and Cardiopulmonary Resuscitation, From the AJR Special Series on Emergency Radiology. AJR Am J Roentgenol 2023; 220:16.

146. Bulger EM, Perina DG, Qasim Z, et al. Clinical use of resuscitative endovascular balloon occlusion of the aorta (REBOA) in civilian trauma systems in the USA, 2019: a joint statement from the American College of Surgeons Committee on Trauma, the American College of Emergency Physicians, the National Association of Emergency Medical Services Physicians and the National Association of Emergency Medical Technicians. Trauma Surg Acute Care Open 2019; 4:e000376.

147. Manzano-Nunez R, Escobar-Vidarte MF, Naranjo MP, et al. Expanding the field of acute care surgery: a systematic review of the use of resuscitative endovascular balloon occlusion of the aorta (REBOA) in cases of morbidly adherent placenta. Eur J Trauma Emerg Surg 2018; 44:519.

148. Whittington JR, Pagan ME, Sharawi N, et al. REBOA placement for placenta accreta spectrum: patient selection and utilization. J Matern Fetal Neonatal Med 2022; 35:6440.

149. Lee LO, Potnuru P, Stephens CT, Pivalizza EG. Current Approaches to Resuscitative Endovascular Balloon Occlusion of the Aorta Use in Trauma and Obstetrics. Adv Anesth 2021; 39:17.

150. Riazanova OV, Reva VA, Fox KA, et al. Open versus endovascular REBOA control of blood loss during cesarean delivery in the placenta accreta spectrum: A single-center retrospective case control study. Eur J Obstet Gynecol Reprod Biol 2021; 258:23.

151. Ioscovich A, Greenman D, Goldin I, et al. Resuscitative Endovascular Balloon Occlusion of the Aorta (REBOA) in the Multidisciplinary Management of Morbidly Adherent Placenta. Isr Med Assoc J 2023; 25:462.

152. Ordoñez CA, Manzano-Nunez R, Parra MW, et al. Prophylactic use of resuscitative endovascular balloon occlusion of the aorta in women with abnormal placentation: A systematic review, meta-analysis, and case series. J Trauma Acute Care Surg 2018; 84:809.

Topic 6714 Version 180.0

GRAPHICS

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

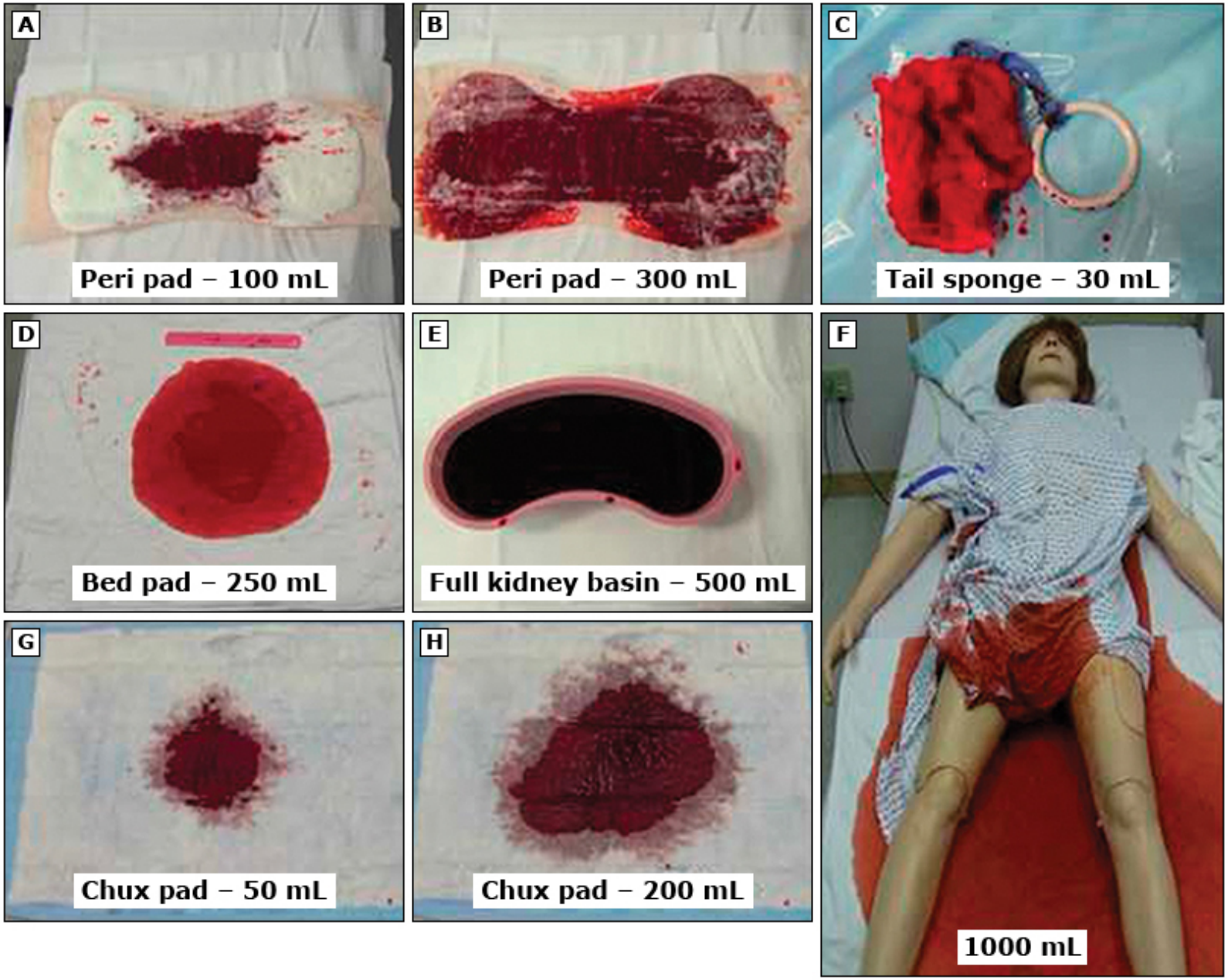
Symptoms related to blood loss with postpartum hemorrhage

Blood loss, % (mL)	Systolic blood pressure, mmHg	Signs and symptoms
10 to 15 (500 to 1000)	normal and ≥90	Palpitations, lightheadedness, no or mild increase in heart rate
15 to 25 (1000 to 1500)	80 to 90	Weakness, sweating, tachycardia (100 to 120 beats/minute), tachypnea (respiratory rate of 20 to 24)
25 to 35 (1500 to 2000)	70 to 80	Restlessness, confusion, pallor, oliguria, tachycardia (120 to 140 beats/minute), cool and clammy skin
35 to 45 (2000 to 3000)	50 to 70	Lethargy, air hunger, anuria, collapse, tachycardia (>140 beats/minute)

Adapted from: Bonnar J. Massive obstetric haemorrhage. Baillieres Best Pract Res Clin Obstet Gynaecol 2000; 14:1.

Graphic 56885 Version 7.0

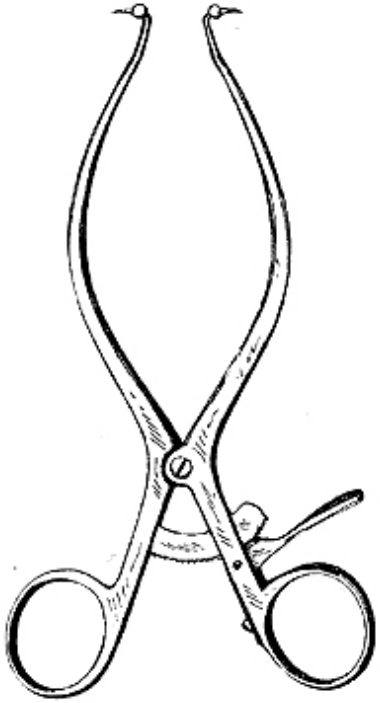
Visual aid for estimating intrapartum blood loss



Visual aid. Pocket card with images of measured volumes of artificial blood. Panel F is a manikin.

Graphic 103418 Version 5.0

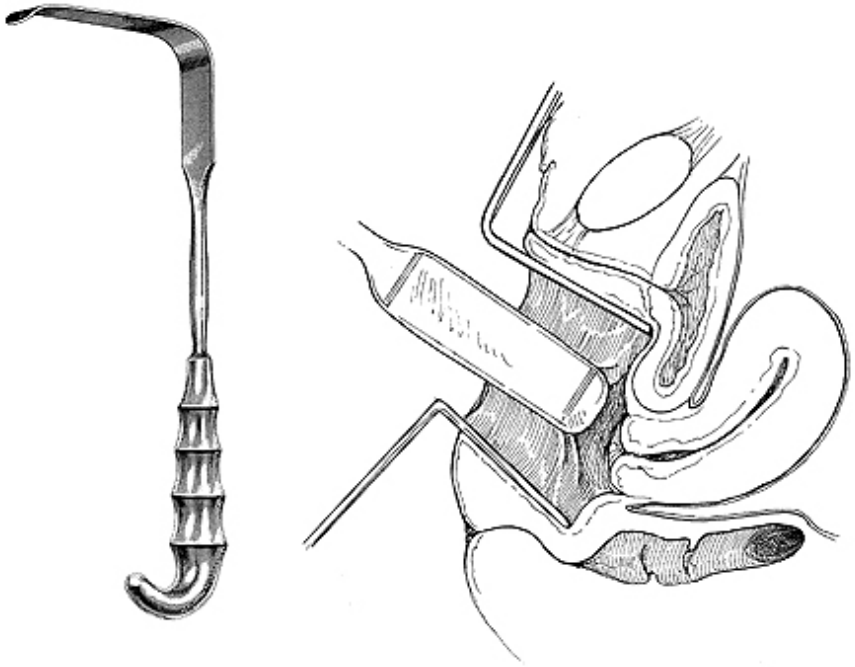
Gelpi retractor



The tips are designed to limit tissue penetration.

Graphic 65767 Version 1.0

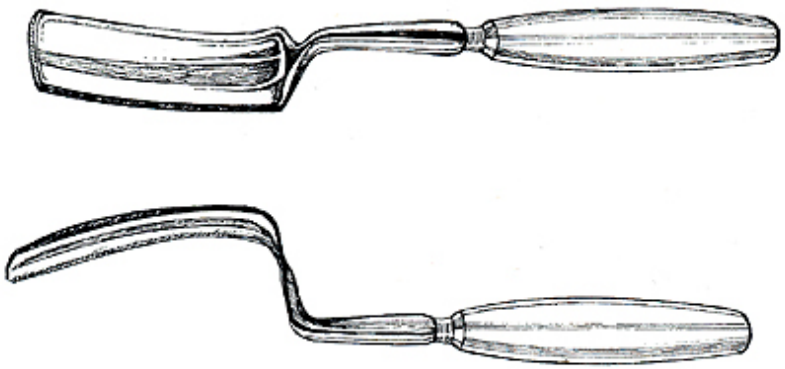
Heaney retractor



This retractor is especially designed for vaginal exposure.

Graphic 70162 Version 1.0

Breisky-Navratil vaginal retractors



Graphic 53830 Version 1.0

Intrauterine hemorrhage-control devices: Advantages and disadvantages

	Advantages	Disadvantages
Balloon tamponade	▪ Relatively easy to insert ▪ Can place through the hysterotomy at cesarean birth or using a vaginal approach ▪ Uses a single device, which reduces the risk of a retained foreign body ▪ Allows monitoring of ongoing intrauterine bleeding (specially designed balloons)	▪ Potential for balloon displacement/expulsion ▪ Potential for catheter occlusion by clot ▪ Discomfort from uterine distension by the balloon ▪ Longer dwell time
Intrauterine vacuum	▪ Advantages are similar to those of balloon tamponade (except for placement through the hysterotomy) **plus**: • Rapid onset of action and shorter dwell time • Collapse rather than distension of the intrauterine cavity, resulting in potentially shorter duration of use	▪ Cannot be used when the cervix is <3 cm dilated ▪ Cannot be placed through the hysterotomy at cesarean birth ▪ More expensive than other methods
Gauze packing	▪ Generally inexpensive ▪ Readily available in most settings ▪ Specialized gauze that is impregnated with hemostatic agents (eg, kaolin, chitosan) may provide additional benefit	▪ Potentially requires a longer time to fully insert gauze compared with other methods ▪ Blood is absorbed into the fabric, which may mask ongoing bleeding ▪ Risk of a retained foreign body (especially when mor than one pack is required) ▪ The pack must be placed so that it exerts sufficient pressure through the uterine cavity, which is essential for success (especially for plain gauze)

Graphic 141783 Version 3.0

Sample checklist for managing postpartum hemorrhage

Complete all steps in prior stages regardless of stage in which the patient presents

Recognize, call for assistance: ☐ Charge nurse ☐ OB Attending

Designate: ☐ Team lead ☐ Checklist reader/recorder ☐ Second RN

Announce: ☐ Cumulative blood loss ☐ Vital signs

Stage 1: Blood loss >500 mL to 1000 mL

Initial steps:

- ☐ Ensure 16 G or 18 G IV access
- ☐ Empty bladder: straight catheter or place indwelling Foley catheter with urimeter
- ☐ Fundal massage
- ☐ Vital signs every 5 minutes

Medications:

- ☐ Oxytocin infusion at bolus rate for up to maximum cumulative dose of 40 units
- ☐ Administer appropriate medications, consider patient history

Action:

- ☐ PPH kit to bedside
- ☐ QBL assessed, announced and recorded every 15 minutes
- ☐ Determine etiology and treat
- ☐ Consider uterine balloon tamponade

Medications

Oxytocin:
30 units per 500 mL solution; 167 mL = 10 units

Methylergonovine:
0.2 milligrams IM every 2 to 4 hours as needed; avoid with hypertension

Carboprost:
250 micrograms IM (may repeat every 15 minutes, maximum 8 doses); avoid with asthma

Misoprostol:
800 micrograms rectal **or**
600 micrograms buccal
(1000 micrograms maximum dose)

Stage 2: Blood loss >1000 mL to 1500 mL

Initial steps:

- ☐ Place second IV (16 to 18 G)
- ☐ Prepare OR if clinically indicated (optimize visualization/examination)

Medications:

- ☐ Continue medications as indicated

Action:

- ☐ Stat labs: CBC, PT/PTT, INR, fibrinogen
- ☐ Type and cross 2 units RBCs
- ☐ Transfuse RBCs per clinical signs/symptoms (do not wait for lab results)

Stage 3: Continued bleeding; blood loss >1500 mL

Initial steps:

- ☐ Activate OB emergency
- ☐ Move to OR; communicate plan (anesthesia/patient position/equipment)
- ☐ Mobilize additional help: Notify back-up provider

Medications:

- ☐ Continue medications as indicated
- ☐ Administer TXA 1 gram IV over 10 minutes; if bleeding persists, administer second dose TXA 1 gram IV
- ☐ Re-dose antibiotics

Action:

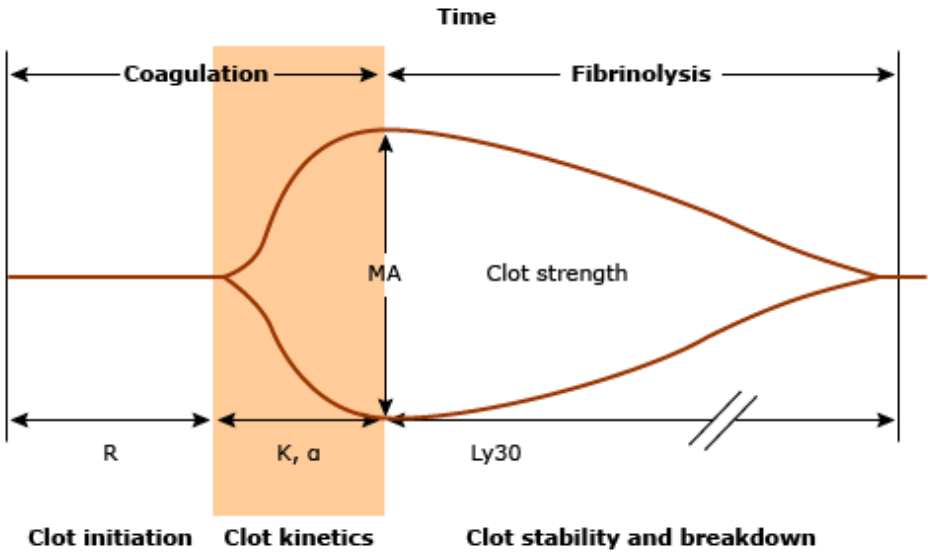
- ☐ Initiate Massive Transfusion Protocol: State "Obstetric patient"
- ☐ Stat labs every 30 minutes: CBC, PT/PTT, INR, fibrinogen, blood gas, electrolytes including ionized calcium
- ☐ Monitor TEG **or** ROTEM
- ☐ Warm all transfused fluids
- ☐ Monitor core temperature; direct warming of the patient to maintain euthermia

OB: obstetrician; RN: registered nurse; IV: intravenous; QBL: quantity of blood loss; IM: intramuscular; OR: operating room; CBC: complete blood count; PT: prothrombin time; PTT: partial thromboplastin time; INR: international normalized ratio; RBC: red blood cell; TXA: tranexamic acid; TEG: thromboelastography; ROTEM: rotational thromboelastography.

Courtesy of Christina Davidson, MD and Catherine Eppes, MD, MPH.

Graphic 126212 Version 2.0

Thromboelastography (TEG) tracing parameters



"R" is the reaction time (the time it takes the coagulation cascade to generate thrombin and fibrin). "K" is the clot firmness. "α" (alpha) is the angle (describes the kinetics of clot formation). MA is the maximum amplitude (describes the maximum clot strength). Ly30 is the percent clot lysis 30 minutes after the MA is reached. Refer to UpToDate topics on platelet function testing and trauma management for details of the use and interpretation of thromboelastography.

Graphic 100078 Version 2.0

Thromboelastography definitions

Clot phase	Parameter	Measurement	TEG abbreviation	ROTEM abbreviation	Enzymatic stage	Abnormalities
Clot initiation	Clotting time	Time from start of sample to 2 mm clot amplitude	Reaction time (R)	Clot time (CT)	Early activation of clotting cascade resulting in initial thrombin burst	Prolonged by clotting factor deficiencies, anticoagulants, and hypofibrinogenemia Shortened in hypercoagulable states.
Clot kinetics	Clot formation time	Time from 2 to 20 mm clot amplitude	Clot formation time (K)	Clot formation time (CFT)	Clot potentiation by activation of platelets and thrombin-mediated cleavage of soluble fibrinogen	Prolonged by clotting factor deficiencies, hypofibrinogenemia thrombocytopenia, and platelet dysfunction.
	Angle	Angle of tangent line from 2 to 20 mm clot formation	Alpha angle	Alpha angle		Abnormally low in clotting factor deficiencies, hypofibrinogenemia thrombocytopenia, and platelet dysfunction.
Clot strength	Maximal clot strength	Amplitude measured at peak clot strength	Maximal amplitude (MA)	Maximal clot firmness (MCF)	Maximal clot strength achieved via GP IIb/IIIa-mediated platelet-fibrin interactions	Abnormally low in hypofibrinogenemia thrombocytopenia, or platelet dysfunction.

	Clot viscoelasticity	Calculated from maximal amplitude	G	Maximal clot elasticity (MCE)		Abnormally high in platelet hypercoagulability.
Clot lysis	Clot lysis	Percentage of loss of amplitude at fixed time after maximal amplitude	Lysis at 30 minutes (LY30), estimated percentage of lysis (EPL)	Lysis index at 30 minutes (LI30), maximal lysis (ML)	Activation of fibrinolytic system	Abnormally high in enzymatic or mechanical hyperfibrinolysis.

TEG: thromboelastography; ROTEM: rotational thromboelastometry.

Graphic 74954 Version 7.0

Blood components: Indications and dosing in adults

Component (volume)	Contents	Indications and dose
Whole blood (1 unit = 500 mL)*	RBCs, platelets, plasma	▪ Rarely required. ▪ May be appropriate when massive bleeding requires transfusion of more than 5 to 7 units of RBCs (increasingly used in early trauma management).
RBCs in additive solution (1 unit = 350 mL)	RBCs	▪ Anemia, bleeding. ▪ The increase in hemoglobin from 1 unit of RBCs will be approximately 1 g/dL; the increase in hematocrit will be approximately 3 percentage points.
FFP or other plasma product¶ (1 unit = 200 to 300 mL)	All soluble plasma proteins and clotting factors	▪ Bleeding or expected bleeding (eg, emergency surgery) in individuals with deficiencies of multiple coagulation factors (eg, DIC, liver disease, massive transfusion, anticoagulation with warfarin or warfarin overdose if not corrected by vitamin K and/or PCC, depending on the clinical setting). ▪ Bleeding in individuals with isolated factor deficiencies (most often factor V) if a factor concentrate or recombinant factor is not available. ▪ Therapeutic plasma exchange in TTP (as a source of ADAMTS13). ▪ In the rare event that FFP is used to replace a clotting factor, the dose is 10 to 20 mL/kg. This dose will raise the level of any factor, including fibrinogen, by close to 30%, which is typically sufficient for hemostasis.
Cryoprecipitate, also called "cryo" (1 unit = 10 to 20 mL)	Fibrinogen; factors VIII and XIII; VWF	▪ Bleeding patients with acquired hypofibrinogenemia, which may be due to cardiac surgery, liver transplant, postpartum hemorrhage, or trauma with massive transfusion. ▪ DIC. ▪ Uremia if DDAVP (desmopressin) is ineffective. ▪ The increase in plasma fibrinogen from 1 unit of Cryoprecipitate per 10 kg body weight will be approximately 50 mg/dL. ▪ Cryoprecipitate is generally provided in pools containing 5 units, and most patients receive 1 to 2 pools.

Platelets (derived from whole blood or apheresis) (1 unit of apheresis platelets or a 5 to 6 unit pool of platelets from whole blood = 200 to 300 mL)	Platelets	▪ The platelet count increase from 5 to 6 units of whole blood-derived platelets or 1 unit of apheresis platelets will be approximately 30,000/microL in an average-sized adult.

Refer to UpToDate topics on these products and on specific conditions for details of use. Frozen blood products (FFP, Cryoprecipitate) take 10 to 30 minutes to thaw. It may take the same amount of time to perform an uncomplicated crossmatch.

DIC: disseminated intravascular coagulation; FFP: Fresh Frozen Plasma; PCC: prothrombin complex concentrate; RBCs: red blood cells; TTP: thrombotic thrombocytopenic purpura; VWF: von Willebrand factor.

* 450 mL blood and 63 mL citrate-phosphate-dextrose (CPD) anticoagulant-preservative solution.

¶ Other plasma products include:
- Plasma Frozen Within 24 Hours After Phlebotomy (PF24)
- Thawed Plasma

PF24 may be used interchangeably with FFP for all of the indications listed above, with the exceptions of factor VIII deficiency or protein C deficiency, which are treated with recombinant products or plasma-derived factor concentrates. In the rare event that specific factor concentrates are unavailable and these deficiencies must be treated with a plasma product, FFP should be used.

Thawed Plasma may be used interchangeably with FFP for all of the indications listed above, with the exception of factor VIII deficiency without access to factor VIII concentrates, in which FFP should be used, or factor V deficiency, in which FFP or PF24 should be used.

Graphic 53854 Version 23.0

Comparison of products containing fibrinogen

	Cryoprecipitate*	Fibrinogen concentrate
Constituents	Fibrinogen Factor VIII Factor XIII von Willebrand factor Fibronectin	Fibrinogen
Efficacy for fibrinogen replacement	Similar	Similar
Volume	50 to 200 mL (5 to 10 units) for at least 750 mg to 1500 mg of fibrinogen	50 mL for 900 mg to 1300 mg of fibrinogen¶
Dosing$^{\Delta}$	Generally 5 to 10 units (1 to 2 pools); each pool contains approximately 5 units	Generally 1 to 2 vials (900 to 1300 mg fibrinogen per vial)
Other aspects of administration	Requires thawing	Requires reconstitution
Adverse events	Thromboembolic events Allergic reactions Volume overload Infection – Each unit approximately equivalent to 1 unit of RBCs	Thromboembolic events Allergic reactions

Fibrinogen concentrate is probably more expensive than Cryoprecipitate in many settings; however, cost differences are highly variable and depend on whether only the cost of the product versus total costs of care are incorporated.

RBC: red blood cell; HIV: human immunodeficiency virus.

* Pathogen-reduced Cryoprecipitate contains the same components and has the same properties as Cryoprecipitate that has not been pathogen-reduced; the major difference is higher cost and lower risk of transfusion-transmitted infections such as HIV and hepatitis C virus (HCV) due to the processing steps that inactivate viruses and other microorganisms.

¶ The amount of fibrinogen per vial varies by product; refer to product labeling.

Δ Refer to UpToDate topic on Cryoprecipitate and fibrinogen concentrate for review of dose estimation and calculation.

Graphic 141747 Version 1.0

PCC products available in the United States

Unactivated prothrombin complex concentrates (PCCs)	
4 factor:* ▪ Kcentra ▪ Balfaxar	Contain inactive forms of 4 factors: Factors II, VII, IX, and X Also contain heparin
3 factor: ▪ Profilnine	Contains inactive forms of 3 factors: Factors II, IX, and X Contains little or no factor VII Does not contain heparin
Activated prothrombin complex concentrate (aPCC)	
4 factor: ▪ FEIBA	Contains 4 factors: Factors II, VII, IX, and X. Of these, only factor VII is mostly the activated form¶ Does not contain heparin

The table lists 4-factor and 3-factor PCC products available in the United States. Potency is determined differently for different products; refer to product information. All PCCs are plasma derived and contain other proteins, including anticoagulant proteins (proteins C and S). Unactivated factors are proenzymes (inactive precursor proteins). Activated factors have higher enzymatic activity. Refer to UpToDate topics for use of these products.

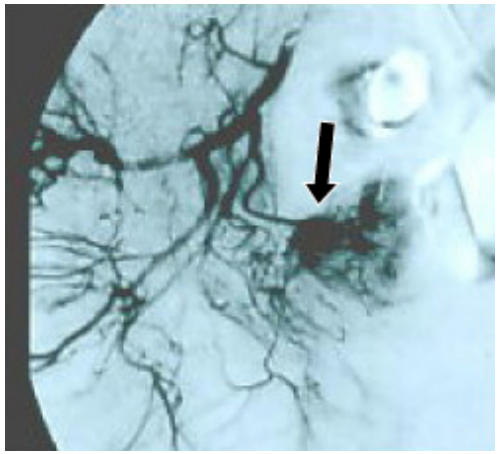
FEIBA: factor eight inhibitor bypassing activity; PCC: prothrombin complex concentrate; US: United States.

* Kcentra is available as Beriplex or Confidex in other countries. Balfaxar is available as Octaplex in other countries.

¶ Single-factor recombinant activated factor VII (rFVIIa) products are also available.

Graphic 94210 Version 10.0

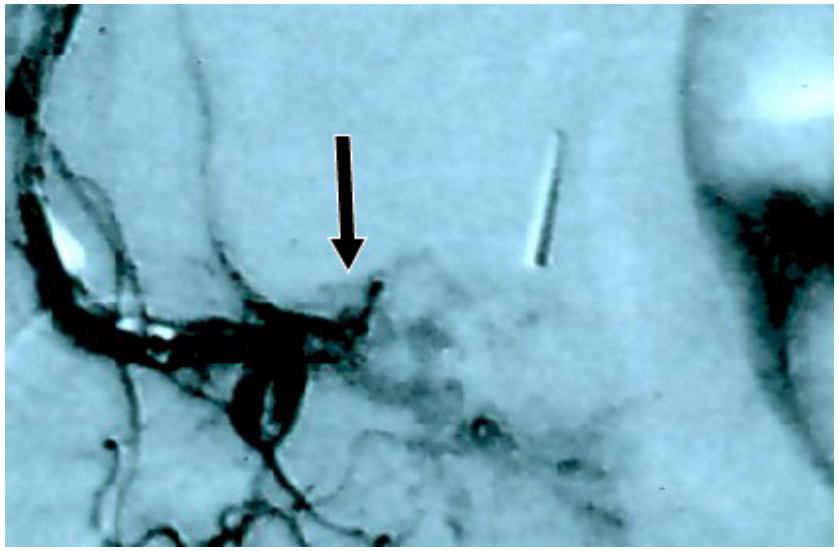
Right hypogastric angiogram



Right hypogastric angiogram on a 34-year-old woman with postpartum hemorrhage shows an area of extravasation (arrow).

Graphic 67041 Version 4.0

Right uterine angiogram



Right uterine angiogram reveals occlusion of the right uterine artery (arrow) after superselective uterine artery embolization. The procedure successfully stopped the bleeding.

Graphic 78839 Version 4.0

Contributor Disclosures

Michael A Belfort, MBBCH, MD, PhD, D.A. (SA), FRCSC, FRCOG, FACOG No relevant financial relationship(s) with ineligible companies to disclose. **Lynne Uhl, MD** Consultant/Advisory Boards: Abbott [Transfusion medicine educational services]. All of the relevant financial relationships listed have been mitigated. **Dena Goffman, MD** Grant/Research/Clinical Trial Support: KOKO Medical [Research support to institution – Abnormal postpartum uterine bleeding]; NICHD [Maternal sepsis bundle]; NIH [R01 postpartum hemorrhage simulation; effectiveness of pictographs to prevent wrong-patient errors in the NICU]; Organon [Research support to institution – Abnormal postpartum uterine bleeding]. Consultant/Advisory Boards: Baymatob [Advisory board – AI-guided solutions to improve health outcomes for mothers and their babies]; Cooper Surgical [Obstetric Safety Council – Fertility and women's health]; FetalEase [Clinical review committee – Shoulder dystocia]; Organon [Scientific Advisory Board – Abnormal postpartum uterine bleeding]. All of the relevant financial relationships listed have been mitigated. **Vanessa A Barss, MD, FACOG** No relevant financial relationship(s) with ineligible companies to disclose.

Contributor disclosures are reviewed for conflicts of interest by the editorial group. When found, these are addressed by vetting through a multi-level review process, and through requirements for references to be provided to support the content. Appropriately referenced content is required of all authors and must conform to UpToDate standards of evidence.

Conflict of interest policy