CHAPTER 4

POSTPARTUM HEMORRHAGE

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Postpartum hemorrhage (PPH) is the leading preventable cause of maternal morbidity and mortality worldwide, with an ***incidence*** of 1.2% of all deliveries (1). The incidence of PPH among women treated with uterotonic prophylaxis is estimated to range from 3-6% (2). Although PPH is the cause of 8% of maternal deaths in developed countries (3), is responsible for one-third (33.9% and 30.8%) of maternal deaths in Africa and Asia (4). In Turkiye, the maternal mortality rate was calculated as 13.1 per 100,000 live births in 2020 (5). PPH ranks first among direct maternal deaths with a rate of 24.9% (6). Also, from 1993 to 2014 in the United States, the rate of PPH requiring blood transfusions increased from about 8 cases per 10,000 births to 40 (7). In conclusion, PPH with increasing incidence is primarily responsible for maternal mortality and since it is preventable, the whole obstetrician should comprehend and manage this clinical entity competently.

DEFINITION OF PPH

Postpartum bleeding can be life-threatening in term pregnant women, due to the blood flow rate to the uterus being approximately 600 ml per minute (8). Despite this, as the increase in physiological blood volume through pregnancy; tachycardia, a significant hemodynamic finding of acute blood loss, does not appear immediately, blood pressure remains normal and PPH may be overlooked as bleeding is compensated. Typical clinical signs of PPH-induced hypovolemia may not appear until blood loss exceeds 25% of total blood volume (>1500 ml in late pregnancy) (9). The previous definition of PPH is the amount of bleeding ≥ 500 ml for vaginal deliveries, ≥ 1000 mL for cesarean deliveries, and ≥ 1500 ml for postpartum hysterectomies, considered to occur within 24 hours of delivery for primary PPH or beyond that for secondary PPH (10). However, the convenient definition of PPH to predict bleeding and prevent maternal mortality is still under

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investigation by various organizations, and the final definitions by organizations (11,12,13,14,15) are presented in **Table 1**.

Table 1. The definition of postpartum hemorrhage according to various organizations

Organizations (references)	Definitions	
WHO (11)	*PPH:* Blood loss of more than 500 mL within 24 hours of birth	
	Severe PHP: More than 1000 mL blood loss in the same period	
RCOG (12)	*Minor PPH:* Blood loss between 500 and 1000 ml	
	Major PPH: Blood loss of more than 1000 mL	*Moderate PPH:* Blood loss between 1000 and 2000 ml
		Severe PPH: Blood loss of more than 2000 mL
ACOG (13)	Cumulative blood loss of more than 1000 mL	
	Any blood loss accompanied by signs of hypovolemia due to hemorrhage	
	Presence of symptoms of hypovolemia (including intrapartum loss) within 24 hours of delivery, regardless of the delivery route.	
SOGC (14)	Any amount of blood loss that threatens hemodynamic stability	
IEP (15)	Active bleeding more than 1000 mL within 24 hours of delivery despite initial measures, including first-line uterotonic agents and uterine massage.	

Abbreviations: PPH; Postpartum hemorrhage WHO; World Health Organization RCOG; Royal College of Obstetricians and Gynaecologists ACOG; American College of Obstetricians and Gynecologists SOGC; Society of Obstetricians and Gynaecologists of Canada IEP; International expert panel

ETIOLOGIES, RISK FACTORS, AND PREVENTION OF PPH

PPH is the most common cause of maternal death worldwide, however, risk factors can be identified in only one-third of PPH cases (1). Risk factors for PPH depend on the etiology of the bleeding. Prevention of PPH also depends on identifying risk factors. The control of postpartum blood loss depends mainly on uterine contractions and, to a lesser extent, on activation of the coagulation cascade. Risk factors for postpartum hemorrhage are closely related to the type of bleeding (4T) and are listed below (16, 17).

1. **T: Uterine atony, responsible for about 70% of PPHs**

- High maternal age
- High maternal parity
- Cesarean delivery
- Conditions that cause increased distention of the uterus such as multiple gestation, polyhydramnios, fetal macrosomia, and uterine fibroids.
- Chorioamnionitis
- Prolonged use of oxytocin
- Prolonged labor or precipitous delivery
- General anesthesia
- The use of therapeutic magnesium sulfate
- Uterine inversion includes excessive umbilical cord traction, short umbilical cord, and fundal implantation of the placenta.

2. **T: Trauma due to obstetric lacerations, responsible for about 20% of PPHs**

- Operative vaginal delivery
- Precipitous delivery
- Deep episiotomy
- Rupture of the uterus

3. **T: Tissue due to retained placenta and abnormal placentation, responsible for about 10% of PPHs**

- Presence of incision due to previous uterine surgery
- Incomplete removal of the placenta at birth
- Placenta with a succenturiate lobe
- Placenta acreaata spectrum (PAS)
- Placenta previa

4. **T: Thrombin: maternal coagulopathy leading to PPH, responsible for less than 1% of PPHs**

- *Inherited* coagulation disorders (eg, von Willebrand disease)
- *Acquired* coagulation disorders (eg, Amniotic fluid embolism, Fetal death in utero, Sepsis, Placental abruption, Disseminated intravascular coagulopathy (DIC), pre-eclampsia and eclampsia, HELLP syndrome)

All pregnant women should be evaluated in the prenatal period, at the admission to labor, in the intrapartum and postpartum period, and managed according to low, medium, and high-risk groups. Despite efforts to identify patients at high risk of postpartum hemorrhage, this life-threatening complication often occurs

in women with no identifiable risk factors (17). PPH is unpredictable, therefore, it is crucial to be careful in all pregnancies. All pregnant women should have their blood group determined. Anemia should be screened and treated in the prenatal period (iron panel, hemoglobin electrophoresis, consider oral versus IV iron). Risk scores should be determined and necessary planning should be made, especially in cases with placenta previa, PAS, history of PPH, and coagulation disorders. Pregnant women with a high risk for PPH should be identified and referred to a specialist center with a blood bank in the prenatal period. According to ACOG (2017), each hospital should have a postpartum bleeding protocol, necessary intervention equipment, a trained team, access to blood products, and a massive blood transfusion protocol (13).

There are toolkits with risk scoring to prevent PPH, designed by the American College of Obstetricians and Gynecologists (ACOG) Safe Motherhood (18), and the California Maternal Quality Care Collaborative (CMQCC) (19). Recommendations have been made to prevent PPH according to risk groups (17,18,19).

The low-risk group (17,18,19) was defined by the absence of these; previous uterine incision, multiple pregnancies, more than 4 previous vaginal deliveries, known bleeding disorders, and a history of postpartum hemorrhage. The risk of PPH was found to be less than 1% (20). In the low-risk group, blood group determination and complete blood count should be done on admission. The third stage of labor should be actively managed with prophylactic uterotonic and controlled cord traction.

The moderate-risk group (17,18,19) was defined by the presence of one of these; prior cesarean delivery or uterine surgery, multiple gestations, >4 previous vaginal deliveries, chorioamnionitis, history of postpartum hemorrhage, large uterine fibroids, fetal death, estimated fetal weight >4000 g, morbid obesity (body-mass index >40), chorioamnionitis, magnesium sulfate therapy, prolonged use of oxytocin (24 hours), prolonged 2nd stage. The risk of PPH was found to be 2% (20). In the moderate-risk group, inform the patient of her condition. Blood group determination and complete blood count should be done on admission. The third stage of labor should be actively managed with prophylactic uterotonic (apply for 8 hours) and controlled cord traction. When >1 risk factor is found, 2 units of erythrocyte suspension (ES) should be crossmatched.

The high-risk group (17,18,19) was defined by the presence of one of these; placenta previa or low-lying placenta, PAS, hematocrit <%30, platelet count <70,000/µl, active bleeding on admission, known coagulopathy, abnormal vital signs, >2 moderate risk scores. The risk of PPH was found to be 7.3% (20). In the high-risk group, inform the patient of her condition and obtain the necessary consent for a potential hysterectomy. Refer to an advanced center if the appropriate team, equipment, and blood bank are not available. Blood group determination and complete blood count should be done on admission and 4 units of ES should be crossmatched. Apply uterotonic prophylaxis for 24 hours. Keep under frequent observation for at least 4 hours in the postpartum period (with the determination of the amount of bleeding).

The third stage of labor refers to the time from the birth of the fetus to the expulsion of the placenta. Active management of the third stage also reduced maternal mortality and morbidity by reducing severe PPH, maternal anemia, and transfusion rates (21). It is defined as the application of prophylactic uterotonics after delivery of the fetal shoulder or fetus, and gentle controlled traction of the umbilical cord until the placenta is spontaneously separated or expelled. Prophylactic uterotonics are effective in reducing the risk of PPH ≥500 mL and have been reported to reduce the risk of postpartum bleeding by approximately 40 percent (22). In addition, routine prophylactic uterotonic use also reduces the need for therapeutic doses of these agents.

MANAGEMENT OF PPH

In the management of PPH, the application of appropriate protocols with the presence of a trained and communicative team (obstetricians, midwives, nurses, anesthesia, etc.), a well-equipped blood products center, and adequate medical and surgical equipment, is life-saving. During pregnancy, risk factors should be determined, multidisciplinary consultations should be taken in the high-risk group (hematology for coagulation disorder, perinatology and gynecologic oncology for PAS, etc...) and hemoglobin value should be optimized before delivery. Afterward, these steps should be reviewed again at admission. All pregnant women should be tested for blood group, baseline complete blood count (CBC), basic metabolic panel (BMP), and coagulation parameters (CP) at admission (17). Intravenous (IV) access with a large diameter cannula should be established (2 IV cannulas and/or central venous and arterial catheters for high-risk patients). The third stage of labor should be actively managed with prophylactic uterotonic and controlled cord traction.

After PPH develops, the steps of primary importance in the management of PPH are to ensure the patient's hemodynamic stability, assess the quantification of blood loss (QBL), replace blood loss, appoint the cause of PPH, and apply appropriate treatment steps immediately. Continuous assessment of vital signs and ongoing estimation of total blood loss is crucial at this stage. As typical clinical signs of hypovolemia due to PPH may not occur until blood loss exceeds 25% of the total blood volume (>1500 ml in late pregnancy) (9), the most critical step in the management of PPH is to assess QBL. QBL can be determined by volumetric measurement (graded measuring cups such as aspirator boxes), gravimetric methods (weight difference in grams between wet and dry material), colorimetric measurements (the effects of non-blood components in drums, surgical gauze, drums, sponges are filtered with an application, then calculates the total blood loss) and visual aids (posters that correlate the size and appearance of blood on surfaces such as maternity pads, bed linens, and the volume of blood absorbed by that surface) (23). Blood loss can also be evaluated based on visual estimations though there is no strong evidence that QBL is better than subjective assessment subjectively, QBL provides a more accurate estimate of blood loss (ACOG 2019) (24). Considering the symptoms related to postpartum hemorrhage and blood loss (25), when blood loss is 10 to 15% (500 to 1000 ml), SBP is normal (≥90 mmHg) and vital signs are close to normal (no increase in HR(<100 beats/min) or mild), symptoms such as palpitation and dizziness may occur. The Shock Index [SI] is found by dividing the heart rate (HR) (beats/min) by systolic blood pressure (SBP) (mmHg), and in the first hour after birth, SI greater than 1 indicates cardiac decompensation and can predict to severe PPH ahead of time (24). The basic principle of PPH is early diagnosis and early intervention. If PPH is predicted at this stage, it will be noticed and intervened at an early stage.

In case of 15 to 25% (1000 to 1500 ml) blood loss, hypotension (SBP 80 to 90 mmHg), weakness, sweating, tachycardia (HR 100 to 120 beats/min), tachypnea is detected (23). At this stage of PPH seek help first (17). First of all, help should be called (midwife, experienced obstetrician, anesthesia team, hematologist, interventional radiologist). Ensure vital signs are monitored, administer an additional IV catheter to the patient (16 gauge if possible), and administer IV fluids (crystalloids, colloids) to primarily compensate for blood loss. Ringers Lactate (RL) replaces blood loss at 2:1. Oxygen should be given with a mask (10-15 L/min). Endotracheal intubation should be applied in cases where the airway cannot be established. Insert a urinary catheter to monitor urine output

and aid uterine contraction. Continue bimanual uterine massage while applying pharmacotherapy (oxytocin, methylergonovine, carboprost, misoprostol). Simultaneously investigate the etiology. In uterine atony, which is responsible for 70% of PPH (16, 17), it is essential to apply medical treatments together with bimanual uterine massage. Bimanual uterine massage, which manually compresses the corpus between the obstetrician's two hands, one hand is made into a fist and placed vaginally in the anterior fornix, and the other hand presses the fundus tightly from the abdomen and massages. If uterine atony is ruled out or bleeding continues despite uterine contraction with intervention, by providing adequate anesthesia and analgesia; the uterine cavity is checked for residual conception and rupture, vaginal and cervix lacerations, arterial damage at the uterine incision site, and retroperitoneal bleeding. Inform anesthesia, blood bank, and the operating room. Delay in treatment of PPH leads to hypothermia, acidosis, and coagulopathy. In the first hour of PPH, effective management should be performed to prevent metabolic acidosis and to ensure maximum surveillance. Interventions are carried out simultaneously to stabilize maternal hemodynamics and determine the cause of PPH.

If blood loss of % 25 to 35 (1500 to 2000 ml) is detected, hypotension (SBP 70 to 80 mmHg), restlessness, confusion, pallor, oliguria (0.5 kg/ml/h), tachycardia (HR 120 to 140 beats/min), cool and moist skin is observed (25). At this stage of PPH (17), insert an arterial catheter or a central venous catheter. Administer blood and blood products. Warm blood products and infusions to prevent hypothermia, coagulopathy, and arrhythmias. Continue to administer pharmacotherapy at maximum tolerated doses. Apply tranexamic acid. It is decided at the end of 30 minutes at the latest whether the effect of the therapeutic drugs is sufficient. Insert uterine tamponade (eg Bakri or Rusch balloon tamponade). Monitor laboratory values (CBC, BMP, fibrinogen, PT, aPTT, lactate). The goals of treatment are to prevent hypoperfusion, provide adequate tissue oxygenation, prevent coagulopathy, and identify and treat the obstetric cause of PPH.

If bleeding continues and the blood loss is 35 to 45% (2000 to 3000 ml), hypotension deepens (SBP 50 to 70 mmHg), lethargy, anuria, tachycardia (HR >140 beats/minute) and collapse occurs. At this stage of PPH (17), continue transfusion of erythrocytes, FFP, and platelets (eg 1:1:1 ratio). Patients frequently (at least every 15 minutes) are monitored, and response to treatment is monitored. Laboratory tests are repeated at intervals of 30-60 minutes (CBC, calcium, potassium, BMP, fibrinogen, PT, aPTT, lactate). Reapply tranexamic acid. Consider

recombinant factor VIIa therapy in hemophilia A or B. If the patient is stable, consider uterine artery embolization with interventional radiology. If bleeding continues and the patient is hemodynamically unstable, proceed to laparotomy. Repair any uterine rupture or genital tract lacerations. In a uterine inversion, the uterus should be brought back to its normal anatomy. Laparotomy is applied for bleeding that cannot be stopped despite all interventions and balloon tamponade. Perform uterine compression sutures (eg B-Lynch, Hayman, Cho, methods) and suture ligation step by step [bilateral uterine artery ligation (O'Leary sutures) → bilateral Utero-ovarian artery ligation → Internal iliac artery ligation]. If bleeding does not stop despite compression and ligation sutures, perform a hysterectomy (total or supracervical). Especially if there is no desire for fertility, a hysterectomy can be performed at the beginning of the surgical treatment (17). Remember to alleviate hypothermia associated with fluid and blood resuscitation and prolonged surgery. Despite hysterectomy; if there is ongoing severe bleeding, pH <7.30, fever < 35 centigrade, and non-mechanical bleeding, pelvic packing is performed and the patient is re-evaluated under general anesthesia after a maximum of 48 hours. After the bleeding is brought under control, the case should be evaluated in terms of follow-up in the intensive care unit. Appropriate antibiotic therapy (ampicillin or sulbactam/ampicillin or 1-2nd generation cephalosporin if there is no allergy) is started as IV/IM. Postpartum bleeding and massive transfusion are risk factors for the development of postpartum venous thromboembolism. Thromboprophylaxis should be initiated after bleeding is controlled. Pneumatic compression, unfractionated and low molecular weight heparin are options for thromboprophylaxis (27).

MEDICAL TREATMENTS

Medical Treatment of PPH	Mechanism of Action (17)	Application in postpartum hemorrhage	WHO (11)	RCOG (12)	ACOG (13) SOGC (14)	Republic of Turkiye Ministry of Health (28)	Considerations (17, 29)	Major Side Effects (17, 29)
Oxytocin (Pitocin, Synpitan)	Stimulates oxytocin receptors in the uterus	Prophylaxis dose	10 IU, im/iv	5 IU, slow iv infusion, cesarean delivery / 5 IU, im, vaginal delivery	10 IU, im/iv 10 IU, im	10 IU, im	**First-line therapy**	Generally well tolerated. Flushing, gastrointestinal (eg, nausea, vomiting). Risk of hypotension, tachycardia, and myocardial ischemia with rapid IV administration of high doses. Risk of hyponatremia (rare) with large doses given for a prolonged period due to water retention.
		Treatment dose	Does not specified	40 IU in 500 cc, 125 ml/h	40 IU in 1000 cc, 10-40 mU/min 20-40 IU in 1000 cc, 150 ml/hour	20 IU in 500 cc, 60 drops/min		

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Methylergonovine (Methergine)	Partial agonist or antagonist at serotoninergic, dopaminergic, α1-adrenergic receptors in the uterus	Prophylaxis dose	0,2 mg, im	0.5 mg ergometrine and 5 IU oxytocin, im	0,2 mg, im	0,2 mg ergonovine, im	0,2 mg, im	Due to vasoconstrictive effects, contraindicated in patients with hypertension (including preeclampsia/ eclampsia), history of migraine, or vascular disease (eg, Raynaud phenomenon).	Often not well tolerated due to vasoconstrictive adverse effects. Cardiovascular (eg, elevated blood pressure, myocardial ischemia), headache, increase in postpartum abdominal pain, gastrointestinal (eg, nausea, vomiting).
		Treatment dose	Does not specified	0.5 mg ergometrine, im	0.2 mg im, every 2-4 hours	0.25 mg ergonovine, im/iv	0.2 mg im, every 2-4 hours		
Misoprostol (Cytotec)	PGE1 agonist in the uterine myometrium	Prophylaxis dose	600 µg, po			600-800 µg, po/ sublingual/ rectal	600 µg, po	It May also be administered rectally; however, onset may be delayed relative to buccal/sublingual. Treatment of uncertain useful ness	Shivering, fever, gastrointestinal (eg, diarrhea, vomiting), headache.
		Treatment dose	800 µg, sublingual	1000 µg, rectal	800-1000 µg, rectal	400-1000 µg, po/ rectal	Dose not specified		

15-methyl PGF2α (Hemabate, Carboprost)	PGF2α agonist in the uterine myometrium	Prophylaxis and treatment dose			250 micrograms IM (may repeat in q15 minutes, maximum 8 doses)		Concern for asthma, cardiovascular disease, hepatic disease, renal disease	Nausea, vomiting, and diarrhea
Carbetocin (PABAL)	Similar to oxytocin	Prophylaxis and treatment dose			100 µg, slow infusion, iv		According to manufacturer labeling, use with caution in patients with asthma, epilepsy, migraine, or cardiovascular disease.	Flushing, cardiovascular (eg, hypotension), headache, abdominal pain, gastrointestinal (eg, nausea).
Tranexamic Acid (TXA) (17)	Diminishes the dissolution of hemostatic fibrin by plasmin, stabilizing clots in uterine vessels 1 gram IV over 10 min (add 1 gram vial to 100mL NS & give over 10 min; may be repeated once after 30 min) For patients who refuse blood products or those with a significant risk for postpartum hemorrhage Generally well tolerated; may increase risk of thrombotic events.							
Recombinant factor VIIa (17)	Activates clotting cascade by cleaving factor IX and factor X, which activates these factors and leads to activation of thrombin and fibrin IV route, 50–100 µg/kg (single dose) Concern for severe anemia, severe thrombocytopenia, hyperfibrinogenemia, allergy to mouse, hamster, or bovine proteins Increase risk of thrombotic events.							
Abbreviations: PPH; Postpartum hemorrhage **WHO;** World Health Organization **RCOG;** Royal College of Obstetricians and Gynaecologists **ACOG;** American College of Obstetricians and Gynecologists **SOGC**; Society of Obstetricians and Gynaecologists of Canada								

BLOOD TRANSFUSION

Blood transfusion is not without risk and it is natural to restrict it to those who need it. Because of its known risks, such as infectious diseases and blood incompatibility reactions, initial treatment of hypovolemia should be with crystalloids (eg, normal saline, Ringer's lactate) or colloids (gelatins, starch derivatives) (30). There is no absolute consensus on when to start a blood transfusion. According to ACOG (18), blood loss > 1500 ml, ongoing bleeding, and abnormal vital signs should be transfused. According to RCOG (12), clinical appearance is the main determinant of transfusion and the opinion of a hematologist and anesthesiologist should be sought. According to CMQCC (19), if maternal vital signs are impaired, disseminated intravascular coagulopathy (DIC) is suspected, and blood loss is > 1500 ml, transfusion should be started. However, if the cardiovascular system cannot be stabilized despite the infusion of 2 liters of crystalloid and 1 liter of colloid in ongoing bleeding, and if the blood volume lost is over 40% and hemoglobin less than 7 g/dl [If hemoglobin <7 or <8 g/dl (depending on local protocols and coexisting maternal conditions)], blood transfusion can be applied (30). The aim of transfusion is hemoglobin higher than 7.5 g/dl, hematocrit higher than 21%, platelet higher than 50000/mm3, fibrinogen higher than 200 mg/dl, prothrombin time, and aPTT less than 1.5 times (31). 1 unit of erythrocyte suspension (ES) is 450 ml and after transfusion, hemoglobin increases by 1 g/dl. If blood is urgently needed, O group Rh (-) ES can be given without testing for compatibility, but a cross match should be performed with a 10-15 minute delay. Fresh frozen plasma (FFP) ensures the availability of all clotting factors. The only indication for FFP is the replacement of coagulation factors in coagulation disorders (32). FFP should be given in case of ongoing bleeding when PT and APTT are above 1.5 compared to control and after every 1, 4, or 6 units of packed red cells (depending on local protocols). In case of severe bleeding, FFP can be given without obtaining coagulation results. 1 Unit FFP is approximately 250 ml in volume; a dose of 10–20 ml/kg will increase clotting factors by 10–20%. Fibrinogen is the first coagulation factor to decrease rapidly in PPH and a low fibrinogen level is an early determinant of PPH severity. Positive predictive value was found to be 100% when fibrinogen was < 200 mg/dL (33). It is appropriate to use cryoprecipitate, which contains fibrinogen and factor VIII, without causing massive transfusion in cases where the fibrinogen level is less than 0.5 g and there is evidence of consumptive coagulopathy. The usual dose of cryoprecipitate is 10 units and increases fibrinogen level by 75 mg/dL. As

with FFP, 20 minutes are needed for melting to be ready for use. The aim is to increase the fibrinogen level to 1.0 gr/l. At low fibrinogen levels, 2-4 g vials of pure fibrinogen IV can be replaced by slow infusion. Platelet replacement (PR) should be performed if the platelet count is <75,000/μl or after every 1, 4, or 6 units of packed red blood cells. Random platelet suspension increases the platelet count by 5000/mm3, while apheresis platelet suspensions increase up to 30000/mm3. Calcium (10 ml of 10%) replacement should be forgotten in massive transfusions. Massive transfusion is defined as more than 10 ES replacements in 24 hours or more than 4 ES replacements in one hour and requires hematology consultation.

MECHANICAL INTERVENTIONS

Balloon Tamponade

Balloon tamponade systems, such as the Bakri balloon (34), first described in 2001, are administered by inflating an intrauterine balloon with a maximum fluid volume of 500 ml after intrauterine insertion of the balloon. If the bleeding stops with bimanual compression, the patient will benefit from balloon tamponade and the tamponade test is considered positive. Balloon tamponade is included in the treatment of postpartum hemorrhage with a success rate of over 85% (35). If 500 ml of bleeding is observed approximately within half an hour after administration, surgical procedures should be started. The purpose of balloon tamponade is to stop or reduce intrauterine bleeding, and the tamponade effect of the filled balloon can be kept for up to 24 hours. This uterine buffering can also be done by using foley catheters and condoms in areas where there is no Bacri balloon.

Radiological interventions

In hemodynamically stable cases, that have ongoing slow bleeding, and fail with fewer medical treatments, uterine artery embolization (UAE) with a success rate of 89% and a serious complication rate of less than 5% can be considered (36). Although fever is the most common complication in UAE administration, menstrual function and fertility seem unaffected, and there is no difference in obstetric outcomes in a subsequent pregnancy, but long case series are still lacking (36). For patients at risk of sudden blood loss, the Resuscitative endovascular balloon occlusion of the aorta (REBOA) technique, with an aortic catheter placed under the renal arteries, can delay bleeding to allow for continued resuscitation (37).

Compression sutures

Laparotomy is applied for bleeding that cannot be stopped despite all interventions and balloon tamponade. It is necessary to apply surgical treatments without losing time in hemodynamically unstable cases, have ongoing rapid bleeding, and other treatments fail. The vertical incision should be preferred in laparotomy performed in PPH after vaginal delivery or in cases with suspected PAS. Adequate abdominal exploration should be provided for PPHs that develop after cesarean delivery with a Pfannenstiel incision. Uterine compression sutures, also known as brace sutures, were first described by B-Lynch et al. in 1997 (38) and various techniques are highly effective in controlling PPH with a 90% success rate (39). Various suture techniques are presented in Figure 1. The B-lynch suture (Figure A) has a cesarean incision scar, while the Hayman suture (Figure B) is the preferred technique for vaginal deliveries. Other than that, many different compression suture techniques are demonstrated, such as Cho (Figure C) and Pereira (Figure D). Before the abdomen is closed, it should be checked whether the compression sutures are working by observing whether there is blood loss. Combining compression sutures and balloon tamponade is defined as the sandwich technique.

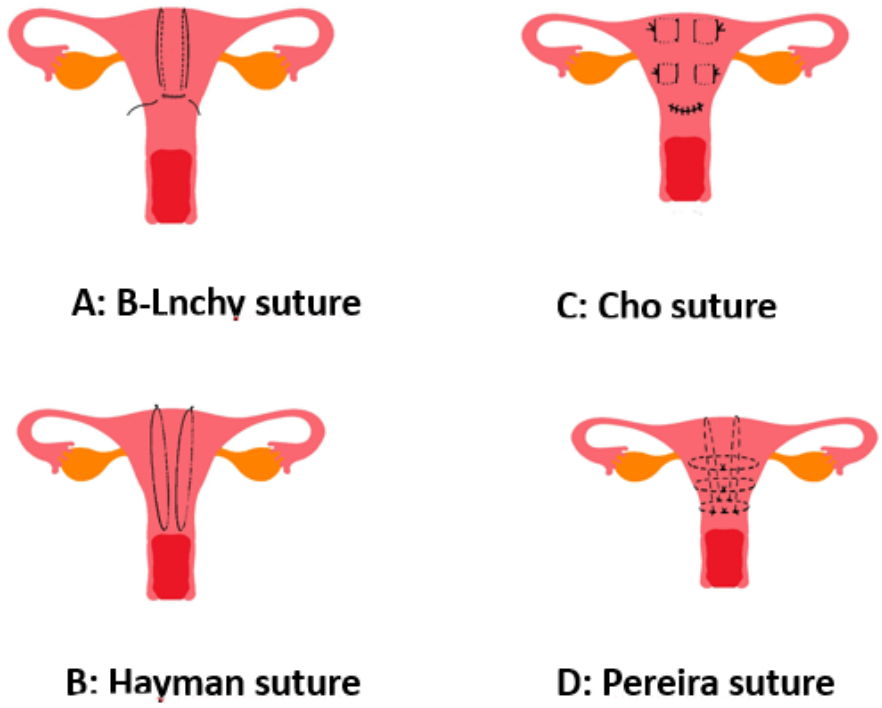

Figure 1. Various uterine compression sutures

ARTERIAL LIGATION SUTURES

Arterial ligation techniques with sutures were first described by Waters et al in 1956 and used successfully in PPH (40). Figure 2 depicts the ligation of the uterine artery (A), utero-ovarian artery (B), and hypogastric artery (C), respectively. Mastery of the pelvic anatomy is of great importance in arterial ligations and the neighborhood of the ureter should always be considered. When ligating the hypogastric artery, after giving its posterior branches, it should be sutured bilaterally with a transition from medial to lateral. All pelvic arteries should be ligated bilaterally and step-by-step ligations should be performed. Arterial ligations provide bleeding control by reducing pulse pressure (%85) and blood flow (%50). Hypogastric artery ligation, which is used as a last resort before hysterectomy, gives a success rate of 50-60% (41).

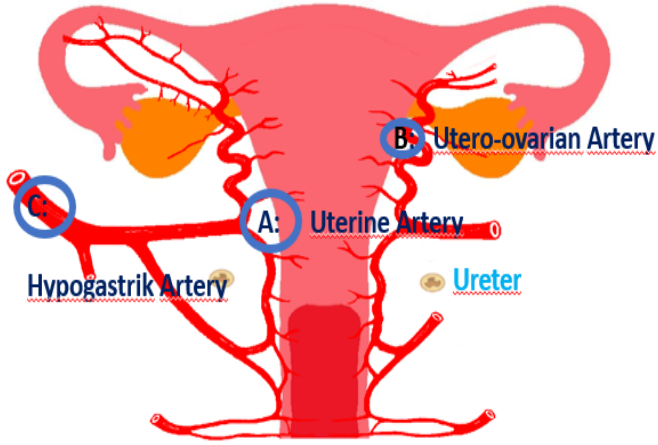

Figure 2. Types of arterial suture ligation

PERIPARTUM HYSTERECTOMY

In a hemodynamically unstable woman, a peripartum hysterectomy is a life-saving procedure and the obstetrician should not be hasty or late in the decision to perform a hysterectomy. Considering the patient's cardiovascular status, the surgeon can immediately perform a hysterectomy without waiting for the patient's DIC to progress. The hysterectomy technique (total or supracervical) should be simple enough to be performed quickly and minimize dead space formation due to the possibility of co-existing coagulopathy. Supracervical hysterectomy provides both

rapid surgery and good postoperative anatomical support, but due to the presence of the cervix, national cervical cancer screening programs should be continued and attention should be paid to existing lesions. When bleeding is severe, control of uterine blood flow precedes surgical dissection, and in a hemodynamically unstable patient, this may entail the risk of urinary tract, adnexal, or bowel injury. An experienced team (perinatologist, gynecologic oncologist, anesthesiologist, urologist, gastroenterologist...) should be present for clinical conditions such as PAS. In PAS cases, midline abdominal incision and fundal uterine incision are planned by experienced surgeons. If there is not enough experience and the patient's bleeding is stable, PAS cases should be referred to adequate centers. The presence of PAS should be questioned, especially in women with a previous history of uterine surgery. Despite hysterectomy; if there is ongoing severe bleeding, pH <7.30, fever < 35 centigrade, and non-mechanical bleeding, pelvic packing is performed and the patient is re-evaluated under general anesthesia after a maximum of 48 hours. After the bleeding is brought under control, the case should be evaluated in terms of follow-up in the intensive care unit.

LATE POSTPARTUM HEMORRHAGE

Late PPH is defined as bleeding that develops between 24 hours and 12 weeks after delivery, and the incidence of PPH is higher in the first 2 weeks, especially in the postpartum period. Endometritis, retention of pregnancy products, inadequate placental implantation site involution, and coagulation disorders are among the common causes of late PPH (42), while uterine artery pseudoaneurysm, arteriovenous malformation, and choriocarcinoma are rarer causes (43). Treatment modality is applied according to the etiology.

OUTCOMES OF PPH

Postpartum hemorrhage remains a clinically important cause of maternal complications and death. In the WOMAN trial (44), which included over 20,000 patients worldwide with PPH, 54% had a transfusion, 60% had organ failure related to hemodynamic instability, and 3.5% had a peripartum hysterectomy, and 0.3% had thromboembolic. As a late postpartum complication, these women are at risk for Sheehan syndrome with panhypopituitarism and Asherman syndrome with uterine synechiae. Maternal death and morbidity are observed due to PPH, and this clinical condition can be prevented if the risk is determined beforehand and managed appropriately. Therefore, rapid identification of patients at risk of

postpartum hemorrhage, routine active management of the third stage of labor, rapid assessment of blood loss, appropriate patient follow-up, and management of postpartum hemorrhage are important.

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