

Postpartum Hemorrhage

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Abstract

Postpartum hemorrhage (PPH) is the most important single cause of maternal death in both developing and developed countries. It arises from abnormalities in one of four basic processes, with uterine atony being the most common. A multidisciplinary approach to management is important. The value of oxytocin and prostaglandins, including misoprostol, in treatment is discussed. Recently developed, less invasive treatment options, namely uterine tamponade and compression sutures, are fast becoming valuable alternatives to the traditional options of pelvic devascularization and hysterectomy. With a stark contrast in maternal mortality from PPH between the developing and developed countries, public health strategies and medical interventions intended to minimize this are further discussed.

Résumé

L'hémorragie post-partum (HPP) est la cause la plus importante de décès maternel, tant dans les pays développés que dans les pays en développement. Elle est attribuable à des anomalies au sein d'un processus fondamental (il en existe quatre); l'atonie utérine est l'anomalie rencontrée le plus fréquemment. Il est important d'aborder la prise en charge sous un angle multidisciplinaire. La valeur de l'oxytocine et des prostaglandines (y compris le misoprostol) en ce qui a trait au traitement est débattue au sein du présent article. Des options de traitement moins effractives élaborées récemment, comme le tamponnement utérin et les sutures de compression, sont de plus en plus considérées comme étant des solutions de rechange précieuses à la dévascularisation pelvienne et à l'hystérectomie, options plus conventionnelles. Étant donné le contraste marquant qui existe entre les taux de mortalité maternelle attribuable à l'HPP des pays développés et ceux des pays en développement, le présent article aborde plus à fond la question des stratégies de santé publique et les interventions médicales visant à réduire cet écart.

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INTRODUCTION

Complications of pregnancy and childbirth remain a leading cause of death and disability among women of reproductive age in developing countries. The estimated number of maternal deaths around the world in the

year 2000 was approximately 529 000. These deaths were divided almost equally between Africa (251 000) and Asia (253 000); about 4% (22 000) occurred in Latin America and the Caribbean, and less than 1% (2500) in the more developed regions of the world.¹

Globally, postpartum hemorrhage (PPH) is the most important single cause of maternal death, accounting for about 25% of the total and claiming an estimated 150 000 lives annually.^{2,3} The majority of these deaths (88%) occur within four hours of delivery,⁴ indicating that they are a consequence of events in the third stage of labour. Furthermore, a significant predisposing factor, anemia, has a high prevalence in developing countries; one half of women of childbearing age in Africa are anemic.^{5,6}

Because immediate and effective professional care during and after labour and delivery can mean the difference between life and death, we present a review of the pathophysiology and recommended management of this most common cause of maternal death in both developing and developed countries.

POSTPARTUM HEMORRHAGE

PPH is defined as the loss of 500 mL or more of blood from the genital tract. Primary PPH occurs within the first 24 hours after delivery, and secondary PPH occurs after this time. The ability of a woman to cope with blood loss depends on a number of factors, including her previous health, the presence or absence of anemia, and the presence of absence of volume contraction due to dehydration or preeclampsia. Estimation of blood loss is subjective and generally underestimated. Emergency measures should be initiated if there is perceived loss of more than one third of estimated blood volume (blood volume [mL] = weight [kg] x 80) or loss of 1000 mL or a change in vital signs.

Excessive bleeding occurs because of an abnormality in one of four basic processes, referred to in the "4Ts" mnemonic, either individually or in combination: tone (poor uterine contraction after delivery), tissue (retained products of conception or blood clots), trauma (to genital tract), or

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Table 1. Etiology and risk factors for the 4Ts processes involved in PPH⁷

Process	Etiology	Risk Factors
Tone	Uterus over-distension	Multiple pregnancy Macrosomia Polyhydramnios Fetal abnormalities e.g., severe hydrocephalus
	Uterine muscle fatigue	Prolonged/precipitate labour, esp. if stimulated High parity (20-fold increased risk) Previous pregnancy with PPH
	Uterine infection/chorioamnionitis	Prolonged SROM Fever
	Uterine distortion/abnormality	Fibroid uterus Placenta previa
	Uterine relaxing drugs	Anaesthetic drugs, nifedipine, NSAIDs, beta-mimetics, MgSO ₄
Tissue	Retained placenta/membranes	Incomplete placenta at delivery, esp. < 24weeks
	Abnormal placenta-succinuriate / accessory lobe	Previous uterine surgery Abnormal placenta on ultrasound
Trauma	Cervical/vaginal/perineal tears	Precipitous delivery, manipulations at delivery Operative delivery Episiotomy esp. mediolateral
	Extended tear at CS	Malposition Fetal manipulation, e.g., version of second twin Deep engagement
	Uterine rupture	Previous uterine surgery
	Uterine inversion	High parity Fundal placenta Excessive traction of cord
Thrombin	Pre-existing clotting abnormality e.g., hemophilia/ vWD/ hypofibrinogenemia	History of coagulopathy/liver disease
	Acquired in pregnancy	High BP, bruising Fetal death
	ITP	Fever, raised WCC
	PET with thrombocytopenia (HELLP)	APH, sudden collapse
	DIC from PET, IUD, abruptio, AFE, severe infection/sepsis	
	Dilutional coagulopathy from massive transfusions	
	Anticoagulation	History of DVT/PE Aspirin, heparin

PPH: postpartum hemorrhage; SROM: spontaneous rupture of membranes; NSAID: non-steroidal anti-inflammatory drug; CS: Caesarean section; vWD: von Willebrand's disease; ITP: idiopathic thrombocytopenic purpura; BP: blood pressure; PET: preeclamptic toxemia; WCC: white cell count; HELLP: hemolysis, elevated liver enzymes, and low platelets; APH: antepartum hemorrhage; DIC: disseminated intravascular coagulation; IUD: intrauterine death; AFE: amniotic fluid embolism; DVT/PE: deep vein thrombosis/pulmonary embolism.

thrombin (coagulation abnormalities).⁷ The many risk factors associated with PPH may be attributed to an abnormality in one of these four physiological mechanisms. Table 1 outlines some of these risk factors.

Prevention of PPH

The prediction of PPH using antenatal risk assessment is poor: only 40% of women with an identified risk factor develop PPH.⁸ However, with changes in the obstetric population (e.g., increased mean maternal age at childbirth, increasing number of women with complex medical

disorders becoming pregnant) and advances in technology (e.g., assisted reproduction leading to an increased rate of multiple pregnancy, increasing Caesarean section rates leading to placenta previa and its sequelae), some of these risk factors may become more important and others less so in the future. Great grand multiparas were traditionally thought to be at high risk of PPH, but some studies suggest that their risk may be no greater than that of women of lower parity.⁹ Women with these risk factors should be transferred to centres with transfusion facilities and an

Table 2. Clinical findings in hypovolemia and varying degrees of shock¹⁴

Blood volume loss	BP (systolic change)	Symptoms and signs	Degree of shock
500–1000 mL (10–15%)	Normal	Palpitation, tachycardia, dizziness	Compensated
1000–1500 mL (15–25%)	Slight fall (80–100 mm Hg)	Weakness, tachycardia, sweating	Mild
1500–2000 mL (25–30%)	Moderate fall (70–80 mm Hg)	Restlessness, pallor, oliguria	Moderate
2000–3000 mL (35–45%)	Marked fall (50–70 mm Hg)	Collapse, air hunger, anuria	Severe

intensive care unit (ICU) for delivery if these are not available locally.

The management of the third stage of labour to minimize the risk of PPH has been discussed comprehensively.⁶ Early oxytocic therapy, cord clamping, and placental delivery by gentle controlled cord traction following signs of placental separation reduce the incidence and severity of PPH, postpartum anemia, and the need for blood transfusion.^{10,11} Syntometrine (combined oxytocin and ergometrine) is superior to oxytocin in the reduction of PPH more than 500 mL, but either is useful in PPH more than 1000 mL, although Syntometrine increases the risk of hypertension.¹² The value of prophylactic prostaglandins, either intramuscular prostaglandins or misoprostol, in a hospital setting was shown to be no better than conventional injectable oxytocin in reducing measured blood loss of 1000 mL or more.¹³

Management of PPH

Rapid recognition, resuscitation, and restoration of circulating blood volume and simultaneous identification and treatment of the cause is the key to the management of PPH. Although the presentation of PPH is often dramatic, bleeding can occur slowly, highlighting the importance of recognizing the clinical signs of varying degrees of hypovolemia and shock¹⁴ (Table 2).

Resuscitation and establishing etiology

Help from a multidisciplinary team is vital at an early stage in PPH, as PPH can lead to circulatory collapse within minutes. Relevant senior staff should be contacted urgently; in our institution, we would alert the obstetric team, consultant obstetrician, midwife in-charge, anaesthetist, operating theatre staff, blood bank, hematologist, hospital porters, and the intensive care unit.

Assessment of vital signs (level of consciousness, pulse, blood pressure, and oxygen saturation if available) and the amount of blood loss must be made initially and continually throughout resuscitation. Fluid resuscitation in obstetric hemorrhage is often overly conservative because of

underestimation of volume and rapidity of blood loss, delay in symptoms of hypovolemia developing in women with good compensatory mechanisms, concerns that over-resuscitation will lead to pulmonary edema, or failure to be aware of the dynamics of fluid shifts in the body. A loss of 1 litre of blood requires replacement with 4 to 5 litres of crystalloid (0.9% normal saline or lactated Ringer's solution) or colloids until cross-matched blood is available, as most of the infused fluid shifts from the intravascular to the interstitial space.

Blood and blood product transfusion may be required if blood loss is continuing, if the blood volume lost is over 30%, or if the patient's clinical status reflects developing shock despite aggressive resuscitation. Uncross-matched group-specific blood or O group, Rh-negative blood may be required until fully cross-matched blood becomes available. Dilutional coagulopathy occurs when approximately 80% of the original blood volume has been replaced. One litre of fresh frozen plasma (FFP) should be administered (15 mL/kg) with every 6 units of blood transfused. Platelet concentration should be kept at more than $50 \times 10^9/L$ or more than $80\text{--}100 \times 10^9/L$ if surgical intervention is necessary. Cryoprecipitate, which provides a more concentrated form of fibrinogen and other clotting factors (VIII, XIII, von Willebrand factor), would be required if there is disseminated intravascular coagulation (DIC) or if the fibrinogen level is less than 10 g/L.

A search for the cause of bleeding should be made while resuscitation is continued. The 4Ts mnemonic provides a simple, systematic approach for identifying the cause of bleeding. Thorough assessment and exploration of the uterus and genital tract should be performed. If the uterus is atonic, vigorous massage and therapeutic uterotonic agents should be commenced. If there is doubt about the completeness of delivered placenta and membranes, manual exploration of the uterine cavity should be undertaken, ideally under anaesthesia. If bleeding persists despite a well-contracted uterus, genital tract trauma should be suspected. Examination under anaesthesia should look for

extended tears in the cervix or high in the vaginal vault, as these may involve the uterus or lead to broad ligament or retroperitoneal hematomas. Care should be taken not to involve the ureters at the lateral vaginal fornices and the bladder at the anterior fornix during repair, as poorly placed sutures can lead to genitourinary fistulas. Although polyglycolic sutures have largely replaced catgut, the latter may be useful in repairing lacerations in these areas as they are less likely to tear the friable tissues of the cervix and vaginal vault. Pressure or packing over the repair may be useful to achieve hemostasis. If exploration has excluded retained tissue or trauma, bleeding from a well-contracted uterus is due to a defect in hemostasis. Blood product replacement should be commenced as appropriate, and consideration given to an underlying cause for the coagulation abnormality (e.g., placental abruption, HELLP syndrome, fatty liver of pregnancy, intrauterine fetal demise, amniotic fluid embolus, or septicemia).

Medical management

Oxytocin. Although the vast majority of women with PPH can be managed without surgical intervention, those with uterine rupture or genital tract trauma cannot. If the uterus remains atonic after initial oxytocic therapy, Syntometrine or ergometrine should be repeated, or, alternatively, oxytocin 10 units can be given by slow IV bolus. Uterine massage should be commenced, either manually (hand on the fundus) or bimanually (vaginal hand in the anterior fornix; abdominal hand on the posterior aspect of the fundus). Bimanual massage reduces bleeding even if the uterus remains atonic, allowing resuscitation a chance to catch up with blood loss. Oxytocin infusion (40 units in 500 mL of 0.9% normal saline, infused at a rate of 125 mL/hour) can be used to maintain uterine contraction.

Prostaglandins. The traditional second-line agent for uterine atony is 15-methyl prostaglandin F_{2α} (PGF_{2α}), 0.25 mg deep intramuscularly and repeated every 15 minutes to a maximum dose of 2 mg.¹⁵ This is 80% to 90% effective in stopping PPH in cases that are refractory to oxytocin and ergometrine. Intramyometrial injection of PGF_{2α} has been used clinically,¹⁶ but its effectiveness and adverse effects have not been adequately evaluated.

Rectal administration of misoprostol (800–1000 µg), a prostaglandin E1 analogue, has emerged as a valuable agent in the treatment of PPH, especially in developing countries, because of its low cost and easier storage.^{17,18}

Other hemostatic agents. The use of intravenous tranexemic acid, an antifibrinolytic widely used in the management of menorrhagia, has been reported.¹⁹ Its use has never been systematically studied in PPH. Similarly, the hemostatic agent recombinant activated factor VIIa has been used

successfully in life-threatening PPH, but its safety and efficacy remain untested in clinical trials.²⁰

Surgical management

Ongoing bleeding requires evaluation in the operating theatre. Uterine tone must be reassessed, uterine inversion excluded, and a re-examination performed to exclude retained tissue and trauma. Bimanual compression and direct pressure over lacerations may help control bleeding while preparations are made for further intervention and correction of superimposed coagulopathy.

Tamponade or uterine packing. Uterine packing fell into disfavor during the 1960s because it was perceived as being non-physiological, concealing ongoing blood loss, and increasing the risk of infection. However, it has had a recent resurgence of interest after reports of favourable outcomes in selected circumstances.²¹ There have been reports of successful uterine tamponade using a variety of balloon devices, namely the Sengstaken-Blakemore esophageal catheter,²² the Rusch urological hydrostatic balloon,²³ and the “Bakri SOS” balloon.²⁴ The insertion of the balloon is simple; a volume of 300 to 500 mL is usually required to exert the desired counter-pressure to stop the bleeding from uterine sinuses. The ability of the tamponade to arrest bleeding, or a positive “tamponade test,” has a predictive value of 87% in successfully managing PPH without the need for further surgical intervention.²⁵ Recent reports of large series have confirmed the high success rates of balloon devices.^{26,27} Similar success rates have been reported with the use of condoms in low-resource settings.²⁸

Compression suture. If the tamponade test fails, or if life-threatening hemorrhage has occurred, a laparotomy should be performed sooner rather than later, as delaying this decision in an attempt to avoid major surgery and possible hysterectomy may be fatal.

At laparotomy, if bimanual compression of the uterus successfully arrests the bleeding, then compression sutures are likely to be of value. The anterior and posterior walls of the uterus are compressed anteroposteriorly from the isthmus to the fundus using a delayed absorbable suture. The B-Lynch suture²⁹ and various modifications have shown promise. Using two or more separate vertical sutures instead of one³⁰ not only increases the tension and compression force but also eliminates the need to open the uterus. Horizontal full thickness compression sutures at the placental site in placenta previa have also been described.³¹

There are numerous advantages of compression sutures: they are easy to perform, can be performed quickly, and require little surgical expertise. Furthermore, recent reports have shown that fertility and subsequent pregnancy outcomes are unaffected, and no deaths were reported in

women who had compression sutures placed for the management of PPH in the recent Confidential Enquiry into Maternal and Child Health.³² The success rate of compression sutures used in 19 cases of massive obstetric hemorrhage was as high as 68%.²⁷

Systematic devascularization. If bleeding continues, ligation of uterine arteries (which provide approximately 90% of uterine blood flow), the tubal branches of ovarian arteries, and the internal iliac artery is an option. Ligating the uterine arteries and the tubal branches of the ovarian arteries is a relatively simple procedure. Internal iliac artery ligation, however, is much more difficult to perform and may cause damage to nearby structures. Since internal iliac artery ligation has a success rate of about 50% in controlling blood loss,²⁷ its use in the management of massive obstetric hemorrhage is questionable.

Subtotal or total abdominal hysterectomy. Hysterectomy is curative and is usually the final option in the management of PPH. It may, however, be warranted earlier if the hemodynamic condition of the patient is unstable or if there is uncontrollable bleeding despite other medical and surgical measures. Although subtotal hysterectomy may be performed faster, may be effective for bleeding due to uterine atony, and is associated with less morbidity and mortality, it may not be effective for controlling bleeding from the lower segment, cervix, or vaginal fornices; thus, total hysterectomy is preferred overall.

Management in a high dependency or intensive care unit is usually necessary after massive blood loss and transfusions, as multiple organ failure with damage to nearly all major organs is possible. The loss of child-bearing potential in those needing a hysterectomy and the psychological consequences must also be addressed.

Interventional radiology. Despite its use for more than 30 years, there are no trials of the effectiveness of uterine artery embolization in the management of PPH. Selective arterial embolization may be useful in situations where preservation of fertility is desired, where bleeding is not severe or in postoperative bleeding, in the management of hematomas, and in the presence of coagulopathy. The drawbacks of the procedure are the need for radiological expertise, the time required to organize and complete the procedure in an acute situation, and the rare complications, which include vessel perforation, hematoma, infection, contrast-related adverse effects, and uterine necrosis.

Postpartum Hemorrhage in Developing Countries

In developing countries, complications of pregnancy and childbirth remain the leading cause of death, disease, and disability in women of reproductive age. There are signs of global improvement in the health and well-being of

mothers, but most maternal deaths occur in the poorest countries. The lifetime risk of maternal death in sub-Saharan Africa is 1 in 16, compared with 1 in 2800 in developed countries. The reasons for these inequalities are complex and include poverty, inequality, war and civil unrest, and the destructive influence of HIV/AIDS, as well as failure to translate life-saving knowledge into effective action and to invest adequately in public health and a safe environment.

Public Health Strategies

The member countries of the United Nations agreed to reduce maternal mortality by three quarters by 2015 as part of the Millennium Development Goals. Unless progress is accelerated significantly, there is little hope of achieving this.³³⁻³⁵

Postpartum hemorrhage can kill even a healthy woman within two hours if unattended. In low-income countries, home birth may be the preferred option and is often the only option for many women. Approximately 60% of births in low-income countries occur outside a health facility.³⁶

The presence of skilled attendants at delivery has been highlighted, as both maternal and neonatal mortality are lower in countries where women giving birth have skilled professional care, with the equipment, drugs and other supplies needed for the effective and timely management of complications.^{37,38} Care by a skilled attendant includes safe delivery, cord care, identification of complications, first aid, and timely referral of complicated cases.

In settings where blood banks and other life-saving operative resources are limited, the non-pneumatic anti-shock garment (NASG) and the pneumatic Military Anti-Shock Trousers (MAST) have been used to provide counter-pressure to the lower body, enabling resuscitation and stabilization of women in hypovolemic shock caused by obstetric hemorrhage until definitive treatment becomes available. A small observational study conducted in Pakistan described six women with hypovolemic shock being managed with the NASG for 16 to 36 hours while awaiting definitive treatment. All women were successfully resuscitated within five minutes using the NASG.³⁹ The use of this reusable and lightweight device for stabilizing and transporting women in low-resource settings needs further exploration as a step towards decreasing maternal mortality and morbidity in developing countries.

Active management of the third stage of labour, with administration of prophylactic oxytocin, cord clamping, and delivery of the placenta by controlled cord traction can reduce the incidence and severity of PPH.¹¹

Health education on the initial management of PPH at the basic level of emergency obstetric services includes the use of additional oxytocin, uterine massage, manual removal of

Table 3. Algorithm for management of atonic postpartum hemorrhage: HAEMOSTASIS⁴³

H	Ask for help
A	Assess (vital parameters, blood loss) and resuscitate
E	Establish etiology, ensure availability of blood, ecbolics (Syntometrine, ergometrine, bolus oxytocin)
M	Massage uterus
O	Oxytocin infusion/prostaglandins – IV/per rectal/IM/ intramyometrial
S	Shift to operating theatre – exclude retained products and trauma/bimanual compression
T	Tamponade balloon/uterine packing
A	Apply compression sutures – B-Lynch/modified
S	Systematic pelvic devascularization – uterine/ovarian/quadruple/internal iliac
I	Interventional radiologist – if appropriate, uterine artery embolization
S	Subtotal/total abdominal hysterectomy

the placenta, the use of balloon tamponade, and repair of lacerations. Care in a facility with comprehensive emergency obstetric services should include the availability of blood transfusion, capacity for the management of hypovolemic shock, and surgical interventions ranging from compression sutures to hysterectomy.

Although effective and efficient maternal health services are available at different resource levels, and preventive, community-based interventions are highly cost effective, universal access to clinical facility-based health services remains a problem. A coordinated response involving other non-health sectors is required to improve education. Health systems need to be strengthened, and financial, moral, and political commitment will be needed to achieve the reduction in maternal morbidity and mortality outlined in the Millennium Declaration.

Anemia

Iron deficiency anemia, a common and widespread nutritional disorder that affects every second pregnant woman in developing countries, is frequently exacerbated by malaria, HIV/AIDS, hookworm infestation, schistosomiasis, and tuberculosis. It contributes to 20% of all maternal deaths.⁴⁰ The management is both inexpensive and effective. Dietary advice and routine iron and folate supplementation during pregnancy prevent anemia in the mother at delivery or postpartum. Controlling infections by immunization and providing control programs for malaria, hookworm, and schistosomiasis in endemic areas can help reduce the incidence of anemia in late pregnancy. Preventing and controlling other nutritional deficiencies, such as vitamin B12, folate, and vitamin A deficiencies, could similarly achieve widespread improvement in maternal health and prevent maternal morbidity and mortality associated with PPH.

Misoprostol

Although misoprostol was shown to be no better than injected oxytocin in a hospital setting, it may have value in

home deliveries in low-income countries where the effective use of injectable oxytocin is more difficult because it requires safe administration and special storage to maintain stability (especially in tropical climates). The life-saving potential of misoprostol, with its ease of administration, stability, and low cost, could have major implications in these rural settings where emergency health care is virtually inaccessible. Misoprostol has been shown to reduce the incidence of PPH resulting in blood loss of greater than 1000 mL.⁴¹ If further research can demonstrate its effectiveness in the many cases where oxytocin is not an option, misoprostol could save many lives and reduce the number of women who suffer anemia as a result of a postpartum hemorrhage, currently 1.6 million every year. A multicentre randomized controlled trial to assess the effects of misoprostol adjunct to the use of injectable oxytocics in women requiring additional uterotonics following active management of the third stage of labour is currently underway.⁴²

We encourage a stepwise management of PPH using the mnemonic “HAEMOSTASIS” (Table 3), following each step in rapid succession until hemostasis is achieved.^{43,44} The speed with which deterioration leads to maternal mortality and the high success rates of simple surgical procedures prompt inclusion of the “tamponade test” with basic emergency obstetric functions and inclusion of compression sutures with comprehensive emergency obstetric functions.

The stark differences between countries in the rates of maternal mortality from PPH highlight the need for better education and universal access to clinical services. Effective medical and surgical interventions are available, and there is increasing evidence of the benefits of more non-invasive surgical management, including uterine tamponade and compression sutures. We hope that this, together with the emerging value of misoprostol and global initiatives in the

management of PPH, will reduce the incidence of this life-threatening condition in the next few years.

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