

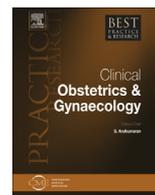


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### Preventing deaths due to haemorrhage



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Prevention of deaths from obstetric haemorrhage requires effective health systems including family planning, commodities, personnel, infrastructure and ultimately universal access to comprehensive obstetric care for women giving birth.

The main causes of death associated with antepartum haemorrhage are placental abruption, placenta praevia and uterine rupture. Preventive measures include preconceptual folate supplementation, management of hypertensive disorders, early diagnosis of placenta praevia and use of uterine stimulants cautiously, particularly misoprostol.

Preventive measures for post-partum haemorrhage include routine active management of the third stage of labour. Treatment involves a cascade of increasingly invasive interventions in rapid sequence until the bleeding is stopped. These interventions include fluid resuscitation, removal of the placenta, bimanual uterine compression, uterotonics, tranexamic acid, suturing of lower genital tract injury, blood product replacement, balloon tamponade, laparotomy, stepwise uterine devascularization, uterine compression sutures and hysterectomy.

Emergency temporizing measures include application of the non-pneumatic anti-shock garment, and at laparotomy, aortic compression and uterine tourniquet application.

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The effectiveness of treatment methods and the optimal dosage of misoprostol are research priorities. Interesting new approaches include transvaginal uterine artery clamping and suction uterine tamponade.

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## Contribution of haemorrhage to maternal and perinatal mortality and morbidity

### 'No woman should die in pregnancy and childbirth'

Globally, about 830 women die every day due to complications in pregnancy and childbirth despite a 44% reduction in maternal mortality between 1990 and 2015, a reduction from 532,000 to 303,000. The approximate global lifetime risk of a maternal death fell considerably from one in 73 to one in 180. The progress has a disparity between developing and developed countries. Developing regions account for approximately 99% of the global maternal deaths in 2015, with sub-Saharan Africa alone accounting for nearly 66%. [1]

There is a large regional variation in the prevalence of post-partum haemorrhage (PPH) – blood loss >500 ml was 7.2% in Oceania compared with 25.7% in Africa with the prevalence of severe PPH – blood loss >1000 ml highest in Africa at 5.1%. [2]

The World Health Organization (WHO) systematic analysis of global causes of maternal death noted that haemorrhage was the leading direct cause of maternal death worldwide, representing 27.1% of maternal deaths. In Africa, 25% of all maternal deaths are due to haemorrhage. It is further estimated that more than two-thirds of reported deaths are due to PPH [3].

Most maternal deaths are preventable, as the healthcare solutions to prevent or manage complications are well known. Pregnant women need access to antenatal care, skilled care during childbirth and care and support in the weeks after childbirth. Most of the life-threatening obstetric complications, especially obstetric haemorrhage, are unpredictable and of dramatic nature that require urgent intervention within minutes and hours to mitigate the impact, and require systems, products and equipments as well as human resource for appropriate effective interventions in a timely manner.

Perinatal mortality due to antepartum haemorrhage (APH) has been reported to be as high as 50% in the developing countries [4].

When the cause of morbidity and mortality for both mother and fetus/neonate is due to haemorrhage, then the 48-h window around labour is critical and is very closely linked. Almost half of all stillbirths, maternal and neonatal deaths occur during the intrapartum and immediate post-partum period, and hence there is a need to emphasize the necessity of lifesaving integrated intrapartum care for both the mother and baby [5].

Optimal quality of care during childbirth and in the neonatal period for facility-based deliveries could avert 113,000 maternal deaths, 531,000 stillbirths and 1.3 million newborn deaths by 2020 [6].

## Interventions and approaches to prevent deaths due to haemorrhage

This chapter will be limited to obstetric haemorrhage: APH and PPH including caesarean section haemorrhage. The WHO has published guidelines for the prevention and treatment of PPH at [http://apps.who.int/iris/bitstream/10665/75411/1/9789241548502\\_eng.pdf?ua=1](http://apps.who.int/iris/bitstream/10665/75411/1/9789241548502_eng.pdf?ua=1).

Strategies to prevent deaths due to obstetric haemorrhage include a broad range of health services, social, educational and clinical interventions. First, we shall discuss general measures, and then those directed specifically towards APH and PPH management.

### General Measures

The most effective and socially beneficial strategy to reduce maternal and perinatal deaths from all causes is prevention of unintended pregnancy, and this is covered in chapter 11.

Other general measures include those that improve the mother's health status and thus her ability to survive major haemorrhage. A recent study in Senegal and Mali [7] found the highest risk factors for deaths due to PPH to be pre-existing chronic disease (adjusted odds ratio (OR) = 7.54 (2.54–22.44)) and severe anaemia (adjusted OR = 6.65 (3.77–11.74)). Among their recommendations were antenatal treatment of anaemia, improved blood transfusion access and inter-facility transport. Ideally before pregnancy, otherwise during pregnancy, we need to pay attention to correcting anaemia, treating infections such as malaria, tuberculosis and HIV, and optimizing the control of chronic conditions such as cardiovascular disease, which might limit a woman's capacity to tolerate acute blood loss. Daily or weekly supplementation of pregnant women with oral iron with or without folic acid reduces the risk of anaemia at term [8].

### *Nutrition*

Increasing evidence is emerging on the importance of nutrition to health. With specific reference to haemorrhagic deaths, folate supplementation before pregnancy reduces the risk of placental abruption. In low-resource settings, iron deficiency is the most common cause of anaemia. Nutritional advice should include advice to aim for a diet with adequate folate and iron. In addition, in most low-income settings, iron and folate supplements are recommended for all pregnant women. A particularly common dietary idiosyncrasy in some cultural settings is pica (sand-eating). Sand is thought to chelate iron in the diet inhibiting absorption and aggravating iron-deficiency anaemia.

A key general strategy to reduce deaths due to haemorrhage is to avoid unnecessary caesarean section, both because caesarean section increases the risk of haemorrhagic death in the current pregnancy and because it increases risk in future pregnancies related to uterine rupture, morbidly adherent placenta and the need for repeat caesarean section.

### **Preventing deaths due to APH**

APH may arise from the lower genital tract due to conditions such as vaginitis, cervicitis, trauma, or most importantly, cervical cancer. Cervical cancer may occur in young women, particularly those infected with HIV. Evaluation of APH must always include a speculum examination to identify lower genital tract sources of bleeding.

Bleeding from the uterine cavity is usually due to placenta praevia or placental abruption. A less common but important cause is uterine rupture.

Antenatal and general community education emphasize that women who experience vaginal bleeding during pregnancy must attend a health service urgently. Health workers require training to evaluate women with vaginal bleeding in pregnancy systematically while instituting prompt and appropriate management.

### *Placenta praevia*

Placenta praevia occurs in about five per 1000 pregnancies. [9] It is characterized by bright red, painless bleeding, which may be profuse, and a healthy baby with high presenting part or abnormal lie. Ultrasound is useful for confirming the diagnosis. APH at term due to placenta praevia is managed by delivering the baby. Vaginal birth is possible if the degree of placenta praevia is minor (type 1 posterior – into the lower uterine segment but not reaching the internal cervical os or type 2 anterior – reaching the internal cervical os but not covering the cervical os). Major placenta praevia requires caesarean section. If the diagnosis or degree of placenta praevia is uncertain, cautious vaginal examination is performed in the operating theatre with everything in place for rapid caesarean section if haemorrhage is provoked.

### *Placental abruption*

Bleeding from separation of a normally situated placenta typically presents with persistent abdominal pain with or without dark vaginal bleeding. The uterus may be tense to palpation and in

severe cases the baby may die before arrival at the health facility. Tocography may show a characteristic undulating uterine contraction pattern with 9–10 contractions per 10 min and no rest period between contractions. If the fetal heart is still beating, there may be reduced variability and recurrent late decelerations producing an undulating mirror image of the tocograph pattern.

Major placental abruption is associated with massive blood loss (often partially concealed) and coagulopathy. Avoiding maternal mortality requires active management to deliver the baby, replacing blood products, controlling haemorrhage and managing concomitant organ failure (e.g., renal). The vaginal route of delivery is usually safest, though caesarean may be undertaken at times for fetal distress.

Uterine rupture may present as either antepartum or PPH (see below).

### **Preventing deaths due to PPH**

Consideration of deaths due to PPH usually focuses on maternal deaths, but it is important to keep in mind that in under-resourced settings, being orphaned increases the risk of neonatal and childhood death as well.

Specific strategies to reduce deaths due to PPH include prevention of PPH and treatment of PPH when it occurs.

### **Preventing PPH**

#### *Avoiding unnecessary caesarean section and labour induction and augmentation*

Caesarean section rates are increasing worldwide. Apart from increased risk of maternal mortality overall, caesarean section specifically increases the risk of PPH. This risk may be further increased by the use of general rather than neuraxial anaesthesia [10]. In the 2011–2013 report of the Committee for Confidential Enquiries into Maternal Deaths in South Africa, caesarean section was highlighted as a contributing factor to deaths due to haemorrhage. Caesarean section also increases the risk of death due to haemorrhage in future pregnancies due to placenta accreta, ruptured uterus or the need for repeat caesarean section.

An important driver for increasing caesarean section rates is overdiagnosis of fetal distress, a problem inherent in cardiotocographic assessment of fetal well-being. In settings where 'non-reassuring' fetal heart rate patterns are accepted by courts as evidence of fetal distress, health workers may feel compelled to perform caesarean section in large numbers of cases with benign fetal heart rate decelerations, just in case there should subsequently be a poor outcome. Overdiagnosis of fetal distress may be reduced by using fetal scalp blood sampling in women known not to be infected with HIV.

Similarly, reducing unnecessary labour induction and augmentation may reduce the risk of PPH.

#### *Primary prevention*

There is evidence from systematic review that routine 'active management of the third stage of labour' (AMTSL) reduces severe PPH (blood loss >1000 ml) by about two-thirds.[11] Adverse effects include hypertension (due to the use of ergometrine), abdominal pain and reduced placental–fetal transfusion. There is less certainty about the relative contribution of the individual elements of AMTSL: routine administration of uterotonics, early cord clamping and active delivery of the placenta with controlled cord traction (CCT).

### **Uterotonics**

#### *Oxytocin and ergometrine*

Oxytocin intravenously or intramuscularly reduces the risk of PPH (blood loss >500 ml) by about half and is associated with fewer side effects than ergometrine [12]. Addition of oxytocin to ergometrine does not improve effectiveness. The use of oxytocin 10 IU is associated with less need for

additional oxytocics than 5 IU, and is therefore the generally recommended dose. From a global health perspective, the greatest limitation of oxytocin is that it requires cold storage and parenteral administration, which limits its availability in rural settings and births not attended by a health professional able to administer injections.

### *Misoprostol*

In the past 20 years, considerable interest has been seen in the use of misoprostol to prevent and treat PPH. The potential game-changing properties of misoprostol are that it is a heat stable and orally active uterotonic, creating the opportunity for self-administration by women giving birth without access to oxytocin. Enthusiasm from early observational studies showing spectacular effectiveness was tempered by less favourable results from two large randomized trials conducted by WHO. First, oral misoprostol 600 µg was found to be much less effective than oxytocin for prevention of PPH (blood loss >1000 ml) [13]. Second, oral misoprostol 800 µg was found to have no benefit over placebo for treatment of PPH in women who had received conventional uterotonics [14]. Misoprostol has been found to reduce blood loss in settings without access to injectable uterotonics, and on this basis it is recommended for use in these settings by WHO. Despite lower effectiveness and higher side effects than oxytocin, such strategies have been considered cost-effective. [15] Distribution of misoprostol to pregnant women with instructions to be taken after birth is an attractive option, which is being rolled out in many countries, though robust evidence of the effectiveness of such strategies is lacking [16]. There remains uncertainty whether any effect on reducing blood loss outweighs adverse effects in terms of overall morbidity and mortality. A systematic review [17] of 78 studies (59,216 women) found no statistically significant difference in maternal mortality for misoprostol compared with control groups overall (11/19,715 vs. 4/20,076 deaths); or for the trials of misoprostol versus placebo (6/4626 vs. 1/4707 deaths) or for misoprostol versus other uterotonics (5/15,089 vs. 3/15 deaths). All 11 deaths in the misoprostol arms occurred in studies of misoprostol ≥600 µg. There was no statistically significant difference in the composite outcome 'maternal death or severe morbidity', excluding hyperpyrexia. Pyrexia >38 °C was increased with misoprostol compared with controls and the effect was greater for trials using misoprostol 600 µg or more. In view of the possibility that adverse effects of misoprostol on organ systems such as thermoregulation, cardiovascular and coagulation may counteract the beneficial effects on uterine contraction, we recommend further research to determine whether lower doses may reduce the risk/benefit ratio.

### *Controlled cord traction*

As originally described, CCT involves immediate clamping of the umbilical cord, palpation for contraction of the uterus and then cord traction with transabdominal counter pressure on the uterus to prevent uterine inversion. Following evidence of the benefits of delayed cord clamping to both preterm and term infants, [18] CCT has been modified to allow delayed cord clamping for 1–3 min. Systematic review of trials of CCT found evidence of reduced blood loss >500 but not >1000 ml and reduced manual removal of the placenta, which may have been related to the use of ergometrine in one study and a policy of manual removal after 30 min of third stage of labour in another [19]. In view of limited benefits, and the investment needed in training health providers, the option of omitting routine CCT from the package of AMTSL may be considered.

### *Uterine massage*

Uterine massage is widely practised as a routine method of maintaining uterine contractions and reducing haemorrhage, yet there is surprisingly little research conducted on its effectiveness, as the procedure is uncomfortable for women and costly in terms of health worker time. Systematic review of two studies found inconsistent results and overall limited evidence of effectiveness [20]. The potential to show an effect may have been limited by the fact that all women received routine uterotonics. Further research is needed, particularly in settings in which uterotonics are not available.

### *Tranexamic acid*

Given the effectiveness of tranexamic acid for reducing mortality from traumatic blood loss, until recently there has been surprisingly little research on the use of tranexamic acid to prevent or treat PPH. A potential advantage of tranexamic acid is that its effect is on fibrinolysis rather than uterine contraction; hence, it would be expected to be useful to reduce bleeding both from uterine hypotonicity and from genital tract trauma.

Moderate quality evidence from systematic review of randomized trials of tranexamic acid used prophylactically in low-risk women in addition to uterotonic agents found a decrease in PPH and blood transfusions both after vaginal birth and caesarean section [21]. Minor side effects were increased with the use of tranexamic acid. Because of potential side effects, tranexamic acid is unlikely to be used prophylactically for normal birth, but there may be a place for prophylactic use in women at high risk of haemorrhage and for caesarean section.

### *Correction of coagulopathies*

Observational studies have shown an increased risk of PPH in women with Factor XI deficiency [22]. The risk appears to be reduced with prophylaxis, but no evidence from interventional studies is available.

### *Secondary prevention: Monitoring blood loss after birth*

Recording blood loss after birth is a cornerstone of post-partum care. However, the volume estimated by clinicians is notoriously inaccurate, mainly due to underestimation. A recent review found that additional training in blood loss estimation and multifaceted interventions had limited impact, and that use of blood volume measuring devices did not improve outcomes [23]. The authors suggested that the rate and nature of blood loss may be more important than volume in the early diagnosis of PPH.

## **Preventing deaths due to PPH**

### *Place of birth*

The WHO has the vision that 'every pregnant women and newborn receives quality care throughout pregnancy, childbirth and the postnatal period' [24]. Although factors that increase risk of PPH may be identified or excluded, PPH may occur unpredictably in apparently low-risk women. Although the risk of PPH may be reduced and certain treatment strategies may be initiated at a primary-level care and even in the home, women with PPH unresponsive to primary-level care need higher-level interventions such as blood transfusion and surgical interventions. Death due to PPH may be rapid, limiting the time available for transfer to a higher level of care. For this reason, in addition to attempts to ensure the presence of a skilled birth attendant at every birth, attention should be given to public health strategies to facilitate access for women in labour to rapidly available higher-level care.

For low-risk women, midwife-led care during childbirth has clear benefits over physician-led care [25]. The principle that all low-risk obstetric care should take place in primary care facilities away from the secondary- and tertiary-level hospitals, is entrenched in many public health services. Although appropriate for antenatal and postnatal care, this paradigm needs to be further investigated with respect to care during labour. Approximately one-third of women with apparently low-risk pregnancies develop complications during or after labour requiring emergency referral to a higher level [26].

Women in early labour arriving at secondary-level facilities are often turned away to go to a primary-level facility at some distance from the hospital. Women develop strategies to bypass the system [27] by delaying presentation at the hospital until birth is imminent in the hope that it will be too late for them to be redirected. This is counterproductive as it increases the rate of unattended labours and births before arrival at a facility. Within a metropolitan setting, we found that women

preferred to give birth on hospital premises where they felt safer because of the availability of higher-level facilities, and most women were able to get to a hospital as easily as to a primary birth facility.

For the above reasons, we have implemented a model of 'On-site, primary care, midwife-led birth units' at two hospitals in the Eastern Cape, South Africa [28]. The units are managed and staffed by the primary care services and provide midwife-led, family-centred childbirth care similar to that which would be provided in a clinic at a distance from the hospital. The difference is that the facility is located on the hospital premises. This facilitates transfer to the appropriate level of care. Women arriving at the hospital in labour can be assessed for risk and triaged to the primary- or secondary-level facility as appropriate. When complications arise in the primary care unit, women can be transferred to the hospital labour ward within minutes, with no need for an ambulance transfer. The result has been an increase in births on the hospital premises, but fewer in the secondary-level service, with overall improvement in cost-effectiveness and outcomes. Similar models have been found to be cost-effective in a well-resourced setting, [29] to be safe in a Japanese setting, [30] and in China to be associated with improved satisfaction and labour outcomes [31]. Several on-site birth centres have been reported on from Australia [32].

### *Treatment of PPH*

Because PPH represents an acute, often life-threatening emergency, research to determine the effectiveness of various methods of treatment is difficult to conduct. Much of the currently recommended treatment is based on extrapolation from methods used for prevention, or empirical treatment based on first principles or historical experience.

Obstetric units should have a written policy for management of acute obstetric haemorrhage, quick availability of all the equipments and consumables necessary and hold regular 'fire drills' to ensure that staff are able to respond to the emergency in a coordinated and efficient manner.

Treatment decisions are also complicated by the fact that the cause of the PPH may not be apparent, and there may be more than one cause. An important general principle is to progress rapidly from one intervention to the next until the bleeding is controlled.

### *Non-pneumatic anti-shock garment*

The 'Medical Anti-Shock Trousers' (MAST) suit was originally developed to maintain upper body circulation in fighter pilots exposed to extreme gravitational forces, by compressing the lower limbs with a suit with inflatable compartments. The non-pneumatic anti-shock garment (NASG) [33] uses elastic neoprene sections with Velcro fasteners to apply compression to the calves, thighs and lower abdomen, including a ball to compress the uterus. It is used as a first-aid device to compress the lower-body vascular system, increasing relative blood volume and circulation to the upper body during resuscitation and transport. A systematic review [34] evaluated the evidence from five observational studies and one cluster randomized trial. The latter found a statistically non-significant reduction in maternal mortality associated with the NASG and suggested that its use to be considered in settings where access to definitive treatment is delayed.

The use of the NASG in combination with uterine balloon tamponade (see below) has been reported in two cases of massive PPH associated with disseminated intravascular coagulopathy (DIC), with successful outcomes [35].

The FIGO Safe Motherhood and Newborn Health Committee have published recommendations for the use of the NASG in women with PPH and shock in primary- and higher-level facilities [36].

### *Uterotonics*

The use of uterotonics to treat PPH is mainly empirical, being extrapolated from evidence based on studies on the use for prophylaxis. There is little direct evidence regarding the effectiveness of additional doses of uterotonics, except that the use of misoprostol 800 mg orally for the treatment of PPH in women who have received oxytocin prophylaxis appears to confer no additional benefits [8]. Empirical

treatment often includes ergometrine (for women who are not hypertensive) and/or oxytocin by continuous intravenous infusion.

#### *Uterine massage*

As mentioned above, evidence for the effectiveness of uterine massage for preventing PPH is conflicting, and limited to studies of women who have received oxytocics. Considering further research, use of uterine massage to treat PPH is probably more likely to do good than harm, particularly if oxytocics are not available.

#### *Bimanual compression of the uterus*

Bimanual compression is used as an emergency first-line treatment based on the general principle of direct pressure at the site of bleeding. The body of the uterus is compressed between the attendant's hand on the abdomen and fist placed in the anterior vaginal fornix.

#### *Intravascular volume replacement*

A key aspect of resuscitation of women with PPH is placement of at least one wide-bore intravenous cannula and rapid volume replacement with crystalloid fluids, pending the availability of blood products.

#### *Supportive treatment*

Depending on the mother's general condition, supportive treatment may range from reassurance to full cardiovascular resuscitation. Monitoring of blood pressure, pulse, respiratory rate, oxygen saturation and urinary output are useful for assessing the need for and response to intervention.

#### *Correction of coagulopathies and blood product transfusion*

Massive blood loss is often accompanied by a varying degree of coagulopathy. There is very little robust evidence available on the effectiveness of treatments for these coagulopathies, and management is usually empirical with fibrinogen, tranexamic acid and balanced transfusion of blood products. The use of viscoelastic haemostatic assays may be useful as a guide to management [37].

Empirical, off-label use of recombinant factor VIIA has recently gained favour in settings where such treatment is affordable.

#### *Suturing of lower genital tract bleeding*

For PPH, which does not respond promptly to uterotonic treatment, the perineum, vagina and cervix should be inspected, preferably in an operating theatre with good lighting, and any traumatic sources of bleeding controlled with haemostatic sutures.

#### *Uterine artery clamps*

A recent innovation is the use of specialized clamps introduced transvaginally bilaterally with one blade inside the cervix and one in the lateral vaginal fornix to occlude the uterine arteries. The clamps may be fitted with Doppler sensors to locate the uterine artery blood flow before clamping.

#### *Retained placenta*

Retained placenta is an important cause of PPH. The definitive management is manual removal of the placenta with or without instrumental evacuation of the uterus. In the case of morbidly adherent placenta, surgical intervention including, in some cases, hysterectomy may be needed. Medical

management is an attractive option. A systematic review of the use of prostaglandins (prostaglandin E2 and misoprostol) found insufficient evidence to make a recommendation [38].

### *Balloon tamponade*

In recent years, there has been increasing advocacy for use of an uterine balloon tamponade (UBT) catheter to treat PPH. Various devices have been used, such as the purpose-designed Bakri balloon, the Sengstaken–Blakemore balloon designed for intra-oesophageal use and various handmade devices using a condom or glove tied over the end of a catheter. A systematic review found no randomized trials [39]. Among 13 case reports, series, retrospective and prospective studies, UBT was reported to be successful in 234/241 cases. The authors concluded that UBT is an effective treatment for PPH in resource-poor settings. It is important to keep in mind that uncontrolled studies may greatly overestimate the effectiveness of interventions, and we would regard UBT as an unproven device pending evidence from randomized trials. Use of UBT is somewhat counter-intuitive as it goes against the principle of emptying the uterus to allow maximum contraction of the uterine muscles. Contraction and retraction with occlusion of spiral arterioles is the main physiological mechanism for post-partum haemostasis.

### *Suction uterine tamponade*

The Inpress Device uses essentially the opposite approach to the UBT. Instead of outward pressure, it applies suction to the uterine cavity by means of a racquet-shaped suction probe with a balloon collar to seal the uterine cervix (<http://www.inpresstechnologies.com/>). The proposed mechanism of action is that suction promotes uterine contraction and facilitates the physiological mechanism of spiral artery occlusion by contracting uterine muscle fibres. This is similar to the principle of vacuum aspiration evacuation of the uterus, which has been shown to reduce blood loss during uterine evacuation compared with non-suction curettage. As for most methods used to treat PPH, the Inpress Device has not been tested in randomized trials.

### *Arterial embolization*

Selective embolization of arteries supplying the uterus has been used in cases of PPH unresponsive to medical management, to avoid major surgical intervention, but it requires specialized equipment and skills, not widely available.

### *Major surgical interventions*

The traditional approach to PPH unresponsive to medical treatment has been immediate hysterectomy. In recent decades, there has been a trend to conservative surgical procedures that are quicker, require less surgical experience and preserve fertility. The potential risk is that if the conservative measures are not effective, the woman's condition may have deteriorated further by the time hysterectomy is undertaken.

### *Aortic compression*

Digital compression of the abdominal aorta above the sacral promontory may temporarily reduce the rate of bleeding while definitive methods are instituted.

### *Uterine tourniquet*

Another temporizing measure is to place a uterine tourniquet. An elastic catheter such as a Foley catheter is passed around the uterus as low down as possible. The tourniquet may encompass the infundibulo-pelvic ligaments, or may be brought through avascular areas in the broad ligaments, in which case additional clamping of the ovarian vessels may be needed. The tourniquet may be crossed

over in the midline anteriorly, pulled tight and clamped at the point of crossing with a small pair of artery forceps. This provides temporary haemostasis while definitive measures are undertaken.

In settings lacking the facilities for definitive treatment, uterine tourniquets have been left in place for some hours during transfer to a higher-level facility.

#### *Stepwise uterine devascularization*

This procedure involves sequential ligation of the uterine arterial supply until haemorrhage ceases [40]. Both uterine arteries; then the descending branches of the uterine arteries, then the ovarian arteries are ligated.

#### *Internal iliac artery ligation*

This may be the first procedure, or may follow ineffective stepwise uterine devascularization as described above. The retroperitoneal space is opened, the ureter identified and the internal iliac artery mobilized and double ligated at least 2 cm from its origin.

#### *Uterine compression sutures*

Several uterine compression sutures have been described. The B-Lynch suture enters the uterus below and exits above the caesarean section hysterotomy on one side, passes over the fundus, enters the lower uterine segment posteriorly on the same side, exits on the opposite side, passes back over the fundus to enter and exit above and below the hysterotomy. The uterine fundus is manually compressed while the suture is pulled tight and tied.

#### *Hysterectomy*

As mentioned above, if bleeding continues despite more conservative options, time should not be lost before proceeding to hysterectomy. For inexperienced surgeons, a subtotal hysterectomy is a quicker and safer option.

#### *Deaths due to PPH in South Africa*

The most recent report of the Committee for Confidential Enquiries into Maternal deaths in South Africa covered the triennium 2011–2013. Obstetric haemorrhage was the second most common cause of maternal death, 671 or 15.8% of all deaths, slightly less than 688 deaths between 2008 and 2010. This represents a maternal mortality ratio (MMR) of 23.9 deaths per 100,000 live births. Maternal age >35 years (28.8%) was a risk factor for deaths from obstetric haemorrhage. Common underlying factors were prolonged labour (21.6%) and anaemia (33.7%). The major causes of death due to haemorrhage were bleeding associated with caesarean section (increased to 31.9%), abruptio placentae (16%), uterine rupture (15.3%), uterine atony (7.2%) and retained placenta (6.7%). Uterine rupture remained a concerning statistic. A possible or probable avoidable factor was found to be present in 89.4% of deaths due to haemorrhage, and 61.5% were considered probably avoidable. Substandard care included infrequent monitoring of vital signs after caesarean section, failure to use ergometrine to treat uterine atony in eligible cases and uterine rupture from use of excessive doses of misoprostol for induction of labour, especially in women with intrauterine death.

Analysis of the deaths led to the following key recommendations:

1. Train community health workers to educate pregnant women about obstetric haemorrhage and promote transport plans.
2. District and facility managers to ensure (a) that district hospitals have 24-h functioning theatres with continuous supply of emergency blood and sufficient staff for the anaesthesia, surgery and recovery areas; and (b) adequately staffed labour wards.

3. Emergency transport to be onsite for transfers from district hospitals.
4. Clinical managers to ensure implementation of PPH monograph, essential steps in the management of obstetric emergency skill training, PPH drills and early warning monitoring charts. A particular focus on skills to perform CS safely is required.
5. Facility auditing of severe PPH and display of trends by graphs/charts in labour wards and theatres.
6. Use of misoprostol for induction of labour to be closely monitored and all healthcare providers to be trained on the correct use so as to prevent uterine rupture. Foley catheter induction to be promoted as a safer method.
7. Avoid performing CS for abruptio placenta with an intrauterine death and without appropriate indications.
8. Syntometrine or ergometrine to be used as second-line treatment for uterine atony in preference to misoprostol, unless contraindicated; and to be considered for prophylaxis at CS.
9. Monitoring after CS, complicated normal vaginal delivery and manual removal of placenta to be improved in terms of frequency of observations and action on abnormal observations; this is to be facilitated with early warning monitoring charts. At-risk women to be monitored in a special care area.
10. All women with blood loss in excess of 1000 ml need to be immediately assessed by a doctor.

### Research agenda

The research agenda is the effectiveness of most treatment methods that are currently used empirically is a research priority, as well as the optimal dosage of misoprostol. Interesting new approaches which require further research, include transvaginal uterine artery clamping and suction uterine tamponade.

### Resource needs and long-term sustainability of the different approaches

In order to achieve reduction of maternal and neonatal morbidity and mortality due to haemorrhage, an organizational sector-wide approach rather than a single intervention is necessary. The provision of essential and emergency obstetric and newborn care starts with preventive and promotive activities during the antenatal period and extends onto the intrapartum/peripartum and early neonatal period when most deaths due to haemorrhage occur.

A review entitled 'Maternal health interventions in resource limited countries' noted that programmes integrating multiple interventions such as training in emergency obstetric care (EmOC), placement of care providers, refurbishment of existing health facility infrastructure and improved supply of drugs, consumables and equipment for obstetric care were more likely to have significant positive impact on maternal health.

Statistically significant reduction of MMR was reported in 55% of the programmes with a conclusion that *'no single magic bullet intervention exists for reduction of maternal mortality and that all interventional programs should be integrated in order to bring significant changes'* [41].

### Emergency obstetric care

A study of the status of EmOC in six developing countries – Kenya, Malawi, Sierra Leone, Nigeria, Bangladesh and India between 2009 and 2011 noted fewer than one in four facilities aiming to provide comprehensive emergency obstetric care (CEOC) were able to offer the nine required signal functions of CEOC (23.1%) and only 2.3% of health facilities expected to provide basic emergency obstetric care (BEOC) provided all seven signal functions.

The maternal case fatality rate (CFR) for obstetric complications ranged from 2.0% to 9.3%, which as per the WHO standard of acceptable level should be <1%. Availability of EOC was well below the minimum UN target coverage levels, and health facilities in the surveyed countries did not have the capacity to adequately respond to and manage women with obstetric complications [42].

### Skilled birth attendance

Research data from 36 nations in sub-Saharan Africa noted that facility delivery was shown to reduce maternal mortality and neonatal mortality, which would be applicable to obstetric haemorrhage [43].

By contrast, a systematic review noted significantly increased risk of maternal mortality for facility-based compared with home births in sub-Saharan Africa [44]. Facility-based birth as a strategy to reduce maternal mortality does not simply entail birth at a health facility, but also access to an enabling environment, such as availability of health workers with midwifery training, diagnostic tools, drug supplies and access to blood bank for effective care. A possible reason for the finding is that very sick women especially those who have haemorrhage are brought to the facilities quite late, with all the three delays of health seeking contributing to the event outcome.

### Training

Pre-service training for all health professionals should be strengthened to ensure that on qualification the provider is capable of providing quality reproductive healthcare. Subsequently, if and when there is a need for in-service training this should preferably be on site.

Several organizations and programmes are providing competency-based trainings for the management of obstetric emergencies using mannequins and mnemonics. Examples are the Advanced Life Support in Obstetrics (ALSO) [45] course, the 'Making it Happen (MiH)' [46] programme conducted by The Centre for Maternal and Newborn Health at the Liverpool School of Tropical Medicine (CMNH-LSTM) and JHPIEGO led maternal and newborn health programmes [47].

In Tanzania following the ALSO [45] trainings, frequency of PPH decreased from 32.9% to 18.2% and the frequency of severe PPH decreased from 9.2% to 4.4%. There was an increase in the number of cases of PPH identified and an increase in the use of manoeuvres such as uterine massage, bimanual compression and use of uterotonics such as oxytocin and misoprostol.

Lessons learned from the JHPIEGO [47] led consortia for the United States Agency for International Development (USAID) flagship maternal and newborn health programmes included the importance of strengthening health facility, competency-based education provider, global leadership, strong government ownership and coordination as essential precursors to scale-up of high-impact, evidence-based maternal and newborn interventions in low-resource settings.

### Summary

Obstetric haemorrhage is the most common direct cause of maternal death globally. Its occurrence is often unpredictable and acute, requiring rapid, coordinated and effective interventions to prevent death, which may otherwise occur within a short time frame. Although some interventions can be initiated at a community- or primary-level care, many cases require secondary- or tertiary-level care. Thus prevention of deaths from obstetric haemorrhage requires effective health systems including family planning, commodities, personnel, infrastructure and ultimately universal access to comprehensive obstetric care for women giving birth.

The main causes of death associated with APH are placental abruption, placenta praevia and uterine rupture. Preventive measures include preconceptual folate supplementation, management of hypertensive disorders, early diagnosis of placenta praevia, and use of uterine stimulants cautiously, particularly misoprostol.

Preventive measures for PPH include routine AMTSL (routine uterotonics, cord clamping (delayed) and CCT if the competency is available). Treatment involves a cascade of increasingly invasive interventions in rapid sequence until the bleeding is stopped. These interventions include resuscitation, fluid volume replacement, removal of the placenta if retained, bimanual uterine compression, uterotonics, tranexamic acid, suturing of lower genital tract injury, blood product replacement, balloon tamponade, laparotomy, stepwise uterine devascularization, uterine compression sutures and hysterectomy.

Emergency temporizing measures include application of the NASG, and at laparotomy, aortic compression and uterine tourniquet application.

Research priorities include the effectiveness of treatment methods as most are used empirically and the optimal dosage of misoprostol. Interesting new approaches include transvaginal uterine artery clamping and suction tamponade.

### Practice points

- Every day 830 women die due to complications in pregnancy and childbirth
- Most deaths occur in developing countries, particularly in Africa
- Prevention of deaths from obstetric haemorrhage is a complex process, which requires effective health systems
- This includes universal access to comprehensive obstetric care for women giving birth
- Family planning is the key to reducing maternal deaths
- The main causes of death associated with antepartum haemorrhage are placental abruption, placenta praevia and uterine rupture
- Preventive measures include preconceptual folate supplementation, management of hypertensive disorders, early diagnosis of placenta praevia and use of uterine stimulants cautiously, particularly misoprostol
- Preventive measures for post-partum haemorrhage include routine active management of the third stage of labour
- Treatment involves a cascade of increasingly invasive interventions until the bleeding is stopped
- These interventions include:
  - fluid resuscitation
  - removal of the placenta
  - bimanual uterine compression
  - uterotonics
  - tranexamic acid
  - suturing of lower genital tract injury
  - blood product replacement
  - balloon tamponade
  - laparotomy
  - stepwise uterine devascularization
  - uterine compression sutures
  - hysterectomy
- Emergency temporizing measures include:
  - the non-pneumatic anti-shock garment
  - at laparotomy, aortic compression and uterine tourniquet application
- Research priorities include:
  - effectiveness of treatment methods
  - optimal dosage of misoprostol
- Interesting new approaches include:
  - transvaginal uterine artery clamping
  - suction uterine tamponade.

### Conflict of interest statements

GJH is the author of some publications used as the evidence base of this chapter.

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