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POSTPARTUM HEMORRHAGE: A DIAGNOSTIC AND THERAPEUTIC CHALLENGE

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ABSTRACT

Postpartum hemorrhage (PPH) is a common, potentially life-threatening obstetric complication and a leading cause of maternal mortality worldwide, accounting for over a quarter of maternal deaths. Effective treatment largely depends on early recognition of hemorrhage and prompt medical intervention.

Aim of the study: The aim of this study was to present current knowledge about PPH, predict its occurrence, and implement appropriate treatment. Analyzing current information, understanding risk factors, and recognizing PPH can prevent many maternal deaths in the future.

Materials and methods: A systematic review of scientific and medical literature from the PubMed and Google Scholar databases was conducted.

Results: PPH remains a serious global mortality issue. In recent years, many studies have described the challenges in diagnosing and treating PPH. Innovative treatment concepts have been presented, and knowledge of various novel methods can provide clinicians with alternatives that can be applied as a last resort in hemorrhage cases that do not respond to conventional methods.

Conclusions: Postpartum hemorrhage (PPH) is still a serious obstetric complication. Innovative approaches and research on diagnostic and therapeutic methods allow for the refinement of guidelines, the establishment of international protocols, and actions that lead to quicker diagnoses and more appropriate responses.

Keywords: postpartum hemorrhage, blood loss, gynecology and obstetrics, uterine atony, cesarean section

INTRODUCTION

Postpartum hemorrhage (PPH) is a childbirth complication occurring in about 2 to 10% of all deliveries. The main cause of PPH is uterine atony, defined as the inability of the uterus to contract properly to stop bleeding after delivery (27). It is estimated that 14 million cases of PPH occur annually, resulting in 140,000 deaths, which equates to one death every four minutes (32). PPH occurs irrespective of location or geographic region: high-income countries have seen an increase in maternal deaths due to PPH, associated with increased maternal age at delivery, cesarean delivery, multiple pregnancies, and labor induction. However, most maternal deaths occur in low- and middle-income countries, reflecting differences in care quality (35).

METHODS

A systematic review of scientific and medical literature from the PubMed and Google Scholar databases was

conducted. The search was based on the following keywords: postpartum hemorrhage AND uterine atony AND cesarean section AND treatment of postpartum hemorrhage AND ballon tamponade AND compression sutures. Inclusion criteria

were patients with postpartum hemorrhage, randomized controlled trials and clinical trials, full-text studies in English language. This paper focuses on presenting current data on PPH, its diagnosis, and various forms of therapy. The results of the latest scientific research and clinical practices aimed at reducing morbidity and mortality in PPH patients were also analyzed.

RESULTS AND DISCUSSION

The large number and diversity of procedures described in recent years attest to the ingenuity of clinicians and to the fact that PPH remains a serious global health problem associated with maternal mortality. Many maternal deaths related to hemorrhage could be prevented.

A thorough understanding and assessment of risk factors allow for the classification of patients into a high-risk group for experiencing hemorrhage. This enables faster identification and an effective therapeutic process in the event of PPH.

DEFINITION

The traditional definition of PPH is blood loss greater than 500 ml after vaginal delivery or more than 1000 ml after cesarean delivery. Recently, PPH has been redefined as cumulative blood loss of 1000 ml or more or blood loss associated with signs or symptoms of hypovolemia, regardless of the delivery route (1). Typical clinical signs of hypovolemia (e.g., hypotension and tachycardia) caused by PPH may not appear until blood loss exceeds 25% of total blood volume (>1500 ml in late pregnancy). PPH is considered primary if it occurs within the first 24 hours after delivery or secondary if it occurs between 24 hours and 12 weeks postpartum (8). The causes of PPH can be summarized using the four "T"s: tone (uterine atony), trauma (lacerations or uterine rupture), tissue (retained placenta or clots), and thrombin (clotting factor deficiency). The most common cause is uterine atony (about 70% of cases), followed by obstetric lacerations (about 20%), retained placental tissue (about 10%), and clotting factor deficiencies (<1%). PPH can lead to severe anemia requiring blood transfusion, disseminated intravascular coagulation, hysterectomy, multiple organ failure, and death (4). Due to the lack of a unified definition of PPH and difficulty estimating blood loss, there is significant discrepancy in PPH incidence rates (23).

THE CHALLENGE OF EARLY DETECTION

Postpartum hemorrhage (PPH) often goes undetected or is detected late, resulting in life-saving treatment not being initiated immediately. In a large, international, randomized trial on PPH prevention involving 29,645 participants, only 53% of those who experienced PPH were diagnosed and administered an uterotonic drug. The current approach to assessing blood loss after birth relies on visual estimation, which is widely recognized as inaccurate and typically underestimates actual blood loss (14).

PPH is a complex, multifactorial process. Accurate quantification of blood loss is crucial but should not be the sole focus of PPH management. Other factors, such as the rate of blood loss, clinical symptoms, patient symptoms, shock index, and physiological response to hemorrhage, are keys to early recognition of high-risk situations, which can help ensure optimal management (4). To address the issue of inconsistent outcome reporting in this area, core outcome sets (COS) have been developed for studies evaluating PPH prevention and treatment interventions through an international, multidisciplinary stakeholder panel following the methodological guidelines of the COMET Initiative (29). Nine COS were selected for PPH prevention: blood loss, shock, maternal death, additional uterotonic use, blood transfusion, transfer for higher level care, women's well-being, acceptability and satisfaction with the intervention, breastfeeding, and adverse events. Twelve primary endpoints were selected for PPH treatment: blood loss, shock, coagulopathy, hysterectomy, organ dysfunction, maternal death, blood transfusion, additional hemostatic intervention, transfer for higher level care, women's well-being, acceptability and satisfaction with the intervention, breastfeeding, and adverse events. Recommendations were made on how to report these outcomes when possible. Researchers evaluating PPH interventions are encouraged to report at least these COS outcomes along with any other outcomes relevant to their study (28).

CESAREAN SECTION

The risk of postpartum hemorrhage (PPH) is significantly higher in cesarean deliveries compared to vaginal births, particularly in emergency cesarean sections (10). As the global rate of cesarean deliveries increases, the concern for PPH during and after cesarean sections also rises (7). Currently, there are no globally standardized strategies for the early detection and management of PPH specifically during and after cesarean sections. To address this, an international consensus of experts has developed evidence-based guidelines for the early detection and management of PPH in obstetric first aid during both intraoperative

and postoperative phases of cesarean delivery (33). The guidelines proposed by the experts are detailed in **Table 1.**

Table 1. Guidelines proposed by experts for the early recognition of postpartum hemorrhage (PPH) during cesarean delivery and triggers for the first reaction in the intraoperative phase:

Early detection of postpartum hemorrhage (PPH) during cesarean section and triggers for the initial response in the intraoperative phase.	Early detection of postoperative postpartum hemorrhage (PPH) and thresholds triggers for the initial response in the postoperative phase.
Quantitative measurement of blood loss: • If possible - direct volume measurement (ability to capture all blood) • Volumetric measurement + gravimetric measurement • Monitor hemodynamic status. Thresholds triggering the initial response: • At least 500 ml of measured blood loss with ongoing active bleeding OR • Clinical symptoms of hemodynamic instability.	Frequent monitoring of hemodynamic status (at least every 15 minutes for the first 2 hours): • Pulse rate • Blood pressure • Shock index • Clinical symptoms/suspected signs of internal bleeding If possible, quantitative assessment of blood loss: • Measured or estimated postoperative blood loss (if possible, added to the quantitative intraoperative blood loss) Thresholds triggering the initial response: • Clinical signs and symptoms of hemodynamic instability, according to local protocols.
Additional comments: • It's important to separate/distinguish amniotic fluid from blood. • The entire blood loss may not be immediately apparent. Examine the back of the uterus for cervical tears and concealed uterine rupture, then apply and monitor buttock padding to assess blood loss from the vagina. • To prevent severe PPH, early first aid treatment should be initiated if bleeding persists, especially in conditions where anemia is common or where inevitable delays in treatment implementation are anticipated.	**Additional comments:** • Relying solely on postoperative blood loss may underestimate internal bleeding. Increase vigilance and frequently assess hemodynamic status. • Early detection of postoperative PPH should primarily rely on frequent monitoring of hemodynamic status and clinical signs of internal bleeding. If possible, assess postoperative blood loss from the vagina using quantitative measurement or estimation (e.g., via electrodes). • If possible, add estimated postoperative blood loss to the quantitative intraoperative blood loss. • The cumulative intraoperative and postoperative blood loss combined with the woman's hemodynamic status may better determine the frequency and characteristics of postoperative monitoring and action thresholds. • Thresholds for hemodynamic

	parameters, vital signs and the obstetric shock index to initiate treatment have not yet been agreed upon.

UTERINE ATONY

Atonia of the uterus, or lack of uterine muscle tone, is the cause of 80% of cases of PPH and can occur both in vaginal deliveries and cesarean sections. Some predisposing factors for PPH include coagulation disorders, placenta previa or accreta, multiple pregnancies, multiparity, uterine fibroids, cesarean delivery, or a history of PPH (11). A study (31) conducted from 2016 to 2020 found that the incidence of postpartum hemorrhage in patients undergoing cesarean section was 3.8%. Atonia of the uterus accounted for 62.7% of cases, and abnormal placenta accounted for 29.3%. Among the analyzed patients, 166 out of 649 (25.6%) experienced massive postpartum hemorrhage (blood loss ≥ 2000 ml). The overall blood transfusion rate was 40.7%, with 264 out of 649 patients requiring transfusion. The incidence of postpartum hemorrhage after cesarean section in this study was comparable to a previous population-based study conducted in Norway, where the rate ranged from 1.9% to 4.7% (3). Risk factors for uterine atony include prolonged labor, precipitous delivery, uterine distention (multiple pregnancies, polyhydramnios, fetal macrosomia), uterine fibroids, chorioamnionitis, indicated magnesium sulfate infusions, and prolonged use of oxytocin. Ineffective uterine contractions, either focal or diffuse, are also associated with various etiologies, including retained placental tissue, placental disorders (such as morbidly adherent placenta, anterior placenta, and placental abruption), coagulopathy (increased fibrin degradation products), and uterine inversion. A body mass index (BMI) above 40 (class III obesity) is also a recognized risk factor for postpartum uterine atony (9).

TREATMENT

Guidelines often recommend a multidisciplinary approach to achieve effective early control of bleeding. Treatment should target the specific cause of PPH (uterine atony, genital tract trauma, retained placenta, and/or coagulopathy), with therapeutic steps progressing from less invasive to more complex and radical methods. The initial set of measures also appears to be consistent across most guidelines and includes maintaining two intravenous accesses, oxygen supplementation, close monitoring of the woman, crystalloid infusion, measures to avoid hypothermia, and assessment of the cause of PPH (13). Clinical management of PPH includes the administration of isotonic crystalloids, tranexamic acid, uterotonic agents, uterine massage, gauze packing, uterine balloon tamponade, non-pneumatic anti-shock garments, external aortic compression, uterine artery embolization, and surgical interventions such as suturing the bleeding site, uterine compression sutures (UCS), arterial ligation, and hysterectomy, etc (25).

For women at increased risk of postpartum hemorrhage, the use of cell-saver technology (blood salvage) should be considered, though it is not cost-effective for routine use. Optimal management of the third stage of labor is a method of intraoperative prevention of uterine atony. Active management of the third stage includes uterine massage with simultaneous continuous low-level umbilical cord traction. Concurrent oxytocin infusion is helpful, though it is reasonable to delay it until after placental delivery. Medications used in the treatment of uterine atony include oxytocin, methylergonovine, 15-methyl-PGF2-alpha, misoprostol, and dinoprostone. If treatment is ineffective and excessive bleeding persists, surgical treatment is employed (16). After ruling out additional sources of postpartum hemorrhage, such as lacerations, retained products of conception, or uterine inversion, mechanical tamponade is still recommended in the Safe Motherhood Initiative and most protocols for the management of treatment-resistant hemorrhage due to uterine atony. The most popular intrauterine balloon tamponade system is the Bakri balloon, which reduces blood flow through the uterus by inward compression of uterine blood vessels. If these uterus- and fertility-sparing procedures fail, hysterectomy becomes the final method of treating postpartum hemorrhage (17).

OXYTOCIN

A meta-analysis of data showed that oxytocin is more effective than misoprostol as first-line treatment for PPH with fewer adverse side effects; adding misoprostol to oxytocin provides little to no benefit; and there is also not much solid evidence on the efficacy of other uterotonic drugs such as ergometrine and injectable prostaglandins (21). Currently, oxytocin is administered via intravenous or intramuscular injection and must be given by a healthcare worker trained in intravenous infusions or intramuscular injections. This complicates its use during childbirth in developing countries, where medical personnel are often unavailable, and in lower-level institutions. A thermostable oxytocin patch with microneedles has been developed, allowing for quick and accurate drug delivery using a simpler administration method. The thermostable patch is designed to mitigate the need for cold chain storage and delivery of the drug (18).

TRANEXAMIC ACID

Systematic reviews have shown that early administration of tranexamic acid in the treatment of postpartum hemorrhage saves lives and is cost-effective (5). Prophylactic administration of tranexamic acid is effective in women that undergo cesarean section, reducing postpartum blood loss and limiting the decrease in hemoglobin concentration (6). If parenteral administration of tranexamic acid is not possible, an oral route of administration is also available. However, a placebo-controlled study did not show improved clinical outcomes with adjunctive oral tranexamic acid in the treatment of postpartum hemorrhage (12).

BALLOON TAMPONADE

Uterine balloon tamponade is recommended for the treatment of postpartum hemorrhage caused by uterine atony in women who do not respond to first-line pharmacological treatment. According to a recent meta-analysis (38), the effectiveness of balloon tamponade is 86% and is comparable to surgical treatment, with better efficacy in cases of uterine atony, vaginal delivery and placenta previa. The complication rate is relatively low (7.6%), including fever or infections (6.5%), endometritis (2.3%), and adverse effects related to improper placement, such as cervical laceration (1.7%), lower vaginal injury (4.8%), uterine incision rupture (1.9%) and uterine perforation (2.0%). The risk of infection can be reduced by using broad-spectrum antibiotics (e.g. Clindamycin with Gentamicin) in cases of suspected endometritis, retained placenta, or membranes (34).

The success of balloon tamponade in controlling bleeding is associated with the proper placement of the device, as incorrect insertion can result in inefficacy and requires time-consuming repositioning maneuvers, leading to further blood loss. The insertion of the Bakri balloon can be performed under ultrasound (US) guidance, which is superior to blind insertion combined with postoperative ultrasound control, as it increases the success rate, shortens application time and blood loss and reduces the need for additional repositioning maneuvers. The ability to check the position of the balloon throughout the placement procedure prevents malposition or expulsion during inflation. Under US guidance, the profile and angle of the uterus can be seen, making it easier and more accurate to insert the device into the uterine cavity, minimizing potential complications (15).

COMPRESSION SUTURES

Uterine compression sutures are effective, safe, and simple to perform in emergency situations, and they allow for the preservation of fertility potential in cases of postpartum hemorrhage (PPH) (30). The efficacy and safety of a new type of uterine compression suture, the stepwise backpack suture technique, were investigated for use in case of treatment-resistant PPH caused by uterine atony and placental factors during cesarean delivery. This stepwise surgical technique of creating backpack uterine compression sutures can completely compress the uterus. It is a uterus- and fertility-preserving technique that requires no special equipment during cesarean section for PPH and is characterized by being safe, simple, and stable (3 S), providing rapid operation, reliable hemostasis, and the ability to be performed by a resident doctor (3R) (19). If laparoscopy can be used in compression suture treatment, it may simplify the procedure, allow obstetricians to perform it independently, reduce treatment costs for the patient, avoid radiation damage, and shorten emergency response time. Laparoscopic suture compression alleviates patient's and obstetrician's concerns about the complications and morbidity associated with laparotomy. It offers advantages in terms of minimal invasion, safety, simplicity, and independence from equipment and other specialities. Sutures can also be removed by pulling them from the uterine cavity through the vagina after cutting the thread on the abdominal wall during disinfection. Further studies are needed to standardize the laparoscopic application of compression sutures (24).

Most women who previously had uterine compression sutures placed experienced similar menstrual and pregnancy courses compared to women who did not have sutures. However, they had a higher risk of developing visceral adhesions, recurrence of hemorrhage, and the need for repeat compression sutures in subsequent pregnancies. Moreover, the couple may be more susceptible to the emotional impact of such interventions (22).

INNOVATIVE CONCEPTS IN DIAGNOSIS AND THERAPY

A large number of innovative treatment methods recently reported demonstrates the ingenuity of clinicians faced with the risk of life-threatening hemorrhage and indicate that there is no single method effective in all cases. Attention has been drawn to the lack of solid evidence for the effectiveness of most individual PPH treatment methods. At the same time, knowledge of various innovative methods described above can provide clinicians with alternatives to be used as a last resort in the event of hemorrhage unresponsive to conventional methods, especially in conditions with limited access to resource-intensive methods (20).

Rapid detection of postpartum hemorrhage (PPH) can reduce mortality, and measuring blood loss with a perineal pad is more accurate than visual estimation. A reusable postpartum blood collection calibrated tray for monitoring blood loss was evaluated for acceptability by patients and providers. The delivery pad was accepted by most obstetricians and patients and appears to function as intended. Further studies are

needed to determine the accuracy of blood loss monitoring compared to other methods and the impact of such monitoring on early diagnosis, early treatment, and PPH outcomes (37).

Consultations led to the definition of two care bundles to be implemented in facilities. The "First Response to PPH Package" includes uterotonics, isotonic crystalloids, tranexamic acid, and uterine massage. The "Response to Treatment-Resistant PPH Package" includes compressive measures (aortic compression or bimanual uterine compression), non-pneumatic anti-shock garments, and intrauterine balloon tamponade. Advocacy, training, teamwork, communication, and the use of best clinical practices were defined as supporting elements of the PPH package (2).

Additional uterine-sparing surgical procedures have been proposed for the treatment of treatment-resistant PPH. The effect of Bakri balloon tamponade combined with various suturing methods on preventing postpartum hemorrhage in women with pregnancy-induced hypertension undergoing cesarean delivery was studied. The hemostatic effect of Bakri balloon tamponade combined with B-Lynch compression sutures is comparable to the effect of Bakri balloon tamponade combined with modified Hayman sutures in the treatment of postpartum hemorrhage in pregnant women with pregnancy-induced hypertension undergoing cesarean delivery. However, the latter is characterized by less blood loss, reduced inflammatory response, decreased impact on coagulation function and ovarian function, and a lower incidence of adverse events. Thus, it deserves further clinical promotion and application (26).

The use of circumferential sutures at the placenta attachment sites was evaluated; the procedure involved placing a circumferential suture around the serosa and myometrium at the placenta attachment site and was used in cases of treatment-resistant PPH regardless of etiology. This approach can quickly arrest treatment-resistant PPH in both vaginal delivery and cesarean delivery patients, with few postoperative complications. This modified surgical approach could potentially be an important adjunct and clinical option in the second-line treatment of PPH (36).

CONCLUSIONS

It is important to review available methods for rapid estimation and quantitative determination of blood loss in the peripartum period and to standardize the criteria for diagnosing PPH. Careful observation of clinical symptoms, patient monitoring, and optimal therapy selection are also crucial. Innovative treatment concepts and knowledge about various innovative methods can help improve guidelines and provide clinicians with alternatives to conventional methods in cases where hemorrhage does not respond to standard treatments. It is worth remembering that besides impacting maternal health and mortality, PPH has significant social implications, as most patients are young women who play a crucial role in their families.

AUTHOR CONTRIBUTIONS

Conceptualization: Anna Pilarz, Julia Sosin, Julia Stachowiak; Methodology: Anna Pilarz, Julia Sosin; Software: Anna Pilarz; Validation: Julia Sosin, Julia Stachowiak, Dariusz Salamon; Formal analysis: Anna Pilarz, Julia Stachowiak; Investigation: Anna Pilarz; Resources: Anna Pilarz; Data curation: Anna Pilarz; Writing – Original Draft Preparation: Anna Pilarz; Writing – Review & Editing: Anna Pilarz, Julia Sosin, Julia Stachowiak,Dariusz Salamon; Visualization: Anna Pilarz, Supervision: Julia Sosin, Julia Stachowiak, Dariusz Salamon; Project administration: Anna Pilarz; Funding acquisition: not applicable.

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CONFLICT OF INTEREST STATEMENT

Authors have declared no conflict of interests.

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