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Manual on Postpartum Hemorrhage

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Newer Modalities in Postpartum Hemorrhage

Deepti Gupta, Shuchi Sehgal

INTRODUCTION

Postpartum hemorrhage (PPH) remains a devastating obstetric emergency and the leading cause of maternal mortality worldwide, accounting for approximately 27% of maternal deaths globally and affecting approximately 12% women in India. Defined as cumulative blood loss ≥1,000 mL or blood loss accompanied by hypovolemia signs within 24 hours of delivery, PPH challenges clinicians with its unpredictable nature—up to 40% of cases occur in women without identifiable risk factors. The traditional "4 T's" framework (Tone, Trauma, Tissue, and Thrombin) continues to guide management, but recent technological and pharmacological innovations are transforming our approach.

Management of PPH revolves around four major components which need to be executed simultaneously-communication, resuscitation, monitoring investigation and arrest of bleeding. Furthermore therapeutic goals include- maintaining hemoglobin >8 g/dL, platelet count >75 × 10^9/L, prothrombin <1.5 × mean control, activated prothrombin time <1.5 × mean control, fibrinogen >1.0 g/L. This chapter examines advances in PPH management that promise to significantly reduce maternal morbidity and mortality through enhanced prevention, rapid diagnosis, and targeted interventions.

PHARMACOLOGICAL REVOLUTION: BEYOND OXYTOCIN

Uterotonic Innovations

The pharmacological armamentarium for uterine atony (responsible for 70–80% of PPH cases) has expanded beyond traditional agents like oxytocin and ergometrine. Novel formulations and delivery systems are optimizing efficacy while minimizing side effects:

- *Heat-stable carbetocin:* This long-acting oxytocin analog represents a breakthrough in tropical settings where cold-chain storage is unreliable. Carbetocin is a long-acting synthetic analogue of oxytocin with half-life of 40 minutes. Following IV administration, onset of contraction is seen in 2 minutes with sustained and rhythmic contractions for 6 and 60 minutes respectively. Following intramuscular administration,

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sustained and rhythmic contractions last for 11 and 120 minutes, respectively. It can be stored at temperatures up to 30°C. single-dose administration provides sustained uterine protection comparable to multiple-dose oxytocin regimens. According to Cochrane review, There is evidence to show the benefit of carbetocin over oxytocin for preventing PPH following cesarean deliveries. Carbetocin should also be considered as an option over syntometrine, due to the lower likelihood of adverse effects. The World Health Organization recommends heat-stable carbetocin for PPH prevention in resource-limited settings, where it demonstrates superior cost-effectiveness despite higher initial costs.

- *Intrauterine instillation:* Research demonstrates that direct intrauterine administration of diluted oxytocin (via intrauterine catheters) achieves 10-fold higher myometrial concentrations compared to intravenous routes. This targeted approach may revolutionize refractory atony management, especially in high-risk patients.

Hemostatic Adjuncts

- *Tranexamic acid (TXA):* The landmark WOMAN trial established TXA as a life-saving intervention when administered within three hours of delivery. New protocols emphasize point-of-care availability and weight-based dosing (1 g IV repeated if ongoing bleeding). Emerging evidence suggests that pre-emptive administration during cesarean delivery for high-risk patients reduces blood loss by 30–40% without increasing thrombotic complications.
- *Fibrinogen concentrate:* Research reveals that fibrinogen depletion (<2 g/L) occurs earlier than previously recognized in PPH and strongly predicts severity. Unlike fresh frozen plasma (requiring thawing and cross-matching), lyophilized fibrinogen concentrate enables rapid, targeted repletion. The FIDEL trial demonstrated that early and systematic administration of 3 g fibrinogen concentrate did not reduce blood loss, transfusion needs or postpartum anemia, but did prevent plasma fibrinogen decrease without any subsequent thromboembolic events.

Novel pharmacological agents in PPH management is shown in **Table 1**.

Minimally Invasive and Mechanical Innovations

Advanced Tamponade Systems

Uterine balloon tamponade (UBT) has evolved from improvised solutions to sophisticated devices with enhanced efficacy:

- *Pressure-controlled balloons:* It was the first uterine tamponade balloon system designed specifically for the treatment of obstetric hemorrhage. It consists of a silicone balloon (maximum recommended fill volume 500 mL), connected to a 24 French silicone catheter 54 cm in length.

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TABLE 1: Novel pharmacological agents in PPH management.

Agent	*Mechanism*	*Advantages*	*Evidence level*
Heat-stable carbetocin	Long-acting oxytocin receptor agonist	Single-dose, thermostable, 60–90 min half-life	WHO recommendation (Phase III trials)
Nanoemulsified TXA	Enhanced antifibrinolytic delivery	Rapid sublingual absorption, no IV access needed	Phase II trials
Polidocanol foam	Sclerosant for persistent oozing	Topical application, minimally invasive	Multicenter prospective studies
Fibrinogen concentrate	Targeted coagulation factor replacement	Rapid administration, no cross-match needed	FIDEL trial (RCT)



Fig. 1: Bakri balloon.

Devices like the Bakri SOS Balloon now incorporate integrated pressure sensors and automated infusion systems (BakriOne) that maintain optimal intrauterine pressure (typically 70–80 mm Hg). This prevents under-distension (ineffective tamponade) and over-distension (tissue necrosis risk). Recent modifications include concomitant intrauterine irrigation channels that permit continuous blood loss monitoring.
Figure 1 showing Bakri Balloon.

- *BT-Cath*—the BT-Cath is a silicone balloon (maximum recommended fill volume 500 mL) with an inverted pear shape to conform to the shape of the uterine cavity. **Figure 2** showing BT Cath balloon
- *EBB tamponade system:* The ebb tamponade system is a dual polyurethane balloon device containing an upper uterine balloon

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Fig. 2: BT-Cath.

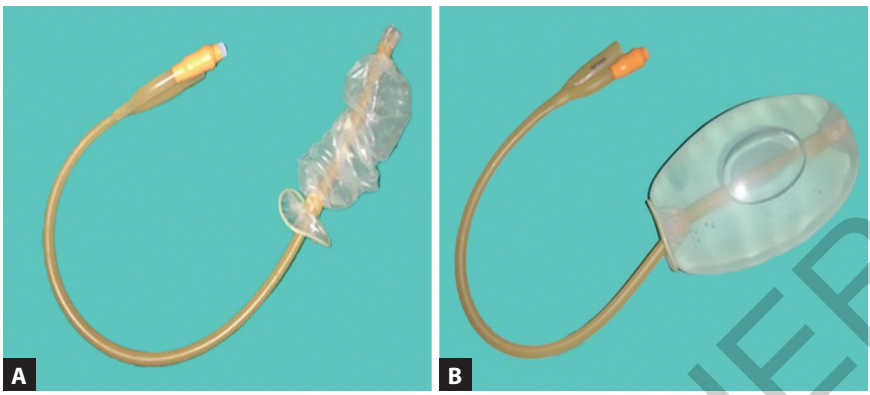


Fig. 3: EBB tamponade system.

(maximum recommended fill volume 750 mL) and a lower vaginal balloon (maximum recommended fill volume 300 mL). A central drain allows for monitoring of possible ongoing or recurrent hemorrhage from above the uterine balloon. **Figure 3** showing EBB tamponade system.

- *Condom catheter tamponade:* In resource-limited settings, low-cost alternatives demonstrate remarkable efficacy. CG Balloon overcomes the major disadvantages of conventional condom balloon tamponade by having a drainage channel for assessing the uterine bleeding. It uses rings cut out of catheter only and not the thread to tie the condom to catheter which avoids loose/too tight knots as well as infection, saves time and is simple to use. CG Balloon is successful in 92.3% cases as a

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Figs. 4A and B: Condom catheter tamponade.

second-line approach in atonic PPH protocols when first-line treatment fails and before more costly and risky surgery. It can also be used for extended indications for lower genital tract tears or placental bed oozing as it allows the drainage of uterine bleeding simultaneously **(Figs. 4A and B)**.

Nonpneumatic Antishock Garment

It is a low technology first-aid device that buys a woman time to seek definitive and adequate treatment. Made of neoprene and Velcro (Velcro Industries), the non-pneumatic anti-shock garment (NASG) comprises six segments: an ankle segment pair, a calf segment pair, a thigh segment pair, a pelvic segment, and two abdominal segments. Its advantages are manyfold including:

- Circumferential counter-pressure decreases blood flow to the lower body while increasing circulation in the vital organs of the upper body.
- Serves to reverse shock and provide time for transportation, blood transfusion, or surgery, particularly in under-resourced and overcrowded settings.
- Designed to provide total perineal access as well as stretching in the abdominal segment so that the condition of the uterus can be assessed.
- NASG application improves access to veins in the arm, thus aiding fluid replacement.
- Can be safely worn for up to 48 hours, may help avoid unnecessary emergency hysterectomy for intractable uterine atony, and may decrease the need for or the number of blood transfusions.
- Reusable and can be disinfected with a 0.01% bleach solution, laundered, hung to dry, and has been tested to last at least 72 washings/uses.

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Radiological Interventions

Interventional radiology offers fertility-preserving options when conventional measures fail:

- *Uterine artery embolization (UAE):* Modern techniques employ temporary embolic agents (gelatin sponge) rather than permanent particles, preserving future fertility. The procedure achieves 85–92% success in controlled studies, with newer approaches utilizing radial artery access (reducing groin complications) and outpatient management. UAE is particularly valuable for abnormally invasive placentation cases, where it reduces intraoperative blood loss by 40% when performed prophylactically.
- *Pre-operative prophylactic balloon artery occlusion (PBAO):* For known placenta accreta spectrum disorders, pre-cesarean placement of internal iliac or common femoral artery balloons enables immediate inflation during delivery. Contemporary protocols emphasize partial inflation rather than complete occlusion, balancing hemorrhage control against ischemic risks.

Point-of-Care Diagnostics and Monitoring

Viscoelastic Hemostatic Assays

Traditional coagulation tests (PT, aPTT, fibrinogen) have 30–60 minute turnaround times—prohibitive in active hemorrhage. Rotational thromboelastometry (ROTEM®) and thromboelastography (TEG®) provide real-time, comprehensive coagulation profiles at the bedside within 10–15 minutes:

- *FIBTEM assay:* Specifically measures functional fibrinogen, identifying depletion earlier than conventional tests. Studies demonstrate that FIBTEM A5 <12 mm predicts severe PPH progression with 92% sensitivity.
- *Goal-directed transfusion:* Viscoelastic hemostatic assay (VHA)-guided algorithms reduce blood product wastage and transfusion-associated complications. The OBS2 trial showed a 35% reduction in FFP and platelet transfusions using ROTEM-guided protocols compared to fixed-ratio resuscitation.

Quantitative Blood Loss Revolution

Visual estimation notoriously underestimates blood loss by 30–50%. Modern quantitative blood loss (QBL) systems integrate multiple modalities:

- *Gravimetric measurement:* Automated systems calculate blood loss by weight differences of soaked materials, validated against artificial intelligence (AI) algorithms.
- *Colorimetric drapes:* Calibrated under-buttock drapes provide instant visual quantification through distinct color zones.

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- *Mobile applications:* AI-enabled apps (e.g., Triton®) use computer vision technology to analyze suction canister images, providing real-time loss estimates.

Ultrasound Innovations

Portable ultrasound extends beyond FAST exams in PPH:

- *Uterine contractility assessment:* 3-D volumetric ultrasound objectively evaluates myometrial contraction strength, differentiating atony from retained tissue.
- *Vascular mapping:* Doppler identifies arteriovenous malformations or pseudoaneurysms requiring targeted intervention.
- *Resuscitation guidance:* Inferior vena cava (IVC) collapsibility index >50% predicts fluid responsiveness better than blood pressure in compensated shock.

Surgical and System-based Advances

Refined Surgical Techniques

Novel approaches minimize morbidity while maximizing efficacy:

- *Stepwise uterine devascularization:* The new FIGO protocol advocates systematic ligation sequence: uterine → utero-ovarian anastomoses → internal iliac arteries. This achieves 90% hemostasis while preserving ovarian function.
- *Compression sutures:* Modified techniques like the "Nieto-Calcified Square Suture" incorporate vertical transverse compression with reduced synechiae risk compared to B-Lynch sutures.
- *Selective embolization:* Combining intraoperative ultrasound with absorbable gelatin pledgets enables targeted vessel occlusion without radiology suite transfer.

Comprehensive Hemorrhage Protocols (Fig. 5)

Comprehensive Hemorrhage Protocols are shown in **Figure 5**.

FUTURE DIRECTIONS AND CONCLUSION

Emerging Frontiers

Several promising technologies approach clinical implementation:

- *Endo-uterine vacuum-induced devices:* The Jada® System applies controlled negative pressure (–80 mm Hg) directly to the endometrial surface, stimulating myometrial contraction and apposing raw surfaces. Early trials demonstrate 94% efficacy for atony refractory to first-line uterotonics.
- *Resuscitative endovascular balloon occlusion (REBOA):* Adapted from trauma surgery, zone III REBOA (infrarenal aortic occlusion) stabilizes

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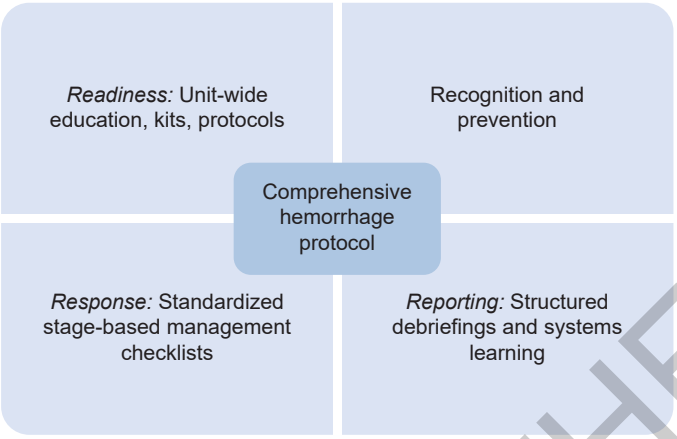


Fig. 5: Comprehensive hemorrhage protocols.

patients in extremis during transfer to definitive care. Newer partial flow catheters mitigate ischemic risks during prolonged use.

- *Topical hemostatic agents:* Fibrin spray patches and gelatin-thrombin matrices show promise for diffuse oozing from placental beds, particularly in coagulopathic patients.

IMPLEMENTATION CHALLENGES AND EQUITY

Despite these advances, disparities in PPH outcomes persist globally. High-income countries report mortality rates <0.02%, while low-resource settings face rates 100-fold higher. Bridging this gap requires:

- *Affordable innovations:* Scaling production of condom tamponade kits and heat-stable carbetocin.
- *Task-sharing models:* Training non-physician providers in balloon tamponade and TXA administration.
- *Digital health integration:* mHealth applications guiding community health workers through PPH algorithms.

CONCLUSION

The landscape of PPH management has transformed dramatically, shifting from reactive, procedure-heavy approaches to proactive, precision-based strategies. By integrating advanced diagnostics (viscoelastic testing, ultrasound), targeted therapeutics (fibrinogen concentrate, TXA), and minimally invasive interventions (embolization, vacuum devices), clinicians can now address hemorrhage with unprecedented precision. However, technology alone cannot eliminate PPH mortality—success requires standardized protocols, interdisciplinary coordination, and equitable implementation. As these innovations permeate global practice, the vision of eliminating

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preventable maternal death from hemorrhage moves steadily toward realization. Continued research into prediction algorithms, novel hemostatics, and system-level interventions remains crucial to achieving this goal.

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