Clinical Review

Update in Anaesthesia

Patient Blood Management in Obstetric Anaesthesia: New Frontiers for Safer Deliveries

Adnane Berdai†, Gita Nath, Darren Lowen, Juan Ruiz Yucuma and Emilia Guasch
†Correspondence email: adnane.berdai@yahoo.fr

Abstract

Patient blood management (PBM) in obstetric anaesthesia represents a structured, patient-centred, and evidence-based strategy aimed at improving maternal safety and outcomes by preserving a woman's own blood and minimising unnecessary transfusion. Built on 3 complementary pillars, PBM addresses key drivers of maternal morbidity and mortality: anaemia, haemorrhage, and impaired physiological tolerance to blood loss. The first pillar focuses on optimising red cell mass, with early screening and treatment of anaemia throughout pregnancy. Iron deficiency remains the leading cause of anaemia worldwide, particularly in low- and middle-income countries. Timely diagnosis and appropriate oral or intravenous iron therapy can significantly reduce transfusion requirements and adverse outcomes. The second pillar targets minimisation of blood loss during childbirth, especially prevention and management of postpartum haemorrhage. Antenatal risk assessment, preparedness, evidence-based obstetric practices, early recognition, and rapid, protocol-driven treatment, including uterotonics, tranexamic acid, and escalation to mechanical or surgical interventions, are central elements. Viscoelastic point-of-care testing enables individualised haemostatic management and reduces unnecessary blood product use. The third pillar emphasises optimisation of physiological tolerance to anaemia through individualised transfusion decisions, appropriate oxygen delivery, haemodynamic stability, normothermia, and effective analgesia. Together, the PBM strategies provide a proactive framework that enhances maternal safety, limits transfusion exposure, and supports safer deliveries worldwide.

Key words: patient blood management, obstetric anaesthesia, postpartum haemorrhage, anaemia, blood transfusion

Adnane Berdai
Mother-Child Anaesthesia and ICU Department, Hassan II University Hospital, Faculty of Medicine, Pharmacy, and Dental Medicine, Sidi Mohamed Ben Abdellah University, 30 000, Fez, Morocco

Gita Nath
Axon Anaesthesia Associates, Hyderabad, India

Darren Lowen
Department of Critical Care, Melbourne Medical School, The University of Melbourne, Parkville, Victoria, Australia

Juan Ruiz Yucuma
Department of Anaesthesia, Hospital Militar Central, Universidad Militar Nueva Granada, Bogotá, Colombia

Emilia Guasch
Servicio de Anestesiología, Reanimación y Unidad del Dolor, Hospital Universitario Fundación Jimenez Díaz, Madrid, Spain

INTRODUCTION

Although the term "patient blood management" (PBM) was originally coined in 2005, it wasn't until 2022 that a global definition of PBM was proposed and accepted.[1,2] The definition is that PBM "is a patient-centered, systematic, evidence-based approach to improve patient outcomes by managing and preserving a patient's own blood, while promoting patient safety and empowerment."[2] By applying the 3-pillar concept of PBM in obstetrics (Table 1), we can work toward safer deliveries and improved patient outcomes.

FIRST PILLAR: OPTIMISE RED CELL MASS

Anaemia in Pregnancy: Aetiology and Screening

Anaemia in pregnancy is defined by the World Health Organisation (WHO) as a haemoglobin level <110 g/L. It has been estimated that in 2023, 35.5% of pregnant women throughout the world were anaemic.[3] Women in African and Southeast Asian regions account for more than 60% of the global burden of anaemia among women of reproductive age.[3]

Anaemia *per se* is not a disease but rather a manifestation of an underlying condition. The leading cause of anaemia during pregnancy and the postpartum period is iron deficiency, and its high prevalence is primarily attributable to the marked increase in iron requirements during pregnancy, driven by expanded maternal erythropoiesis, progressive foetal and placental iron uptake, and adaptive changes in maternal iron metabolism.[4] In addition, many women of reproductive age are already iron deficient prior to conception. Nevertheless, less common causes of anaemia should also be considered in appropriate populations. These include haemoglobinopathies such as sickle cell disease, anaemia of chronic disease,

Table 1 – Three Pillars of Patient Blood Management Applied across Pregnancy, Delivery, and Postpartum Period

	Pregnancy	Delivery	Postpartum
Pillar 1: Optimise red cell mass	• Anaemia screening and treatment • Iron deficiency assessment • Oral/intravenous iron therapy • Nutritional optimisation	• Planned delivery for women at risk with haematological optimisation	• Screening and treatment of postpartum anaemia • Iron replacement
Pillar 2: Minimise blood loss and bleeding	• Antenatal risk assessment • Evaluation of haemostasis	• Postpartum haemorrhage prevention • Early haemorrhage recognition and bundles • Administration of uterotonics • Active coagulation management (tranexamic acid, fibrinogen replacement) • Mechanical and surgical techniques minimising blood loss • Adequate use of viscoelastic haemostasis assays	• Close monitoring of blood loss • Targeted haemostatic support
Pillar 3: Optimise physiological tolerance to anaemia	• Optimise patient's physiological reserve and risk factors	• Haemodynamic optimisation • Optimise oxygenation • Maintain temperature and calcium control	• Maximise oxygen delivery • Restrictive transfusion strategy • Follow-up and recovery

infectious causes such as malaria, and gynaecological or obstetric conditions, including heavy menstrual bleeding and postpartum haemorrhage (PPH) following childbirth.

Women should be screened for anaemia early in their pregnancy as well as at 24–28 weeks of gestation.[5] If no accurate assessment has been done beforehand, haemoglobin levels should be obtained when labour begins.[5,6]

Access to prenatal clinics and appropriately skilled personnel allows opportunistic testing and treatment for anaemia. Full blood count testing is the recommended method for diagnosing anaemia in pregnancy. In settings where full blood count testing is not available, on-site haemoglobin testing with a haemoglobinometer is recommended.[7] Access to prenatal clinics also allows education with regard to dietary education and eating foods that are rich in iron, folate, vitamin B_{12}, and vitamin A.

Prevention and Therapy of Iron Deficiency Anaemia

In low-resource countries with an increased prevalence of iron deficiency and anaemia, routine supplementation of iron seems to be an appropriate strategy. WHO and Network for the Advancement of Patient Blood Management, Haemostasis and Thrombosis recommend daily supplementation of 30–60 mg of elemental iron and 400 μg (0.4 mg) of folic acid.[5,7] If the known side effects of oral iron therapy are unacceptable or in populations wherein the prevalence of anaemia among pregnant women is <20%, WHO recommends an intermittent supplementation of 120 mg of elemental iron and 2.8 mg of folic acid once weekly.[7]

In high-income countries, routine iron supplementation for all pregnant women is not recommended; however, serum ferritin measurement is recommended at the beginning of pregnancy or at the booking visit. If serum ferritin is <30 ng/ml, 40–80 mg oral iron supplementation should be offered.[8]

Intravenous iron may be considered for the following:[5]

- Gestational age >14 weeks
- Lack of response or adherence: haemoglobin levels fail to increase adequately (<10 or 20 g/L within 2 or 4 weeks, respectively)
- Severe intolerance to conventional oral iron therapy
- Severe, or progressive anaemia (haemoglobin <80 g/L)
- Rapid correction of anaemia is required because of newly diagnosed anaemia beyond 34 weeks of gestation.

Such treatment should be administered only in settings where appropriate monitoring is available to allow prompt recognition and management of anaphylaxis.[7]

In severely anaemic patients with impaired erythropoiesis secondary to infection and/or inflammation who show an inadequate response to intravenous iron therapy, as well as in severely anaemic patients who refuse blood transfusion, the use of erythropoiesis-stimulating agents may be considered after consultation with a haematologist.[6]

Association of Maternal Anaemia with Severe Maternal and Foetal Morbidity

Treatment of anaemia during pregnancy is of paramount importance because anaemia is associated with severe morbidity. A meta-analysis by Jung *et al.* of over 4 million pregnancies found that maternal anaemia is associated with a significantly increased risk of postpartum anaemia (odds ratio [OR] 3.07, 95%, confidence interval [CI] 1.83–5.15), blood transfusion (OR 2.90, 95% CI 1.34–6.28), and caesarean delivery (CD) (OR 1.65, 95% CI 1.29–2.11).[9]

A systematic review of 46 studies by Glonegger *et al.* showed an association between the WHO definition of anaemia of 110 g/L with PPH, with an OR of 1.45 (CI 1.23–1.71), which increased to an OR of 2.88 (CI 3.38–6.02) for studies using lower anaemia thresholds.[10] In the systematic review and meta-analysis by Young *et al.*, the association between anaemia and PPH increased in a linear manner with increasing thresholds of anaemia with ORs of 1.84, 2.40, 4.02, and 6.15 for haemoglobin thresholds of 110, 100, 90, and 80 g/L, respectively.[11]

For the foetus and newborn, maternal anaemia—particularly iron deficiency—is associated with preterm birth, low birth weight, and reduced neonatal iron stores, which may persist beyond infancy.[9,11] Increasing evidence links prenatal iron deficiency and maternal anaemia to adverse long-term neurodevelopmental outcomes, including impaired cognitive performance, behavioural disorders, and a higher risk of autism spectrum disorders.[12]

Implementation and embedding just one component of PBM, the testing and treatment of anaemia during pregnancy, has the potential to dramatically reduce mortality worldwide. Low- and middle-income countries may avail themselves of the WHO's guidance on implementing PBM to improve global health status.

SECOND PILLAR: MINIMISING BLOOD LOSS AND BLEEDING

The second pillar of PBM deals with the intrapartum and immediate postpartum period, with the aim of decreasing obstetric blood loss and minimising exposure to allogeneic blood products while preserving optimal maternal and foetal outcomes. This pillar is central to the prevention and management of PPH, which remains a leading contributor to maternal morbidity and mortality worldwide.[13]

PPH complicates approximately 1%–10% of all deliveries, with substantial regional variation. A recent meta-analysis including more than 800 million women identified the most frequent causes of PPH as uterine atony (70.6%), genital tract trauma (16.9%), retained placenta (16.4%), abnormal placentation (3.9%), and coagulopathy (2.7%).[14] Despite structured antenatal risk assessment, the majority of PPH events occur unexpectedly, emphasising the importance of preparedness, early recognition, and protocol-driven response.[13,14]

Antenatal Risk Assessment and Preparedness

Several antepartum risk factors for PPH can be identified in advance, including the following:[13,14]

- Maternal anaemia
- Previous PPH
- Multiple pregnancy
- Foetal macrosomia
- Chorioamnionitis
- Pregnancy-induced hypertension
- Assisted reproductive technology use
- Prior caesarean delivery
- Placenta praevia
- Placenta accreta spectrum
- Coagulation disorders
- Antepartum haemorrhage

In women with identifiable risk factors, a systematic assessment of institutional readiness is essential. This should include evaluation of access to blood products, viscoelastic testing, cell salvage, interventional radiology, critical care support, and consideration of planned referral to a higher-level centre if appropriate. The incidence of placenta accreta spectrum has increased markedly since the 1950s and can often be detected on second-trimester ultrasound, supplemented by magnetic resonance imaging when required.[15] Routine blood reservation is not recommended in low-risk women; instead, group and screen are sufficient, with cross-matched blood reserved for those at increased risk.[16]

Intrapartum Risk Factors and the "Four Ts"

Intrapartum factors associated with PPH include prolonged second stage of labour, operative vaginal delivery, episiotomy, uterine inversion, and abnormal placentation. Clinically, the causes of PPH are classically categorised using the "Four Ts" framework: tone (uterine atony), trauma (genital tract or uterine injury), tissue (retained placental tissue), and thrombin (inherited or acquired coagulopathy). This pragmatic schema facilitates rapid diagnosis and targeted management.[13,14]

Prevention of Postpartum Haemorrhage

Prevention is a cornerstone of PBM. Recent consolidated international guidelines emphasise evidence-based obstetric practices to reduce blood loss.[7] During the second stage of labour, routine episiotomy is discouraged and spontaneous vaginal delivery is preferred, because instrumental delivery is associated with increased blood loss.[7] Active management of the third stage of labour includes controlled cord traction and administration of uterotonics. Oxytocin remains the first-line agent; intravenous oxytocin (5–10 IU administered as a slow bolus or infusion) is the reference standard for the prevention of postpartum haemorrhage, whereas intramuscular oxytocin (10 IU) is an effective alternative when intravenous access is not available or feasible.[7,17] Carbetocin (100 μg intravenous) offers the advantage of heat stability, whereas misoprostol (400–600 μg orally) is effective in low-resource settings and does not require intravenous access. Sustained uterine massage and prophylactic tranexamic acid are not recommended for routine prevention.[7,13]

Early Recognition and First-Line Treatment in Postpartum Haemorrhage

Early diagnosis is critical. Regular assessment of uterine tone and maternal haemodynamics, particularly during the first 2–3 h postpartum, is essential. Objective quantification of blood loss using calibrated drapes is superior to visual estimation.[13,14]

Prompt application of the E-MOTIVE bundle—early, massage, oxytocics, tranexamic acid, intravenous fluids, and examination/escalation—has been shown to reduce the incidence and severity of PPH.[18] Treatment should be triggered by clinical concern or measured blood loss ≥500 mL or ≥300 mL with abnormal clinical observations.[18]

Second-line uterotonics (ergometrine, misoprostol, or carboprost) may be used if bleeding persists despite first-line oxytocin therapy:[13,14,19]

- Ergometrine 200–500 μg intramuscular or slow intravenous (contraindicated in women with hypertensive disorders)
- Oxytocin-ergometrine fixed-dose combination (e.g., oxytocin 5 IU/ergometrine 0.5 mg intramuscular) in women without contraindications to ergometrine
- Misoprostol 800 μg (sublingual, per rectum, or intravaginal)

- Carboprost 250 μg intramuscular or intramyometrial (intravenous administration contraindicated); may be repeated every 15 min if required (maximum 8 doses; use with caution in women with asthma)

The choice of agent should be guided by the clinical context, contraindications, drug availability, and institutional protocols, with early escalation to additional medical, mechanical, or surgical interventions if bleeding persists.

Uterine massage, bimanual uterine compression, or external aortic compression may be used as temporising measures. Early administration of tranexamic acid (1 g intravenous), ideally within 3 h of birth, is recommended, with repeat dosing if bleeding continues.[7] In a subset analysis of the WOMAN trial, tranexamic acid did statistically reduce death caused by bleeding (155 [1.5%] of 10 036 patients versus 191 [1.9%] of 9985 patients in the placebo group, relative risk 0.81, 95% CI 0.65–1.00; p = 0.045).[20]

Supportive care is essential at this stage and includes maintenance of normothermia, acid–base balance, and calcium homeostasis.[21] Management should also focus on avoiding excessive crystalloid administration.

Management of Refractory Postpartum Haemorrhage

Approximately 10%–20% of women with PPH fail to respond to first-line measures. Management requires rapid escalation, including uterine balloon tamponade, interventional radiology (uterine or internal iliac artery embolisation), or surgical intervention when conservative measures fail. Timely decision-making is essential to avoid maternal deterioration.[7,13]

During PPH, distinguishing active from nonactive bleeding is critical when considering red blood cell (RBC) transfusion. In the acute phase, transfusion decisions should be based on measured or estimated blood loss, haemodynamic status, indicators of tissue hypoxia (e.g., lactate), haemoglobin or haematocrit levels, and the anticipated severity of haemorrhage.[7,19]

In PPH, viscoelastic testing (VET), including rotational thromboelastometry, thromboelastography, and Quantra (HemoSonics), enables early identification of coagulation abnormalities, supports individualised haemostatic management, and is associated with reduced blood product use and transfusion-related adverse events.[22] VET is indicated in moderate to severe postpartum haemorrhage when bleeding is ongoing or rapidly progressive, when coagulopathy is suspected, or when rapid haemostatic decision-making is required.[16]

Low fibrinogen levels detected by VET correlate with haemorrhage severity.[23] Because fibrinogen is essential for clot formation and declines early during major bleeding, it constitutes an important initial therapeutic target. A countrywide implementation of standardised PPH algorithm management that included measured blood loss and goal-directed fibrinogen and haemostasis management guided by VET was associated with a decrease in the use of blood products as fresh frozen plasma and RBCs and in the number of massive bleeds >2500 ml.[24]

In the absence of haemostatic testing and when bleeding persists or coagulopathy is suspected to be ongoing, some guidelines suggest that empirical administration of blood products, including plasma, RBCs, and platelets, may be considered.[13,16,21] Such approaches should be implemented through institution-specific transfusion protocols as part of standardised PPH emergency management bundles, adapted to local practice and resource availability. However, empirical transfusion strategies may expose patients to unnecessary plasma and platelet administration, with a risk of overtransfusion.[21]

To summarise, the second PBM pillar in obstetrics is founded on risk identification and preparedness, preventive obstetric strategies, early recognition with rapid bundle-based treatment, and structured escalation for refractory haemorrhage. Together, these measures reduce progression to severe PPH, limit transfusion requirements, and improve maternal outcomes.

THIRD PILLAR: OPTIMISING PHYSIOLOGICAL TOLERANCE OF ANAEMIA

Current guidelines recommend the use of restrictive RBC transfusion strategies when haemoglobin levels fall below 70 g/L in non–massive bleeding patients with symptoms of anaemia in the setting of haemorrhage.[6] However, the third pillar of PBM aims to move away from fixed transfusion thresholds and instead emphasises individualised assessment of transfusion requirements. This approach focuses on optimising the patient's physiological reserve and tolerance to anaemia, primarily by improving tissue oxygen delivery and reducing oxygen consumption.

Optimisation of Cardiac Output

Maintaining and improving adequate cardiac output is essential. Early optimisation of maternal haemodynamic stability, including the prompt use of vasopressors and the objective evaluation of volume status during the intraoperative and perioperative periods, is crucial to ensure adequate venous return and enhance cardiac output. This approach improves perfusion of vital organs while avoiding fluid overload, which is associated with dilutional coagulopathy.[25]

Optimisation of Arterial Oxygen Content

Adequate oxygen support may enhance tolerance to anaemia by optimising oxygen delivery. However, in contemporary practice, routine supplemental oxygen during elective caesarean delivery under spinal anaesthesia is not recommended in haemodynamically stable women; supplemental oxygen should be reserved for maternal desaturation or foetal distress or should be administered after delivery when clinically indicated.[26] In contrast, in the context of major obstetric haemorrhage or significant anaemia, maintaining adequate oxygenation remains essential. A target pulse oximetry saturation of 94%–98% should be achieved. In the postoperative period following major haemorrhage, maintaining oxygen supplementation and adjusting the fraction of inspired oxygen to achieve saturation targets enhance haemoglobin oxygen saturation and increase dissolved oxygen in plasma, thereby optimising arterial oxygen content and tissue oxygen delivery.[27]

Reduction of Oxygen Consumption

Preventing hypothermia is a key strategy, because hypothermia exacerbates coagulopathy. Shivering is a well-recognised complication following

caesarean delivery under regional anaesthesia, with a reported incidence of 29%–54%. It is associated with increased plasma catecholamine levels and results in a two- to threefold increase in metabolic rate and oxygen consumption.[28] Active warming measures—including thermal blankets, forced-air warming devices, and warmed intravenous fluids—should be initiated in the preoperative period and continued intraoperatively and postoperatively to achieve a body temperature >36°C.[29]

Caesarean delivery is also associated with high postoperative pain intensity, with a reported prevalence of up to 60%. The use of multimodal analgesia—including intrathecal opioids, nonsteroidal anti-inflammatory drugs, and acetaminophen—ensures optimal intraoperative and postoperative pain control. Effective analgesia reduces anxiety and pain, both of which are associated with significant increases in metabolic rate and oxygen consumption.[30]

Transfusion and Postpartum Anaemia Management

When transfusion is deemed necessary, a single unit of packed RBCs should be administered at a time, followed by reassessment to determine the need for additional transfusion. Iron supplementation should be initiated promptly, preferably via intravenous administration when feasible, or alternatively with oral iron therapy. Appropriate follow-up is essential to confirm correction of anaemia and ensure sustained maternal recovery.

SUMMARY

In obstetrics, where haemorrhage and anaemia continue to be leading contributors to maternal morbidity and mortality, PBM offers a structured approach to support improved clinical outcomes. Antenatal care offers an opportunity to implement the 3 pillars of PBM through early detection and treatment of anaemia, antenatal risk stratification, and protocol-driven interventions to minimise bleeding and transfusion. In parallel, optimisation of physiological tolerance to anaemia further supports maternal safety. Accumulating evidence supports an association between PBM-based strategies and reduced exposure to allogeneic blood transfusion, without compromising maternal or neonatal safety.

Authors' Contributions

All the authors participated to the conceptualisation, writing, review and editing of the manuscript.

Conflict of Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

REFERENCES

1. Leahy MF, Hofmann A, Towler S, et al. Improved outcomes and reduced costs associated with a health-system–wide patient blood management program: a retrospective observational study in four major adult tertiary-care hospitals. *Transfusion*. 2017;**57**(6):1347-1358.
2. Shander A, Hardy JF, Ozawa S, et al. A global definition of patient blood management. *Anesth Analg*. 2022;**135**(3):476-488.
3. World Health Organization. Global anaemia estimates. Geneva, Switzerland: World Health Organization; 2025.
4. Mégier C, Peoc'h K, Puy V, Cordier AG. Iron metabolism in normal and pathological pregnancies and fetal consequences. *Metabolites*. 2022;**12**(2):129.
5. Muñoz M, Peña-Rosas JP, Robinson S, et al. Patient blood management in obstetrics: management of anaemia and haematinic deficiencies in pregnancy and in the post-partum period: NATA consensus statement. *Transfus Med*. 2018;**28**(1):22-39.
6. Muñoz M, Stensballe J, Ducloy-Bouthors AS, et al. Patient blood management in obstetrics: prevention and treatment of postpartum haemorrhage. A NATA consensus statement. *Blood Transfus*. 2019;**17**(2):112-136.
7. World Health Organization. Consolidated guidelines for the prevention, diagnosis and treatment of postpartum haemorrhage. Geneva, Switzerland: World Health Organization; 2025.
8. Pavord S, Daru J, Prasannan N, Robinson S, Stanworth S, Girling J; BSH Committee. UK guidelines on the management of iron deficiency in pregnancy. *Br J Haematol*. 2020;**188**(6):819-830.
9. Jung J, Rahman MM, Rahman MS, et al. Effects of hemoglobin levels during pregnancy on adverse maternal and infant outcomes: a systematic review and meta-analysis. *Ann N Y Acad Sci*. 2019;**1450**(1):69-82.
10. Glonnegger H, Glenzer MM, Lancaster L, Barnes RF, von Drygalski A. Prepartum anemia and risk of postpartum hemorrhage: a meta-analysis and brief review. *Clin Appl Thromb Hemost*. 2023;**29**.
11. Young MF, Oaks BM, Tandon S, Martorell R, Dewey KG, Wendt AS. Maternal hemoglobin concentrations across pregnancy and maternal and child health: a systematic review and meta-analysis. *Ann N Y Acad Sci*. 2019;**1450**(1):47-68.
12. Wiegersma AM, Dalman C, Lee BK, Karlsson H, Gardner RM. Association of prenatal maternal anaemia with neurodevelopmental disorders in offspring: a population-based cohort study. *JAMA Psychiatry*. 2019;**76**(12):1294-1304.
13. Escobar MF, Nassar AH, Theron G, et al. FIGO recommendations on the management of postpartum hemorrhage 2022. *Int J Gynaecol Obstet*. 2022;**157**(Suppl 1):3-50.
14. Yunas I, Islam MA, Sindhu KN, et al. Causes of and risk factors for postpartum haemorrhage: a systematic review and meta-analysis. *Lancet*. 2025;**405**:1468-1480.
15. Einerson BD, Weiniger CF. Placenta accreta spectrum disorder: updates on anesthetic and surgical management strategies. *Int J Obstet Anesth*. 2021;**46**:102975.
16. Royal College of Obstetricians and Gynaecologists (RCOG). Blood transfusion in obstetrics. Green-top guideline no. 47. London: RCOG; 2015.
17. Heesen M, Carvalho B, Carvalho JCA, et al. International consensus statement on the use of uterotonic agents during caesarean section. *Anaesthesia*. 2019;**74**:1305-1319.
18. Mammoliti KM, Althabe F, Easter C, et al. When is postpartum haemorrhage treatment initiated? A nested observational study within the E-MOTIVE trial. *BJOG*. 2025;**132**:1664-1672.
19. Mavrides E, Allard S, Chandraharan E, et al.; Royal College of Obstetricians and Gynaecologists. Prevention and management of postpartum haemorrhage: Green-top Guideline No. 52. *BJOG*. 2017;**124**(5):e106-e149.
20. WOMAN Trial Collaborators. Effect of early tranexamic acid administration on mortality, hysterectomy, and other morbidities in women with post-partum haemorrhage (WOMAN): an international, randomised, double-blind, placebo-controlled trial. *Lancet*. 2017;**389**(10084):2105-2116.
21. Hofer S, Blaha J, Collins PW, et al. Haemostatic support in postpartum haemorrhage: a review of the literature and expert opinion. *Eur J Anaesthesiol*. 2023;**40**(1):29-38.
22. Snegovskikh D, Souza D, Walton Z, et al. Point-of-care viscoelastic testing improves the outcome of pregnancies complicated by severe postpartum hemorrhage. *J Clin Anesth*. 2018;**44**:50-56.

23. Collis RE, Collins PW. Haemostatic management of obstetric haemorrhage. *Anaesthesia*. 2015;**70**(Suppl 1):78-86.e27–e28.

24. Bell SF, Collis RE, Pallmann P, et al. Reduction in massive postpartum haemorrhage and red blood cell transfusion during a national quality improvement project, Obstetric Bleeding Strategy for Wales (OBS Cymru): an observational study. *BMC Pregnancy Childbirth*. 2021;**21**:377.

25. Zhou F, Liu N, Huang G, Yu H, Wang X. Fluid resuscitation strategy in patients with placenta previa accreta: a retrospective study. *Front Med (Lausanne)*. 2024;**11**:1454067.

26. Raghuraman N, Temming LA, Stout MJ, et al. Maternal oxygen supplementation compared with room air at delivery: a systematic review and meta-analysis of randomized controlled trials. *JAMA Netw Open*. 2021;**4**(1):e2034744.

27. Zampieri FG, Park M, Azevedo LCP, Amato MBP, Costa ELV. Effects of arterial oxygen tension and cardiac output on venous saturation: a mathematical modeling approach. *Clinics*. 2012;**67**(8):897-900.

28. Kumar K, Lin C, Symons T, Railton C. Narrative review on perioperative shivering during caesarean section under neuraxial anaesthesia. *Rom J Anaesth Intensive Care*. 2022;**29**(1):41-46.

29. Landau R, Sultan P. Neuraxial anesthesia and pain management for cesarean delivery. *Am J Obstet Gynecol*. 2026;**233**(6 Suppl):S135-S152.

30. Espinós Ramírez C, Roca Amatria G, Castellví Obiols P, et al. Assessing the experience and management of acute post-operative pain from caesarean delivery: a multi-centre cohort study. *J Clin Med*. 2025; **14**(13):4638.