

Perioperative Anaemia: When to Act, How to Treat, and Who Should Be Involved?

Maria Alejandra Echeto-Cerrato[†] and Suraphong Lorsomradee

[†]Correspondence email: echetof504@gmail.com

Abstract

Anaemia is a common and modifiable perioperative risk factor associated with increased transfusion requirements, complications, and mortality. Despite its high prevalence, it remains frequently underdiagnosed or identified too late for effective optimisation.

This narrative review provides a practical, evidence-based, and resource-adaptable framework for perioperative anaemia management, addressing when to screen, how to establish the underlying diagnosis, and how to initiate timely treatment. Particular emphasis is placed on achievable optimisation even in the short preoperative window, supported by emerging evidence demonstrating a rapid haemoglobin response to intravenous iron.

A structured diagnostic approach and pragmatic management algorithm are proposed to facilitate implementation across diverse healthcare settings, including low- and middle-income environments. By promoting a consistent and context-sensitive approach, this review aims to support broader adoption of patient blood management principles and ultimately improve perioperative outcomes globally.

Key words: anaemia, iron deficiency, perioperative care, ferric compounds, ferrous sulphate, erythropoietin

INTRODUCTION

Anaemia is a major global health concern, affecting approximately 1.92 billion people worldwide, with a disproportionate burden in low- and middle-income countries (LMICs), as consistently shown in large epidemiological studies.^{1,2} Beyond its global burden, accumulating perioperative and clinical evidence highlights the importance of early identification and management of anaemia, given its association with haemoglobin optimisation, transfusion exposure, and surgical outcomes.^{3–7}

In the perioperative setting, anaemia is common and consistently associated with adverse outcomes, including an increased likelihood of blood transfusion.^{2,8,9} Even mild preoperative anaemia has been linked to higher risks of postoperative infection, renal injury, cardiopulmonary complications, delayed recovery, and mortality.^{8,9} Importantly, anaemia often represents a modifiable risk factor when identified in a timely matter.

Despite strong evidence and multiple consensus guidelines supporting structured screening and treatment strategies, perioperative anaemia remains underdiagnosed and undertreated in routine clinical practice.^{3,10–13}

Standardised approaches to its detection and management are still lacking in many healthcare settings, and limited interdisciplinary coordination often reduces opportunities for effective optimisation across the surgical pathway.¹⁰ As a result, anaemia is frequently identified only at the preoperative assessment clinic, a few days before or on the day of surgery, when opportunities for meaningful optimisation are limited.

Patient blood management (PBM) provides a structured, patient-centred approach to optimise anaemia, reduce unnecessary transfusions, and improve surgical outcomes. Pillar 1, the optimisation of red cell mass, begins with the timely identification and treatment of anaemia. For PBM to be effective, clinicians need to recognise when to intervene, select appropriate diagnostic tests, and tailor management according to available resources. This review provides a practical, evidence-based overview of perioperative anaemia, including definitions, epidemiology, screening strategies, diagnostic approaches, and clinical algorithms. It aims to support a consistent, adaptable approach to anaemia management across healthcare systems with varying resource levels worldwide.

Maria Alejandra Echeto-Cerrato

Department of Anaesthesiology, Hospital del Valle and Hospital Quirúrgica Integral, Universidad Nacional Autónoma de Honduras en el Valle de Sula (UNAH-VS), San Pedro Sula, Honduras

Suraphong Lorsomradee

Faculty of Medicine, Chiang Mai University, Thailand, Asia Anesthesia Forum (AAF); Asian Society of Cardiothoracic Anesthesia (ASCA)

DEFINITION AND EPIDEMIOLOGY

Anaemia is defined by the World Health Organization (WHO) according to haemoglobin (Hb) thresholds: $<130 \text{ g}\cdot\text{L}^{-1}$ in adult men, $<120 \text{ g}\cdot\text{L}^{-1}$ in nonpregnant women, and $<110 \text{ g}\cdot\text{L}^{-1}$ during pregnancy.^{1,14} Although WHO haemoglobin thresholds remain sex-specific, perioperative evidence suggests that risk increases progressively as haemoglobin declines, even within the normal range, raising questions about whether current cutoffs are optimal and whether a unified threshold may be appropriate in selected settings.¹⁵ It is important to distinguish between the diagnostic definition of anaemia, which is based on WHO haemoglobin thresholds, and perioperative optimisation targets used within patient blood management (PBM) frameworks. While WHO criteria define anaemia, PBM strategies often aim for higher haemoglobin levels to improve physiological reserve and reduce perioperative risk.

Global Prevalence

Globally, the prevalence of anaemia is estimated at approximately 24.3%.¹ The burden is highest in low-resource settings, where nutritional deficiencies and chronic infections coexist with limited access to diagnostic testing. Iron deficiency is the leading cause of anaemia worldwide and is particularly relevant in the perioperative setting due to its strong association with surgical risk.⁷

Anaemia in Surgical Populations

Preoperative anaemia is present in 20–40% of surgical patients in high-income countries and 30–60% of patients in LMICs. Prevalence may be higher in urgent and emergent surgical settings, where delayed presentation and underlying conditions such as bleeding, malnutrition, and malignancy are more common, as reported across diverse clinical settings.^{2,7}

Clinical Impact

Large cohort studies have demonstrated that preoperative anaemia is independently associated with a 3–5-fold increase in transfusion, as well as higher rates of sepsis, acute kidney injury, major cardiac events, mortality, prolonged hospitalisation, and increased healthcare costs.^{2,8,9} (Figure 1) Even modest increases in haemoglobin prior to surgery have been associated with improved clinical outcomes.^{3,4,11,12}

PATHOPHYSIOLOGY AND COMMON AETIOLOGIES

Anaemia in the perioperative setting arises from disruption in one or more components of erythropoiesis, including iron availability, erythropoietin (EPO) production, bone marrow responsiveness, or ongoing blood loss (Figure 2). Understanding these mechanisms is crucial for recognising modifiable targets during preoperative optimisation.¹⁶

Iron Deficiency Anaemia

Iron deficiency anaemia (IDA) is the most common cause of anaemia worldwide and represents a key contributor to perioperative risk. Reduced iron stores may arise from chronic blood loss (such as gastrointestinal or gynaecological causes, or parasitic infections in low- and middle-income countries), increased physiological demands (including pregnancy or growth), inadequate intake or poor

bioavailability, and malabsorption (for example after gastric or bariatric surgery, or in inflammatory bowel disease). In IDA, impaired haemoglobin synthesis leads to characteristic findings such as microcytosis, low ferritin, reduced transferrin saturation (TSAT), and decreased reticulocyte haemoglobin. Importantly, iron deficiency—even in the absence of anaemia—may impair oxygen delivery and reduce perioperative resilience, potentially affecting recovery.¹⁶

Anaemia of Chronic Disease or Chronic Inflammation

Systemic inflammation increases hepcidin production, resulting in sequestration of iron within macrophages and reduced gastrointestinal absorption. In this context, ferritin levels may be normal or elevated, while TSAT is reduced.¹⁷ This results in functional iron deficiency, which limits erythropoiesis despite apparently adequate iron stores. This pattern is commonly observed in conditions associated with chronic inflammation, including malignancy, autoimmune disorders, chronic infections such as tuberculosis or human immunodeficiency virus, and chronic diseases such as heart failure or chronic obstructive pulmonary disease. It may also occur in postoperative or ongoing inflammatory states.

Chronic Kidney Disease

Anaemia in chronic kidney disease (CKD) arises from insufficient endogenous EPO production, reduced RBC lifespan, and functional iron deficiency due to chronic inflammation. CKD-related anaemia contributes significantly to perioperative morbidity, and these patients often require combined iron supplementation and erythropoiesis-stimulating agents (ESAs).¹⁸

Nutritional Deficiencies

Vitamin B12 and folate deficiencies (common in vegetarian or vegan diets, alcoholism, malabsorption, or after gastric or intestinal surgery) lead to impaired DNA synthesis and macrocytic anaemia. Mixed nutritional and iron deficiency is common in resource-limited settings.¹⁹

Perioperative Blood Loss and Iatrogenic Anaemia

Repeated phlebotomy, occult bleeding, and significant surgical haemorrhage reduce circulating red cell mass. Without timely replacement or optimisation, patients may enter surgery with reduced reserve. The cumulative effect of minor phlebotomy can be substantial in hospitalised or critically ill patients.²⁰

Multifactorial Causes in the Surgical Population

Most perioperative patients present with overlapping aetiologies—iron deficiency combined with inflammation, CKD, nutritional insufficiency, or malignancy. A structured diagnostic approach is essential for identifying the dominant contributor and guiding appropriate treatment.²¹

SCREENING AND DIAGNOSIS—WHEN TO ACT

When to Screen

Screening should ideally take place 4–8 weeks prior to major elective surgery, allowing sufficient time for diagnosis and optimisation.^{2,10} However, emerging evidence suggests that meaningful optimisation

Preoperative Anaemia

INDEPENDENT RISK FACTOR FOR:

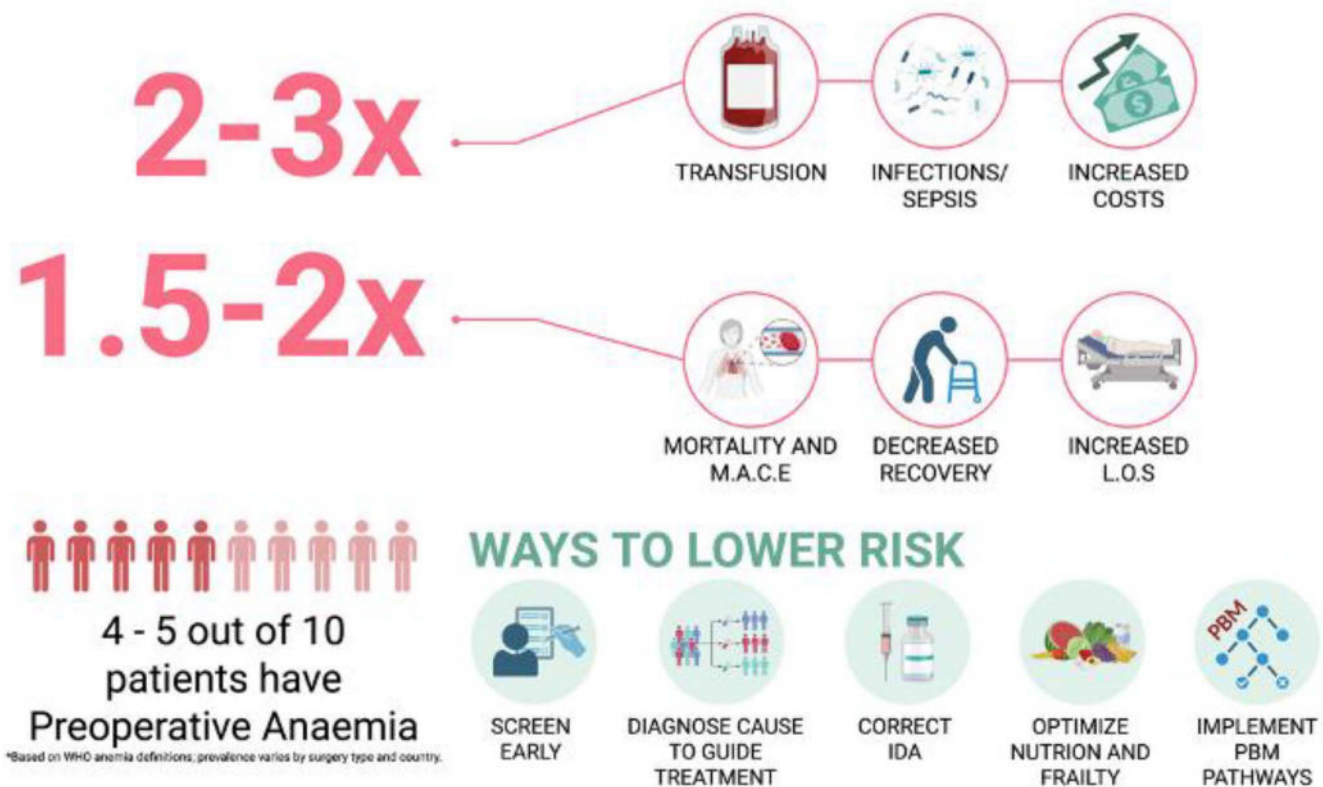


Figure 1 – Clinical impact of preoperative anaemia and the role of patient blood management

remains possible even when anaemia is diagnosed ≤ 2 weeks preoperatively, particularly with intravenous (IV) iron.³⁻⁵ Clinicians should resist abandoning optimisation solely because of a short preoperative period.

Recommended Screening Triggers

Screening for anaemia should be considered in patients undergoing major elective surgery or procedures with a significant risk of blood loss, particularly when expected blood loss exceeds 500 mL. Screening is also important in individuals with underlying conditions such as chronic kidney disease, heart failure, cancer, or chronic inflammatory states,² where anaemia is more likely and may be under-recognised. Additional groups who may benefit from screening include women of reproductive age, frail older adults, and patients at nutritional risk or with limited access to healthcare, as these factors can contribute to undiagnosed or untreated anaemia.^{1,7} Even in urgent or emergency surgical settings, early identification remains valuable for planning transfusion and PBM strategies.^{2,10,12}

Diagnostic Evaluation

A practical diagnostic approach to preoperative anaemia includes a set of key laboratory investigations that help identify the most common

underlying causes.^{2,22} This approach should be interpreted within a structured framework that distinguishes between core diagnostic tests, adjunct investigations, and pragmatic alternatives in resource-limited settings. Initial evaluation begins with haemoglobin (Hb) measurement to determine the presence of anaemia based on established international thresholds.^{14,23} Ferritin measurement is then used to assess iron stores. A ferritin concentration $< 30 \mu\text{g}\cdot\text{L}^{-1}$ is indicative of absolute iron deficiency; however, ferritin should not be interpreted in isolation, as it is an acute-phase reactant and may be elevated in the presence of inflammation. In this context, levels $< 100 \mu\text{g}\cdot\text{L}^{-1}$ may still suggest iron deficiency.^{2,5} Transferrin saturation (TSAT) provides an estimate of circulating iron available for erythropoiesis, and when interpreted alongside ferritin and inflammatory markers such as C-reactive protein (CRP), it supports differentiation between absolute and functional iron deficiency.^{5,17} Additional investigations may be considered to further define the underlying cause of anaemia. Reticulocyte haemoglobin (Ret-Hb) may provide early insight into iron-restricted erythropoiesis; however, its availability remains limited in many healthcare settings, and its use should be considered supplementary rather than essential.⁶ Assessment of renal function, using serum creatinine or estimated glomerular filtration rate (eGFR), helps identify anaemia related to CKD.¹⁸ Measurement of vitamin B12 and folate levels is important when nutritional deficiency is suspected.^{16,19}

Common Anaemia Etiologies in the Perioperative Patient

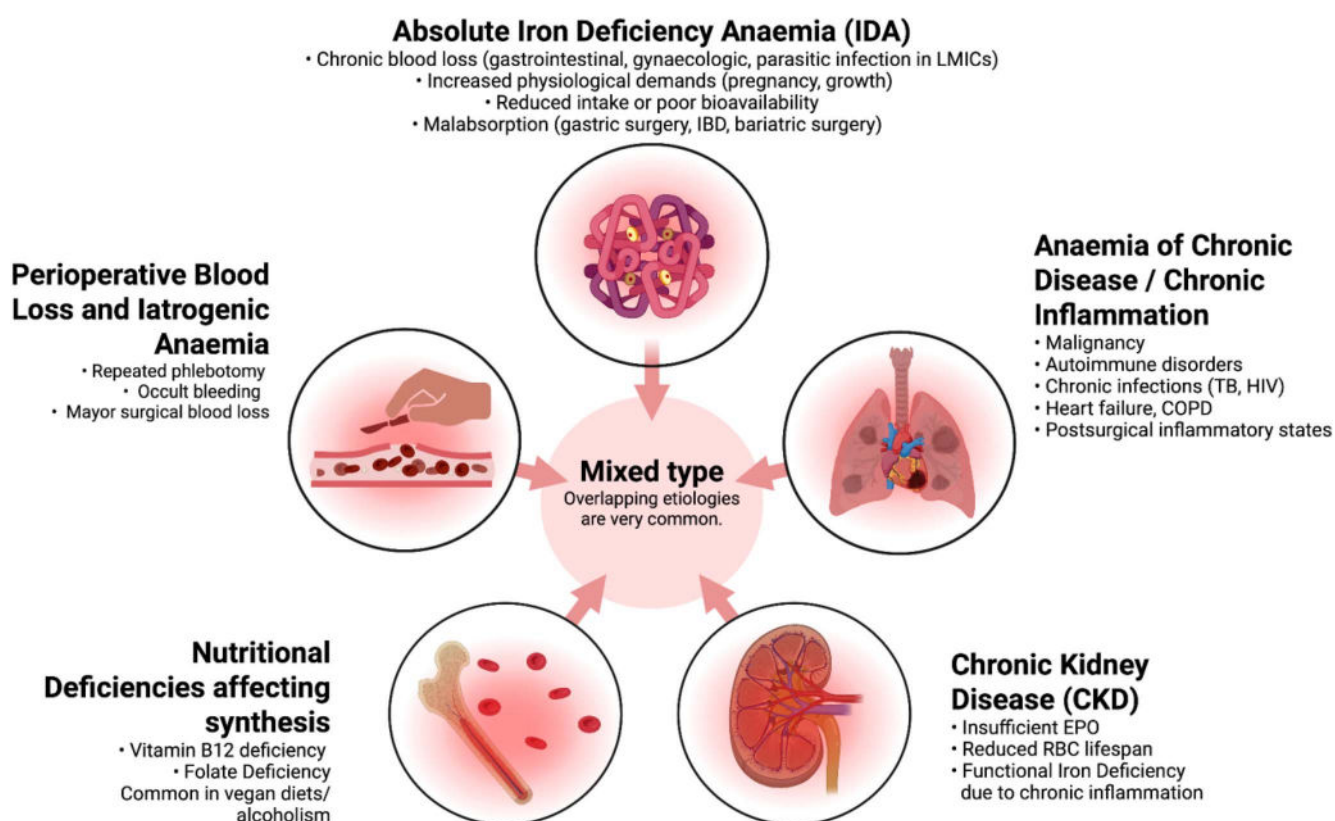


Figure 2 – Common aetiologies of preoperative anaemia. CKD, chronic kidney disease; COPD, chronic obstructive pulmonary disease; HIV, human immunodeficiency virus; IBD, inflammatory bowel disease; IDA, iron deficiency anaemia; LMICs, low- and middle-income countries; TB, tuberculosis

In clinical practice, interpretation of iron studies requires integration of laboratory values with clinical context, particularly in the presence of inflammation.²³ Absolute iron deficiency reflects depleted iron stores, typically with ferritin levels $<30 \mu\text{g}\cdot\text{L}^{-1}$, whereas functional iron deficiency is suggested by ferritin levels between $30\text{--}100 \mu\text{g}\cdot\text{L}^{-1}$ in combination with TSAT $<20\%$, reflecting impaired iron utilisation in inflammatory states.^{5,17} Anaemia of chronic disease is typically characterised by normal or elevated ferritin levels with impaired iron utilisation, whereas anaemia related to CKD is suggested by low haemoglobin in the context of impaired kidney function.¹⁸ From a practical perspective, core diagnostic tests include haemoglobin, ferritin, and TSAT, which are recommended in most clinical settings. Adjunct investigations, such as CRP and reticulocyte haemoglobin, may refine interpretation where available. In resource-limited environments, pragmatic approaches—such as haemoglobin-based screening combined with clinical assessment and empirical iron therapy—may be necessary when access to full laboratory panels is restricted. Recent perioperative and consensus-based literature emphasises that ferritin must be interpreted in the context of inflammation and that differentiation between absolute and functional iron deficiency is essential for guiding appropriate therapy. Diagnostic frameworks incorporating ferritin, transferrin saturation, CRP, and—where available—reticulocyte haemoglobin have been proposed.²

Certain patient groups may benefit from earlier investigation and more proactive optimisation strategies, including children and adolescents, pregnant or postpartum patients, individuals with cancer, and those undergoing major surgical procedures such as bariatric, gastrointestinal, or orthopaedic surgery.^{1,2,7,10,22} Additional high-risk populations include frail older adults and patients with limited physiological reserve, in whom anaemia may have a greater impact on outcomes.^{1,2,7}

ORAL IRON TREATMENT STRATEGIES

Oral iron supplementation remains a widely used and accessible option for the treatment of iron deficiency anaemia, particularly in settings where intravenous formulations are unavailable or contraindicated. It is most effective when there is sufficient time before surgery and adequate gastrointestinal absorption to support a gradual increase in haemoglobin.²⁴ In clinical practice, several formulations are available, including ferrous sulphate, ferrous gluconate, and ferrous fumarate, with ferrous sulphate being the most commonly prescribed due to its availability, low cost, and well-established efficacy (Figure 3).

In clinical practice, dosing strategies have evolved towards more flexible and patient-centred approaches. Rather than routine high-dose divided regimens, lower or alternate-day dosing may be used, as it can achieve comparable haemoglobin responses while

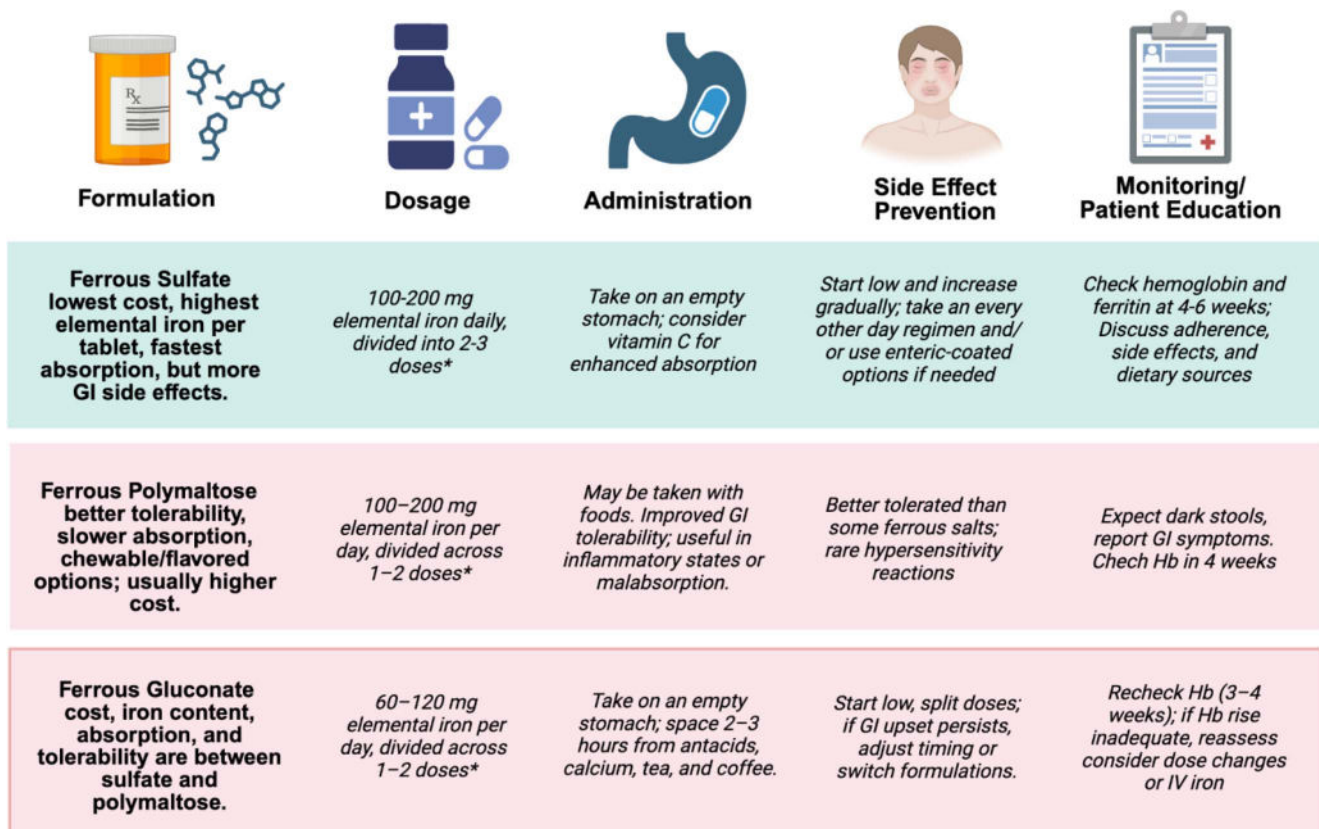


Figure 3 – Oral iron treatment strategies. *Exact content varies by brand; label-check recommended

improving gastrointestinal tolerability and adherence. Iron is traditionally taken on an empty stomach to optimise absorption; however, this should be balanced against patient tolerance, and administration with food may be appropriate when needed. The routine co-administration of vitamin C is not universally required and should not be considered essential.^{24,25}

Gastrointestinal side effects, including nausea, constipation, and abdominal discomfort, are common and may limit adherence. Strategies such as initiating treatment at a lower dose, using alternate-day dosing, or selecting better-tolerated formulations can improve tolerance and support continued therapy.^{26,27} Regular monitoring of haemoglobin and iron indices is recommended to assess response, with an increase in haemoglobin of approximately 10 g·L⁻¹ within 4 weeks generally indicating an adequate response to therapy.

Patient education remains a key component of successful therapy. Clear counselling on the importance of adherence, expected side effects, and dietary measures (including the intake of haem and non-haem iron sources) can improve treatment effectiveness and overall outcomes.

IV IRON TREATMENT STRATEGIES

IV iron plays a central role when rapid optimisation is required, particularly in late-presenting anaemia or when oral iron is ineffective or poorly tolerated.^{27–30}

Indications for IV Iron in the Perioperative Period

Intravenous iron should be considered in patients with limited time before surgery, particularly when time to surgery is less than 6 weeks (especially within 2–3 weeks) as well as in those with moderate to severe iron deficiency anaemia. It is also appropriate in the presence of functional iron deficiency related to inflammation, when oral iron is not tolerated, or absorption is impaired, or when adherence is unlikely. Intravenous iron is particularly beneficial in functional iron deficiency, where inflammation limits iron availability despite adequate stores, making oral iron less effective.^{17,27} Additional indications include patients with chronic kidney disease receiving erythropoiesis-stimulating agents and those with ongoing blood loss, such as from gastrointestinal or gynaecological sources.^{2,10,27}

Increasing evidence suggests that intravenous iron can produce clinically meaningful rises in haemoglobin within 7–14 days, even when anaemia is identified late in the preoperative period. This haematological response is consistently demonstrated in randomised controlled trials and systematic reviews; however, the impact on clinical outcomes, such as transfusion requirements, length of stay, or mortality, remains variable and appears to depend on patient population, timing, and surgical context.^{3,4,28,29}

Common IV Iron Regimens

The choice of intravenous iron regimen is influenced by factors such as availability, cost, and the total dose required. In clinical practice, commonly used options include ferric carboxymaltose,

Intravenous (IV) Iron Formulations



Formulations	Ferric carboxymaltose (Ferinject)	Iron sucrose (Venofer)	Ferric Derisomaltose (Monoferric/Monofer)
<p>Adult dosing (typical total per treatment course)</p>	1000 mg total per course (can be given as a single 1000 mg infusion or split into two 500 mg infusions)	1000 mg total per course. Commonly 200 mg/infusion, given every other day- days 1, 3, 5, 7, 9 for a total of 1000 mg over 1–2 weeks	Flexible high-dose regimen: 1000 mg per infusion, completed over 1–2 visits
<p>Maximum Single Dose (Adult)</p>	1000 mg	200 mg	1000 mg
<p>Pediatric dosing (mg/kg; and max per dose and treatment course)</p>	7.5-15 mg/kg per dose; max per dose 500-750 mg; infuse in 15-30 min FDA not approved - off label use common in clinical practice. Max per course 1000 mg (2 dose strategy common)	0.5-1 mg/kg per dose; max per dose 100-200 mg; infuse in 30-60 min FDA approved > 2 years. Up to ~1000 mg total per course (or up to 15 mg/kg, whichever limit is reached)	15 mg/kg per dose; max per dose 1000 mg; infuse in 20-30 min FDA not approved - off label use common in clinical practice. Up to 20 mg/kg total or max 1000 mg per course.
<p>Special Considerations</p>	Often no test dose required; monitor during/after infusion; rapid administration possible; suitable for rapid repletion	Test dose recommended in many guidelines; slower infusion (2–4 hours) with monitoring	Often no test dose required; monitor during/after infusion

Figure 4 – Intravenous (IV) iron formulations. All formulations can cause infusion reactions that are not histamine-mediated (frequency 1%–4%); true anaphylaxis with IV iron is exceedingly rare (<0.0005%). Dosing regimens vary by country or institution; always verify the current local labelling and consult the infusion protocol in your institution

which is typically administered as a single infusion of 500–1000 mg, and ferric derisomaltose, which allows for larger single doses of 1000–1500 mg. Iron sucrose remains widely used, although it requires smaller doses (usually 200 mg) given over multiple sessions, often on alternate days. In resource-limited settings, iron sucrose and older formulations remain effective options, despite the additional logistical challenges associated with multiple administrations. Most modern preparations permit full replacement dosing in a single visit, improving feasibility in low- and middle-income (LMIC) settings (Figure 4).^{28–30} This is particularly relevant where simplified dosing strategies can facilitate implementation and improve access to timely anaemia treatment.³¹

Expected Response

Intravenous iron therapy is associated with a predictable rise in haemoglobin of approximately 10–20 g·L⁻¹ within 2–4 weeks, with earlier changes often observed in markers such as reticulocyte haemoglobin and transferrin saturation within the first 7–10 days. Improvements in iron indices are consistently observed, and some studies report reductions in transfusion requirements; however, these effects are not uniform across all settings and appear to depend on patient population, timing, and surgical context. However, the impact on patient-centred outcomes, such as

mortality and length of hospital stay, remains variable across studies.^{28,29} Intravenous iron is generally well tolerated, and serious hypersensitivity reactions are uncommon with contemporary preparations, although adherence to local safety protocols during administration is recommended.²⁹ Overall, intravenous iron provides reliable haematological correction, but its translation into broader clinical benefit should be interpreted within the context of individual patient and surgical factors.

ERYTHROPOIESIS-STIMULATING AGENTS

Erythropoiesis-stimulating agents (ESAs) promote red blood cell production and may be particularly useful in patients whose anaemia is related to reduced endogenous erythropoietin production or when a rapid increase in haemoglobin is required before surgery. To be effective, ESAs should always be administered alongside iron therapy to ensure sufficient iron availability for erythropoiesis.^{2,32}

In clinical practice, ESAs may be considered in selected situations, including anaemia associated with chronic kidney disease, or in patients with moderate to severe anaemia when time to surgery is limited (for example, less than 2–3 weeks) and intravenous iron alone is unlikely to achieve an adequate haemoglobin increase. It is important to note that evidence supporting ESA use in the perioperative setting should be interpreted separately from data

Table 1 – Treatment Timeline and Dosing Examples for Preoperative Anaemia Optimisation

Time Frame	Treatment Options Strategies	Goal
Option A		
Day 0	IV iron (1000 mg of carboxymaltose) + EPO (40,000 UI)	Replenish iron stores and initiate erythropoiesis (fill the tank and start the engine).
Day 7	IV iron (1000 mg of carboxymaltose)* + EPO (40,000 UI)	Maintain erythropoietic drive and support ongoing Hb synthesis.
Day 14	EPO (40,000 UI)	Maximise Hb response ahead of surgery.
Day 21	Recheck CBC	Ensure target Hb achieved ($\geq 120 \text{ g}\cdot\text{L}^{-1}$) before surgery.
Option B		
Day 0	IV iron (500 or 1000 mg of carboxymaltose)**	Replenish iron stores and initiate Hb recovery.
Day 7	IV iron (1000 mg of carboxymaltose)	Assess response and reinforce iron availability if needed.
Day 14	Recheck CBC	Confirm adequate Hb target ($\geq 120 \text{ g}\cdot\text{L}^{-1}$) prior to surgery.
Option C		
Day before surgery	IV iron (1000 mg of carboxymaltose)* + EPO (40,000 UI)	Provide rescue stimulation of erythropoiesis to support perioperative Hb recovery and reduce transfusion exposure in patients with insufficient time for standard optimisation.

CBC, complete blood count; EPO, erythropoietin; Hb, haemoglobin; IV, intravenous

* Always ensure the total iron dose does not exceed the patient's calculated needs to avoid iron overload

** Dose will depend on body weight and anaemia severity

derived from critically ill or ICU populations, as these contexts differ in underlying physiology and treatment goals. They may also be appropriate in oncology patients with inflammation-related anaemia, with careful consideration of risks, as well as in individuals who decline blood transfusion, such as Jehovah's Witnesses. In addition, ESAs can be beneficial in chronic inflammatory conditions where functional iron deficiency contributes to impaired red cell production.^{2,27,33} In this context, ESA use in the perioperative setting should be individualised and guided by surgical context rather than extrapolated from non-surgical populations.

Dosing Considerations for Erythropoiesis-Stimulating Agents

The choice of an ESA is mainly governed by the time available before the procedure and local supply issues. In general terms, short-acting agents such as epoetin alfa can be given weekly and offer advantages in cases where surgery is expected in a matter of weeks. The dose can be readily adjusted. Agents such as darbepoetin can be given 1–2 weeks apart and offer a reduced administration burden. Ultra-long-acting agents such as methoxy polyethylene glycol-epoetin beta (CERA) can be given monthly and might be useful in patients with CKD or in cases where optimisation of Hb is required over a longer period. These approaches reflect commonly used clinical regimens described in perioperative anaemia management guidelines, although specific protocols may vary across institutions and should be adapted to local practice.³³

Timeline Example

In the perioperative setting, haemoglobin targets are guided by optimisation strategies rather than diagnostic thresholds alone. Within PBM frameworks, haemoglobin levels of $\geq 120 \text{ g}\cdot\text{L}^{-1}$ are often targeted, depending on the clinical context, to reduce

transfusion requirements and support better outcomes. In a patient who is awaiting elective surgery in 3 weeks, with a Hb level of $80 \text{ g}\cdot\text{L}^{-1}$ and a target Hb of $120 \text{ g}\cdot\text{L}^{-1}$, a timeline as presented in Table 1 (option A), illustrates an example framework that may be adapted according to local resources, patient characteristics, and institutional protocols. In most cases, FCM may be given in a first dose, with a second dose given in a further 1-week interval if the calculated iron deficit is not completely corrected. In mild cases of anaemia as presented in Table 1 (option B), or in patients with lower body weights, a 500-mg dose may be adequate, while a further 1000 mg may be needed if the patient presents with more severe forms of anaemia, with Hb levels lower than $90 \text{ g}\cdot\text{L}^{-1}$, or if the calculated iron deficit using the Ganzoni formula is not met. In all cases, total iron given must be matched with iron deficit calculated in each patient to avoid iron overload.

In situations where surgery is imminent and there is insufficient time for standard optimisation, a “rescue” haematopoiesis approach³⁴ may be considered such as the one in Table 1 (option C). This approach combines intravenous iron and an erythropoiesis-stimulating agent administered within 24 hours before surgery to enhance early erythropoietic activity. While preoperative haemoglobin changes may be minimal, this strategy may improve postoperative haemoglobin recovery and reduce transfusion exposure in selected high-risk patients.³⁴ Table 1 is intended as an illustrative example rather than a prescriptive protocol, and dosing strategies should be individualised based on clinical context and local practice.

Risks and Considerations

The use of erythropoiesis-stimulating agents (ESAs) requires careful consideration of safety and patient selection, as potential risks—including thromboembolic complications—may arise, particularly

when haemoglobin increases rapidly or in patients with underlying risk factors. For this reason, most guidelines recommend conservative haemoglobin targets, typically below 120–130 g·L⁻¹ depending on the clinical context. In oncology patients, ESAs should be used with caution due to historical safety concerns and regulatory warnings, although short perioperative courses may be considered selectively to reduce transfusion requirements.

To optimise effectiveness, ESAs should always be administered in combination with intravenous iron therapy, as functional iron deficiency may significantly blunt the erythropoietic response.^{32,33} In selected surgical settings, short-course ESA combined with intravenous iron has been associated with reduced exposure to transfusion in selected settings; however, this approach requires careful individualised assessment of risks and benefits.

MULTIDISCIPLINARY ROLES

The management of anaemia, particularly in the perioperative setting, requires a collaborative, multidisciplinary approach. Each member of the healthcare team plays a critical role in optimising patient outcomes.

Surgeons

Surgeons play a crucial role in detecting and managing anaemia in patients. They should proactively screen for and diagnose anaemia before surgery. Staying current with available treatment options for anaemia, coordination with the operating team, as well as management strategies are critical. Additional responsibilities include patient education, monitoring, follow-up, and contributing to the development of standardised guidelines for safe, efficient care.

Anaesthesiologists

Anaesthesiologists must treat perioperative anaemia as a major driver of anaesthesia planning and patient safety. They should support anaemia clinics and PBM pathways throughout the perioperative period providing support and access to necessary tools, such as viscoelastic tests (VET), cell savers, and antifibrinolytics. Anaesthesiologists also must adhere to restrictive, goal-oriented transfusion strategies based on preoperative Hb and daily assessments in postoperative care. This proactive approach enhances patient safety and surgical outcomes for anaemic patients.³⁵

Physicians and Haematologists, Nurses, and Pharmacists

Haematologists and other physicians can identify the causes of anaemia and tailor treatment—for example, iron therapy or ESAs—based on each patient's needs. Nurses educate patients, administer treatments, monitor for complications, and assist in communication to ensure the management plan is clear to everyone. Pharmacists provide information about the availability of iron drugs and educate the patient on how to take these drugs and their side effects.

Hospital and Institutional Leaders or PBM Champions

Institutional leaders play a vital role in developing and sustaining protocols for early identification and managing anaemia within their respective institutions.

By encouraging a team-based approach, institutional leaders and/or PBM champions can unite all healthcare professionals and enhance the quality of care for patients with anaemia, ultimately improving surgical outcomes and reducing complications.

ANAEMIA TREATMENT PATHWAYS ACROSS RESOURCE SETTINGS

Global perioperative practice varies widely, and anaemia management pathways must be adapted to local realities. While the challenges differ across high-, middle-, and low-resource settings, effective implementation of patient blood management (PBM) strategies is achievable in all environments through context-specific approaches. International consensus statements and PBM guidance consistently support the development of resource-adapted pathways that align with local infrastructure and clinical capacity.^{2,12,13,31} These recommendations are intended as pragmatic, context-dependent strategies and should be adapted according to local epidemiology, resource availability, healthcare infrastructure, and surgical urgency.

In high-resource settings, perioperative care is typically supported by near-universal access to comprehensive diagnostic testing, including ferritin, transferrin saturation, C-reactive protein, and reticulocyte haemoglobin. Intravenous iron formulations that allow single-dose repletion are widely available, and electronic health systems facilitate early identification of anaemia through automated screening triggers. These settings often benefit from established multidisciplinary PBM programmes integrated into routine clinical practice. As a result, where resources allow, pathways commonly emphasise systematic screening 4–8 weeks before surgery, early initiation of intravenous iron in late presenters, and selective use of erythropoiesis-stimulating agents in patients with chronic kidney disease, complex oncology conditions, or major cardiac surgery. Standardised algorithms are frequently embedded within preoperative assessment clinics, enabling consistent and timely optimisation, although implementation may vary depending on local resources and healthcare infrastructure.^{28,33}

In middle-resource settings, implementation is often challenged by limited time for preoperative assessment, variable availability of intravenous iron formulations, and fragmented communication between surgical, anaesthesia, and medical teams. Delayed referral for anaemia evaluation further contributes to suboptimal optimisation. In these contexts, pragmatic strategies can significantly improve care. A simplified diagnostic panel—typically haemoglobin, ferritin, and transferrin saturation, with or without C-reactive protein—can provide sufficient information for decision-making. Where available, cost-effective IV iron strategies (such as iron sucrose protocols) may be prioritised, and anaesthesia-led PBM initiatives can help bridge gaps in coordination. Integrating anaemia assessment into existing preoperative pathways and using simple, widely accessible clinical algorithms can enhance consistency and uptake across different levels of care.^{31,33}

In low-resource settings, including many low- and middle-income countries and rural facilities, the challenges are more pronounced. Access to laboratory testing such as ferritin or transferrin saturation

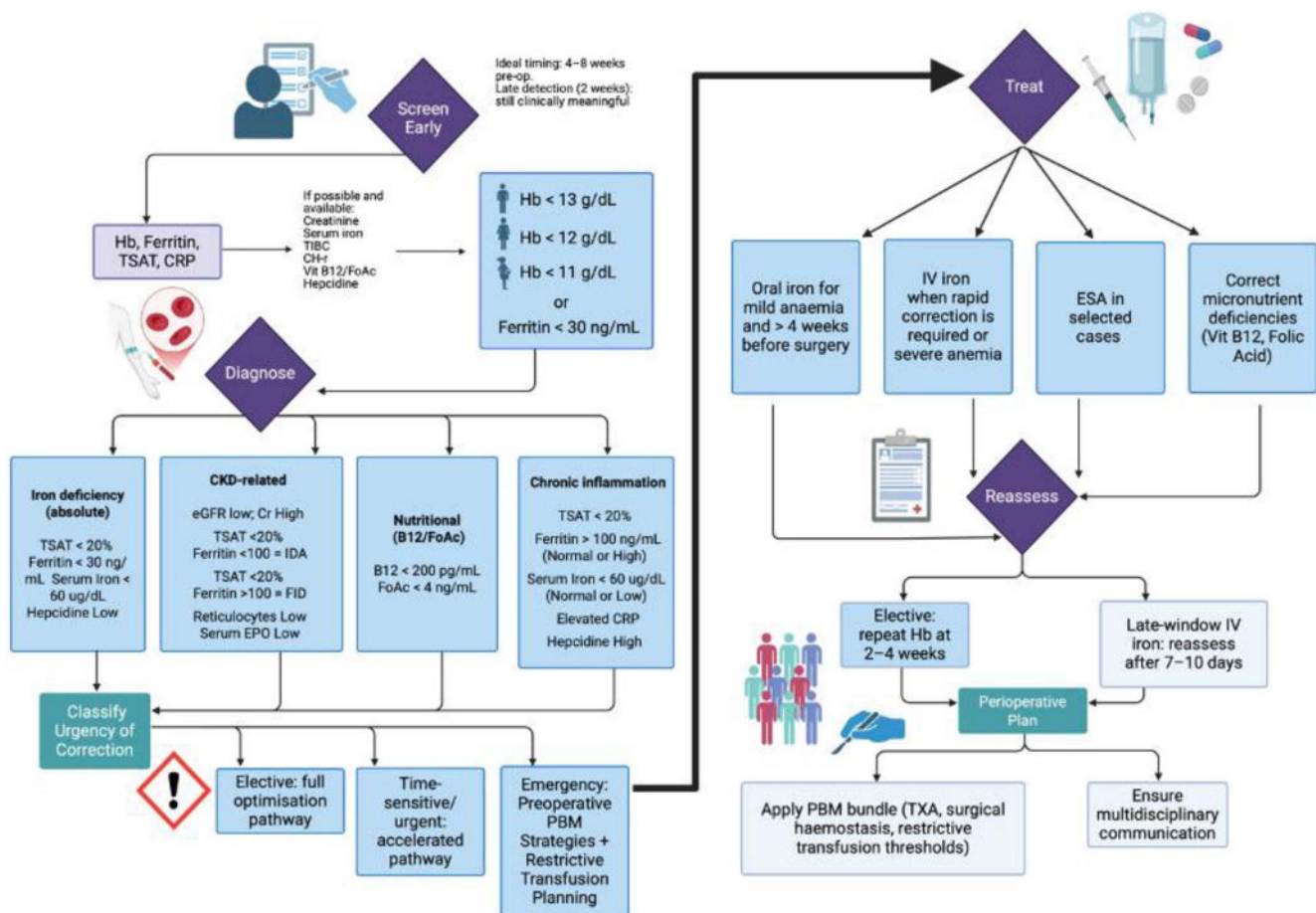


Figure 5 – Practical 6-step framework for perioperative anaemia care. CKD, chronic kidney disease; CRP, C-reactive protein; eGFR, estimated glomerular filtration rate; ESA, erythropoiesis-stimulating agent; Hb, haemoglobin; IV, intravenous; PBM, patient blood management; TSAT, transferrin saturation; TXA, tranexamic acid

is often limited or absent, and intravenous iron may be unavailable or inconsistently supplied. These constraints are compounded by a high prevalence of nutritional deficiencies, parasitic infections, and chronic inflammatory conditions, as well as shorter preoperative windows due to delayed presentation. Despite these limitations, feasible and impactful strategies exist. Haemoglobin measurement alone can serve as an initial trigger for treatment, with point-of-care or capillary devices offering practical solutions. Empirical iron therapy—either oral or intravenous where available—may be initiated when confirmatory testing is not feasible. Empirical treatment of suspected nutritional deficiencies (e.g., vitamin B12 or folate) may be appropriate when diagnostic confirmation is not feasible. Addressing underlying causes, such as parasitic infections or malnutrition, is essential, and community-based optimisation programmes may be considered based on local epidemiology and help prepare patients scheduled for elective surgery. Strengthening postoperative anaemia management pathways is equally important to prevent recurrence and improve long-term outcomes.^{1,31}

Across all settings, overcoming system-level barriers is critical for sustainable implementation. Training nurses and general clinicians in PBM principles, developing low-cost local guidelines aligned with international standards, and disseminating simplified algorithms

within surgical and perioperative areas can facilitate broader adoption. In addition, advocating for the procurement of intravenous iron as a cost-effective alternative to transfusion represents an important strategy for improving both clinical outcomes and resource utilisation.^{31,33}

Perioperative anaemia pathways should be designed in accordance with the availability of healthcare resources, without compromising the fundamental principles of patient blood management (PBM). In a high-resource setting, a comprehensive PBM pathway may be implemented, which includes extensive iron assessment and treatment with a single-dose IV iron, with or without ESAs, when indicated. In a middle-resource setting, a modified PBM pathway may be adopted by anaesthesia teams, which includes a minimum iron assessment panel consisting of haemoglobin (Hb), ferritin, TSAT, and where available C-reactive protein, along with iron sucrose protocols and selective ESA use, as a treatment strategy for patients with perioperative anaemia. In a low-resource setting, pragmatic approaches of PBM, such as early Hb screening, empirical iron therapy and nutritional support may result in a worthwhile optimisation. These resource-adapted strategies demonstrate that effective perioperative anaemia management is feasible across diverse healthcare environments when guided by key PBM

principles.^{2,13,31,35} Implementation of these strategies should be guided by local health system capacity and prioritised according to feasibility and clinical impact.

PRACTICAL CLINICAL PRACTICE FLOWCHART

A practical 6-step algorithm for the optimisation of perioperative anaemia management is shown (Figure 5). It provides a structured approach to clinical decision-making, guiding clinicians through sequential steps that include initial screening, etiological assessment, urgency classification, targeted treatment, and reassessment, with integration into a PBM-centred perioperative plan. Screening is ideally undertaken 4–8 weeks before surgery; however, even when anaemia is identified as late as 2 weeks preoperatively, meaningful optimisation may still be achieved. Treatment selection should be guided by the severity of anaemia and the time available before surgery, followed by reassessment and implementation of appropriate PBM strategies to support perioperative care.

SUMMARY

Anaemia is a common and highly modifiable risk factor in the perioperative period, closely linked to increased morbidity, transfusion needs, and mortality. Routine screening should ideally occur 4–8 weeks before surgery, but even late preoperative identification—within 2 weeks—can still be clinically meaningful and may allow optimisation. Using a minimal diagnostic panel that includes Hb, ferritin, TSAT, and CRP allows for accurate identification of most anaemia causes, including in settings with limited resources. Implementing a structured, stepwise pathway from screening to treatment enhances patient outcomes and supports global PBM efforts. Ensuring safe perioperative care for anaemic patients requires collaborative, multidisciplinary communication among healthcare teams.

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