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REVIEW

Blood transfusion in older surgical patients: the only option or is there a better approach?

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Abstract

Anemia is a common clinical condition that can significantly affect patient outcomes, particularly in those undergoing surgery. In older adults, the presence of anemia combined with cardiovascular disease can increase surgical morbidity and mortality, influencing surgical decisions and creating a cascade of complications that may negatively impact recovery. Blood transfusion remains the primary response to anemia in the perioperative setting, despite evidence suggesting potential adverse effects on survival and recovery. However, older adults present unique challenges due to age-related physiological changes anda reduced tolerance to anemia and blood loss. The debate between restrictive and liberal blood transfusion strategies in this population remains unresolved. Patient Blood Management (PBM) protocols have been developed to systematically address perioperative anemia. This review emphasizes the need for a nuanced approach to transfusion in older adults, suggesting that while a restrictive strategy may not be universally applicable, decisions should be guided by thorough clinical evaluations. These assessments should prioritize not only hemoglobin levels but also patient-specific factors, including life expectancy, comorbidities, and patient preferences, with the involvement of a multidisciplinary team to tailor the best approach for everyone.

Keywords Anemia · Perioperative care · Blood transfusion · Patient blood management · Geriatrics

Introduction

Anemia is an increasingly prevalent issue, with data showing a rise in its occurrence from 4.0 to 7.1%, and moderate to severe cases nearly doubling from 1.0 to 1.9% between 2003 and 2004 and 2011–2012 [1]. In older adults, anemia is associated with higher rates of hospitalization [2] and has a detrimental impact on quality of life, contributing to a substantial social and economic burden due to increased healthcare needs and costs [3]. The condition is also particularly common in the surgical population, with a prevalence rate of approximately 47% among older adults, especially those undergoing colorectal surgeries or hip and knee arthroplasty, showing significant gender disparities [4, 5]. Even mild anemia can negatively impact the mortality in older adults.

Given the limited availability of blood resources and the potential complications associated with transfusions, conservative or restrictive transfusion strategies are recommended in perioperative management [6, 7]. However, there is a lack of robust evidence supporting specific hemoglobin thresholds, particularly in frail older patients who are more prone to adverse outcomes due to diminished physiological

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reserves. Current guidelines often rely on reference values, but these may not adequately address their unique needs of this vulnerable population.

The aim of this review is to examine the key studies on patient blood management (PBM), emphasizing the importance of individualized clinical judgment rather than strict adherence to hemoglobin cut-offs. In elective surgeries involving anemic patients, early identification of the underlying causes of anemia is crucial. This should involve timely diagnostic evaluations and preventive measures to reduce perioperative and postoperative blood loss. Strategies such as nutritional supplementation and the implementation of a comprehensive, interdisciplinary approach to the management of older adults are recommended. The Orthogeriatric care model serves as an effective framework, integrating multidisciplinary expertise in the management of fragility fractures and related surgical challenges [8].

Methodology

This narrative review employed a comprehensive narrative synthesis approach to evaluate the current evidence on anemia management, transfusion strategies, and perioperative blood conservation in older surgical patients. A search was conducted using PubMed, Scopus, Web of Science, and the Cochrane Library, covering publications from 2000 to 2024. Key search terms included "anemia management," "blood transfusion," "older patients", "geriatric patients", "elderly patients", and "patient blood management". Studies were included if they focused on adults aged 60 and above undergoing surgery and reported on outcomes related to anemia management, transfusion strategies, or blood conservation techniques, excluding pediatric studies, non-surgical populations, and case reports. Data extraction was performed by two independent reviewers, focusing on study design, patient demographics, interventions, and outcomes such as mortality, morbidity, and transfusion rates. Given the heterogeneity of studies, a narrative synthesis was applied to highlight the impact of anemia on surgical outcomes, the efficacy of restrictive versus liberal transfusion strategies, and the role of patient blood management, along with alternative pharmacological and non-pharmacological interventions to reduce perioperative blood loss.

Anemia in aging: clinical implications and management strategies

Anemia is characterized by a reduction in the normal number of RBCs due to factors such as underproduction, increased loss, or destruction of RBCs, and a decrease in the quantity of hemoglobin (Hgb) in the blood. This leads to a diminished oxygen-carrying capacity [9]. In older adults, untreated anemia can trigger a cascade of adverse effects across multiple systems, impacting cardiac function, exercise tolerance, cognitive function, perceived quality of life, immune response, and increasing morbidity, hospitalization duration, and mortality rates [10–16].

The World Health Organization (WHO) defines anemia as a hemoglobin concentration below 13 g/dL in adult men and below 12 g/dL in non-pregnant women. However, this definition is often criticized for older populations, as it is derived from statistical distributions of healthy younger individuals [17]. Advanced age brings significant physiological and pathophysiological variability, meaning that hemoglobin thresholds may not adequately reflect the clinical impact of anemia in older adults. Regardless of these cutoffs, the clinical presentation can vary significantly in this population.

The primary causes of anemia in older adults include iron deficiency, vitamin B12 deficiency, renal insufficiency, and chronic inflammation. Additionally, there is growing recognition of "unexplained anemia of the elderly" (UAE), which encompasses cases where no clear etiology can be identified [18, 19]. In cases of myelodysplasia, red blood cells often present as macrocytic, with potential abnormalities in white blood cells or platelets observed in a peripheral blood smear. Bone marrow examination, including cytogenetic studies, may be necessary for accurate diagnosis. Some patients with myelodysplastic syndrome (MDS) may present solely with anemia, which may overlap with features of UAE before a definitive diagnosis is made [20]. Figure 1 highlights the primary causes of anemia in older adults, emphasizing the multifactorial nature of the condition.

Plasma iron levels are tightly regulated to ensure a daily supply of approximately 20 mg to the bone marrow for hemoglobin synthesis in erythroid precursors and mature red blood cells [21]. UAE is now recognized as a distinct condition among older adults with anemia who do not meet the criteria for other forms of anemia. It is characterized by hypoproliferative normocytic anemia that is not attributed to nutritional deficiencies, chronic kidney disease, or inflammatory conditions, with a blunted erythropoietin response (Fig. 1) [22]. A thorough assessment of an individual's medical history is crucial in identifying UAE, as several conditions not traditionally linked to inflammation (e.g., hypothyroidism) can be associated with anemia [23].

Several age-related physiological changes contribute to reduced red blood cell production or shortened lifespan of RBCs. These changes include reduced bone marrow cellularity, decreased erythroid colony-forming units, elevated inflammatory markers that reduce erythropoietin (EPO) sensitivity, and a maturational shift towards the myeloid lineage, increasing the risk of myeloid pathologies [20]. The

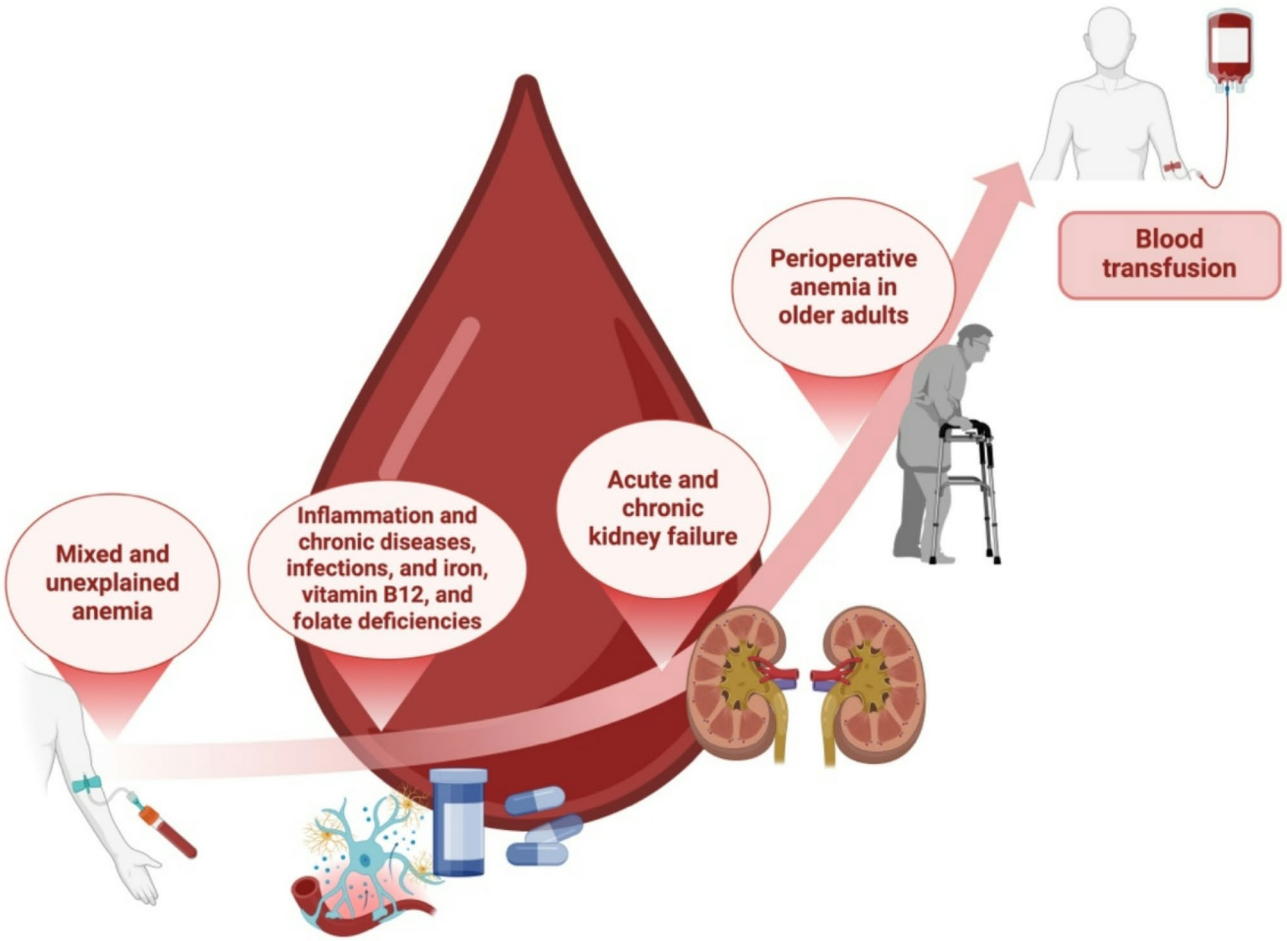

Fig. 1 Anemia in older adults. This infographic illustrates the multifactorial aspects of perioperative anemia in aging patients, emphasizing its association with blood transfusion requirements. This figure underscores the importance of comprehensive anemia management in improving perioperative outcomes for older adults

prevalence of anemia among individuals older than 80 years ranges between 28 and 50% [24–26].

The consequences of anemia in older adults include functional and cognitive decline, increased risk of falls, hospitalization, iatrogenic complications such as delirium, postoperative complications, mortality, and cardiovascular instability [2, 10, 27]. Notably, even mild anemia (i.e., hemoglobin levels no lower than 10 g/dL) can result in reduced physical performance, higher rates of falls, increased frailty, impaired cognitive function, and greater mortality risk [26]. This highlights the importance of early detection and proactive management of anemia in the aging population to mitigate its systemic impact.

Anemia and blood transfusion in older surgical patients

Approximately 30.1% of adult elective inpatient surgery patients across 27 countries present with preoperative anemia [28]. Older age is an independent risk factor for increased perioperative morbidity, mortality, and greater healthcare resource utilization [29]. Furthermore, older adults are particularly susceptible to postoperative cognitive dysfunction, with an incidence of 40–60% following major cardiac, vascular, and orthopedic surgeries, often due to hypoxia [30].

Preoperative anemia may be linked to underlying chronic conditions, while perioperative anemia may result from acute hemorrhage, chronic blood loss, chronic inflammation, or treatments such as chemotherapy and radiotherapy [31]. Acute hemorrhage is particularly common in emergency surgeries, such as those involving ruptured abdominal aortic aneurysms or trauma, while chronic blood loss often arises from gastrointestinal or urologic procedures.

Etiology and management of perioperative anemia

Perioperative anemia is a multifactorial condition that significantly influences surgical outcomes, particularly in older patients. Chemotherapeutic agents often contribute to anemia due to their myelosuppressive effects, which impair bone marrow hematopoiesis and reduce the production of RBCs. Additionally, these agents can have cytotoxic effects on the kidneys, diminishing EPO production, which is critical for stimulating RBC synthesis [32]. Similarly, radiotherapy can further compromise bone marrow reserves, particularly in patients undergoing pelvic or abdominal irradiation, leading to a sustained decline in hematopoietic function.

Intraoperative factors, such as acute normovolemic hemodilution (ANH)—a blood conservation technique involving the withdrawal of the patient's blood and simultaneous fluid replacement—can also lead to anemia, especially if not properly managed. This is often compounded by the infusion of priming solutions during cardiopulmonary bypass, which dilutes the blood, thereby lowering hemoglobin concentration [31].

Preoperative anemia is recognized as an independent predictor of increased perioperative mortality and poor outcomes [33]. Therefore, timely identification and correction of anemia before surgery is critical to optimize patient outcomes. Routine preoperative blood tests are essential for diagnosing anemia early. When anemia is identified, the underlying cause must be addressed—this includes correcting iron deficiency, supplementing vitamins B12 and folate, managing chronic kidney disease, and controlling chronic inflammatory conditions that may impair erythropoiesis. Nutritional interventions, such as iron supplementation or intravenous iron in cases of severe deficiency, can help improve hemoglobin levels and reduce the need for perioperative transfusions.

In cases where anemia is detected in patients scheduled for surgeries with expected significant blood loss (e.g., major orthopedic or cardiac procedures), postponing elective surgery may be necessary to allow for adequate anemia correction. This approach provides time for interventions like erythropoiesis-stimulating agents or iron supplementation to enhance red cell mass [26, 34]. Additionally, a multidisciplinary team approach involving surgeons, anesthesiologists, and hematologists can be instrumental in developing tailored strategies to optimize the patient's hematologic status before surgery, thereby reducing perioperative risks and improving recovery.

Optimization strategies: patient blood management

In elective orthopedic surgery patients, the Network for Advancement of Transfusion Alternatives (NATA) recommends measuring hemoglobin at least 28 days prior to surgery, alongside evaluations of iron status, renal function, and levels of vitamin B12 and folate [6, 35]. Preoperative management should focus on addressing iron deficiency, which includes assessing serum iron, transferrin saturation, and ferritin levels. Early intervention (2–4 weeks before major surgery) with intravenous (i.v.) iron can significantly improve hemoglobin concentrations and reduce the need for perioperative blood transfusions [36].

For patients at high risk of severe anemia, especially those undergoing orthopedic surgeries, short-term treatment with i.v. iron formulations like ferric carboxymaltose, is recommended due to its efficacy, safety, and cost-effectiveness [37]. Ferric carboxymaltose is a stable molecule resembling ferritin, which facilitates efficient iron delivery with minimal risk of hypersensitivity reactions [38, 39]. Studies suggest that a single dose of 500–1,000 mg i.v. iron may rapidly replenish iron stores and enhance recovery [40].

The transfusion strategy remains a subject of debate, especially regarding restrictive versus liberal approaches. Traditionally, transfusion is indicated for symptomatic anemia or when hemoglobin levels fall below 6 g/dL, while levels above 10 g/dL generally do not warrant transfusion. However, restrictive transfusion strategies have gained support due to the risk of transfusion-associated circulatory overload (TACO) and transfusion-related acute lung injury (TRALI), particularly in older, frail patients [41, 42]. Figure 2 describes a hypothetical patient blood management protocol and underscores the importance of an integrated, phase-specific approach to optimize outcomes in older surgical patients.

Hemoglobin targets and individualized management

Current guidelines vary significantly, with thresholds often set at 7–9 g/dL for active bleeding and patients with cardiovascular disease [43]. The French National Authority for Health suggests a hemoglobin threshold of 7 g/dL for asymptomatic patients, 8 g/dL for those with cardiovascular disease, and 10 g/dL for cases of poor clinical tolerance. However, beyond hemoglobin levels, comprehensive management must consider the patient's overall health status, comorbidities, and quality of life to guide the optimal clinical approach [44]. The aim of red blood cell transfusion is to correct tissue hypoxia rather than simply increasing hemoglobin levels. An Italian consensus suggests transfusions are warranted primarily in the presence of intraoperative hypoxia or lactic acidosis, rather than relying solely on anemia severity [45]. Patient Blood Management emphasizes an individualized approach to minimize exposure to blood products while maximizing red cell mass, minimizing

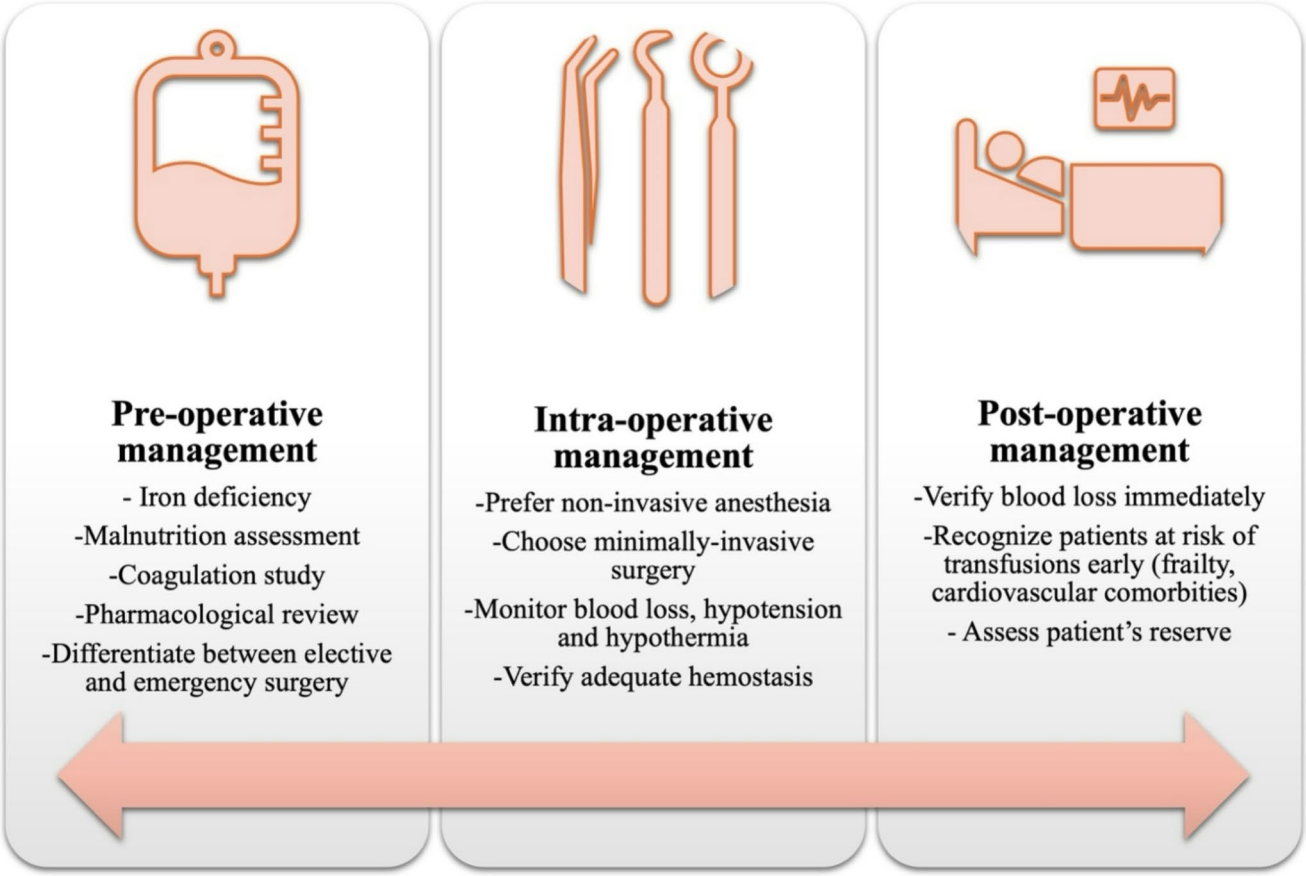

Fig. 2 Principles of Patient Blood Management (PBM) in older adults. This figure presents a comprehensive overview of PBM strategies tailored for older adults, focusing on three critical phases: pre-operative, intra-operative and post-operative management

perioperative blood loss, and enhancing tolerance for anemia [46]. Both anemia and transfusion are associated with increased risks of organ injury and poorer postoperative outcomes [47]. However, PBM implementation varies widely across healthcare settings, especially in primary care, where decisions often rely on individual clinical judgment rather than standardized protocols. In geriatric care, the approach to transfusion is often ambiguous. General practitioners in France, for instance, struggle to balance the perceived life-saving benefits of transfusions with their transient effects, often feeling isolated from hospital specialists when making these decisions [48]. There is also limited integration of geriatric syndromes into transfusion decision-making, with a tendency to prioritize prolonging life over addressing the patient's quality of life and personal values. Blood transfusion is one of the most overused medical procedures, particularly among patients over 60 years old, with up to 79% of transfusions occurring in this population. A global push for better management of transfusions is needed to optimize patient outcomes [49]. Rather than focusing solely on hemoglobin cut-offs, a comprehensive assessment of physiological factors, comorbidities, and patient-centered outcomes is crucial for guiding optimal transfusion strategies in older surgical patients. The goal should be to enhance tissue oxygenation, improve clinical outcomes, and reduce unnecessary transfusions while considering patient preferences and quality of life.

Evidence on surgical procedures in older adults

A single-center, retrospective study on patients aged over 60 years who underwent 81 open abdominal surgical procedures revealed a significant correlation between preoperative hemoglobin levels and 30-day postoperative mortality: rates were 28%, 20%, and 12% in the lower, median, and upper hemoglobin quartiles, respectively. Notably, patients who received transfusion therapy had higher postoperative mortality, except for those with critically low hemoglobin levels, suggesting that a restrictive transfusion strategy may be beneficial [50]. In a prospective study involving patients with extracapsular femoral neck fractures treated with intramedullary nailing (IMN), lower preoperative hemoglobin levels and extended surgery times were significant risk factors for blood transfusions. Additional risk factors included

female gender, age > 80 years, and hospital stays exceeding 7 days [51]. The American Academy of Orthopedic Surgeons recommends a transfusion threshold no higher than 8 g/dL in asymptomatic postoperative patients [52].

The Danish Transfusion Requirements in Frail Elderly (TRIFE) study, a prospective, assessor-blinded randomized controlled trial, found no statistically significant differences in daily living activities or 90-day mortality rates between patients assigned to restrictive versus liberal transfusion strategies, despite adherence to the Danish Health Authority's recommendations for hemoglobin levels below 9.7 g/dL post-hip surgery [53]. Conversely, in patients aged ≥ 65 undergoing major non-cardiac surgery, intraoperative blood transfusions were associated with reduced 30-day postoperative mortality. However, transfusions were linked to increased mortality when blood loss was less than 500 mL during surgery [54]. In trauma settings, older patients (defined as age > 55 years) received more transfusions regardless of clinical condition, potentially due to undertriaging and concomitant use of antiplatelet and anticoagulant therapies [55]. In a study of cardiac surgery patients, older adults constituted nearly 10% of the cohort. Logistic regression analysis identified transfusion as an independent predictor of mortality and acute kidney injury. The propensity for transfusion was linked to patient comorbidities rather than age, underscoring the complex interaction between transfusion effects and patient vulnerability [56]. A study on patients aged ≥ 65 hospitalized for acute myocardial infarction found that red blood cell transfusion reduced 30-day and 1-year mortality when hemoglobin levels fell below 8 g/dL. However, transfusions were associated with increased mortality when hemoglobin levels exceeded 10 g/dL [57]. This aligns with previous meta-analyses showing that restrictive transfusion strategies may increase myocardial infarction risk in patients with preexisting cardiovascular disease [58, 59]. In orthopedic surgery, meta-analyses have demonstrated that restrictive transfusion strategies may increase the risk of cardiovascular events, especially in hip fracture patients compared to those undergoing elective arthroplasty [60]. The Transfusion Requirements in Critical Care (TRICC) trial highlighted no significant difference in mortality between restrictive and liberal transfusion strategies, although frail older patients may benefit from a more liberal approach [53, 61, 62]. Table 1 summarizes the main evidence from the literature.

Alternatives to blood transfusion

In the context of managing perioperative anemia and reducing reliance on blood transfusions, a range of pharmacological and non-pharmacological strategies have been developed. Pharmacological agents such as fibrinogen concentrates, recombinant factor VIIa, desmopressin, and antifibrinolytics, particularly tranexamic acid (TXA), are proven effective in reducing blood loss during surgery [63, 64]. TXA, administered intravenously or topically, is widely used to minimize perioperative bleeding in major orthopedic and cardiac surgeries. It works by inhibiting fibrinolysis, thus stabilizing clots [65, 66]. Recent studies suggest that TXA may also reduce the need for transfusions without significantly increasing the risk of thromboembolic events, though further investigation is needed to confirm its safety profile in older adults, who often have higher comorbidity burdens [67, 68].

Techniques such as ANH, intraoperative cell salvage, and autologous blood transfusion play critical roles in minimizing exposure to allogeneic blood. ANH involves withdrawing a patient's blood immediately after induction of anesthesia while maintaining normovolemia through crystalloid or colloid infusions. This technique is particularly advantageous in surgeries with high anticipated blood loss, as it reduces the need for allogeneic transfusions and preserves clotting factors [69, 70]. Intraoperative cell salvage involves collecting and reinfusing the patient's own blood lost during surgery, which has shown efficacy in reducing allogeneic transfusions in high-blood-loss procedures such as cardiac and orthopedic surgeries.

Minimally invasive surgical techniques, such as laparoscopic and robotic-assisted procedures, are also effective in reducing intraoperative blood loss and should be prioritized for elective surgeries whenever feasible [36]. These approaches not only decrease blood loss but also reduce surgical trauma and enhance postoperative recovery, which is especially beneficial for older adults with limited physiological reserves.

Maintaining normothermia during surgery is another critical factor in blood conservation. Hypothermia, defined as a core body temperature below 36 °C, can impair coagulation and platelet function, leading to increased bleeding and transfusion requirements [71, 72]. Techniques to prevent hypothermia include the use of warming blankets, fluid warmers, and maintaining ambient operating room temperatures.

Patient Blood Management is an evidence-based approach that encompasses a range of strategies to optimize hemoglobin levels, minimize blood loss, and improve tolerance for anemia. It includes comprehensive preoperative assessments focused on optimizing hemoglobin through iron supplementation, vitamin B12 and folate correction, and the use of erythropoiesis-stimulating agents when appropriate [73, 74]. For older adults, the integration of prehabilitation—a program of exercise, nutritional support, and psychological preparation—can enhance physical resilience, thus reducing perioperative risks [45, 75].

Table 1 Main evidence on surgical procedures in older adults

CLINICAL SETTINGS	MEAN AGE	HEMOGLOBIN THRESHOLD	RESULTS (restrictive vs. liberal transfusion)
Orthopedic (Intramedullary Nailing for Extracapsular Femoral Neck Fracture) (Testa et al., 2023)	80.2 10.7 years (range 65–94 years)	Lower preoperative Hb levels and longer durations of surgical treatment	Risk factors for red-blood-cell transfusion: female gender, age > 80years, and hospital stay > 7days
Trauma (Mador et al., 2017) retrospective study	68.68 (22.6%)	Not, but 42% transfused	No difference in red cell transfusion or mortality
Acute Myocardial infarction (Zhang et al., 2021) meta-analysis	69.0 to 79.5 years	Prevalent Hb ≤ 8 g/dl or Hct ≤ 24%	*Restrictive transfusion*: higher risk of in-hospital mortality
All clinical setting (Simon et al., 2017) meta-analysis 9 orthopaedic surgery, 3 cardiac surgery, 1 oncology surgery	> 65 years Nine geriatric-transfusion-related RCTs	Heterogeneous definition: 97 g/L vs. 113 g/L 80 g/L vs. 100 g/L	*Restrictive transfusion*: risk of 30-day mortality and 90-day mortality
Emergency surgery (open abdominal surgery in the elderly) (Buhl et al., 2023) retrospective	76.6 years Death within 30 days 80.9 years	Normal range for plasma hemoglobin: 7.3–9.5 mmol/L for women and 8.3–10.5 mmol/L for men preoperative median -minimum hemoglobin level: 5.2 mmol/L -minimum intraoperative hemoglobin level: 6.5 mmol/L	-Low preoperative hemoglobin level: increased mortality -Transfusion therapy: higher postoperative mortality, except in patients with very low hemoglobin values
Miscellaneous (cardiac, vascular, oncologic, burn, orthopedic) (Lenet et al., 2022) meta-analysis	Foss et al., 2009 (81) So-Osman et al., 2010 (70) Shehata et al., 2012 (67.2 ± 11.2; 68.8 ± 9.2) Nielsen et al., 2014 (68 vs. 72) Laine et al., 2017 (70.5, 7.8–73.2) Mazer et al., 2018 (72 ± 10) Møller et al., 2019 (71.3 ± 9.4 vs. 73.7 6 7.3)	Heterogeneous definition (prevalent Hb < 8, range from 7 g/dL to 9 g/dL)	Intraoperative *restrictive transfusion* strategies: decreased perioperative transfusions without added postoperative morbidity and mortality in 12/14 trials (two trials worse outcome)
Cardiac, vascular, abdominal, orthopedic surgery, hemato-oncology, miscellaneous, trauma, upper GI bleeding or surgery bleeding, neuro-ICU, post-partum, septic shock (Hovaguimian et al., 2016) meta-analysis	Group 2: Elderly, orthopedic surgery -Carson et al., 1998; restrictive 83 vs. liberal 81 -Carson et al., 2011, restrictive 82 vs. liberal 82 -Foss et al., 2009, restrictive 81 vs. liberal 81 -Fan et al., 2014, restrictive 73 vs. liberal 75, -Gregersen et al., 2015, restrictive 86 vs. liberal 87, -Grover et al., 2006, restrictive 71 vs. liberal 72, -Nielsen et al., 2014, restrictive 68 vs. liberal 72, -Parker, 2013, restrictive 84 vs. liberal 84, -So-Osman et al., 2010, restrictive 71 vs. liberal 70 + -Holst et al., 2014, restrictive 67 vs. liberal 67, Walsh et al., 2013, restrictive 67 vs. liberal 68	Heterogeneity definitions: in > orthopedic surgery 8 gr vs. 10 gr/dL	*Restrictive strategy* in orthopedic patients: inadequate oxygen supply, mortality, composite outcome
Surgical service, cardiac, general, gynecologic, neurosurgery, orthopedic, otolaryngology/plastic and reconstructive, thoracic, urology, and vascular (Brown et al., 2014) retrospective	73.3 ± 6.2	Lowest hemoglobin concentration below 10 g/dL (difference between younger and older)	Odds of transfusion for older adults were significantly higher (age as predictor)

Table 1 (continued)

CLINICAL SETTINGS	MEAN AGE	HEMOGLOBIN THRESHOLD	RESULTS (restrictive vs. liberal transfusion)
Myocardial infarction (Putot et al., 2017) prospective	57% 65–79 y 43% ≥ 80 y	> 10 g/dL, between 8 and 10 g/dL	Transfusion: increased 1-year mortality for haemoglobin > 10 g/dL, but no effect between 8 and 10 g/dL. Benefit on 1-year mortality hemoglobin < 8 g/dL in patients ≥ 80 y
Hip surgery (Gupta et al., 2021) retrospective	83 + 10 y	Not thresholds, 425(50.5%) transfused peri-operatively	*Intra-operative blood transfusion*: increase in morbidity and mortality within 60 days, AKI SCr > 0.3 mg/dl within 48 h or SCr to 1.5 within7days
Cardiac surgery (De Santo et al., 2017) retrospective	Octogenarians (n = 176) Non transfused: 82.1 ± 1.7 Transfused: 82 ± 1.8	Pre-operative anemia: Non transfused: 13.4 ± 1.7 Transfused: 12.4 ± 1.6	Transfused subsets: higher AKI and mortality rates, RBC transfusions with more comorbidities

Table 2 Comparative analysis of blood management techniques: procedures, advantages, and disadvantages

PROCEDURES	ADVANTAGES	DISADVANTAGES
Topical agents including fibrin sealants, gelatine–thrombin matrices and oxidized cellulose	Quick procedure	Expensive, not available, not useful in emergency
Acute normovolemic hemodilution	Reduces volume of blood transfusions	Risk for sepsis, renal injury, cardiovascular complications
Procoagulant factors	Reduces red cells and fresh frozen plasma transfusion	Thrombotic events
Desmopressin	Limited use (acquired platelet dysfunction secondary to drugs, uraemia or cardiopulmonary bypass)	Thrombosis, hyponatremia, seizures
Tranexamic acid	Reduces blood transfusion and perioperative anemia	Thromboembolic complications
Permissive hypotension	Balances the risks of organ hypoperfusion	Severe risks for coronary artery disease and cerebrovascular disease.
Laparoscopic and robotic surgery	Reduces blood loss, decrease pain	Special considerations for comorbities
Tourniquet technique (especially total knee arthroplasty)	Reduces blood loss	Post-operative pain, risk of thrombosis

Furthermore, the use of fibrin sealants and hemostatic agents during surgery can reduce localized bleeding without the need for systemic blood products. Topical agents such as fibrinogen and thrombin-based sealants have been effective in controlling surgical bleeding, especially in high-risk procedures such as liver resection and spinal surgeries [76].

Lastly, erythropoiesis-stimulating agents (ESAs), particularly in patients with chronic kidney disease or preoperative anemia, can be used to stimulate RBC production, reducing the need for transfusions [77]. These agents, when combined with iron supplementation, have been shown to effectively increase hemoglobin levels in the preoperative period, especially in elective orthopedic surgeries where blood loss is anticipated. Table 2 summarizes advantages and disadvantages of alternative procedures to transfusion in older patients.

Overall, employing a multimodal approach combining pharmacological, non-pharmacological, and surgical strategies tailored to the patient's individual needs can significantly reduce transfusion rates and improve outcomes, especially in older adults who are more vulnerable to the risks associated with blood transfusions. Future research should focus on the comparative effectiveness of these interventions in older patients, particularly in light of their complex comorbidities and frailty.

Conclusion and future directions

Addressing anemia is a critical aspect of optimizing perioperative outcomes, particularly in older adults; however, it is only one component of a comprehensive blood conservation strategy. Decisions regarding blood transfusion should prioritize clinical judgment over rigid hemoglobin thresholds, especially given the complexities of managing older patients with multiple comorbidities [78, 79]. A holistic approach is essential, involving thorough preoperative geriatric assessments that encompass cardiovascular and thromboembolic risks, functional capacity, and nutritional status to enhance patient safety and recovery.

Currently, there is a notable gap in specific guidelines for managing perioperative anemia in older adults, particularly when considering the interplay of geriatric syndromes. Tailored evidence-based strategies are needed to guide clinicians in balancing the risks and benefits of transfusion, especially in frail, high-risk patients. Such strategies should emphasize a patient-centered approach that incorporates not only hemoglobin levels but also individual patient preferences, life expectancy, and quality of life [80].

Despite advancements in PBM and the use of alternatives to transfusions, open research questions remain regarding the optimal management of anemia in older surgical patients. Key areas for future investigation include:

1. What are the most effective preoperative interventions to optimize hemoglobin levels in older patients with anemia, especially in the presence of comorbidities such as chronic kidney disease or heart failure?
2. How can we better define transfusion thresholds that are individualized for frail older adults, accounting for their unique physiological reserves and risks of transfusion-related complications?
3. What is the role of emerging pharmacological agents, such as new erythropoiesis-stimulating agents or intravenous iron formulations, in reducing the need for transfusions in elective surgeries?
4. How can multidisciplinary approaches be further integrated into perioperative care to optimize anemia management and reduce postoperative complications in older adults?

Addressing these questions through robust clinical trials and real-world studies will be essential for developing more refined guidelines that can improve surgical outcomes and enhance the quality of life for older patients.

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Declarations

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