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Review Article

Hip Fracture and Anemia in the Elderly: A Systematic Review of Transfusion Strategies and Patient Blood Management

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Abstract

Background: Perioperative anemia is a common and consequential comorbidity in elderly patients with hip fracture, yet the optimal management strategy between transfusion and alternative therapies remains a critical clinical dilemma. Objective: This systematic review synthesizes contemporary evidence (2016-2026) on transfusion thresholds and perioperative anemia management in geriatric hip fracture patients, focusing on clinical outcomes and guideline recommendations. Methods: A systematic literature search was conducted in PubMed, Embase, and the Cochrane Library. Randomized controlled trials, meta-analyses, cohort studies, and clinical guidelines were included. Data were extracted and synthesized narratively. Results: Perioperative anemia affects 40-46% of patients and is an independent predictor of increased mortality, delirium, prolonged hospitalization, and functional decline. High-level evidence supports a restrictive transfusion strategy (hemoglobin threshold <8 g/dL for asymptomatic patients), which reduces transfusion exposure without increasing mortality or impairing recovery compared to liberal strategies. Liberal transfusion is associated with higher risks of infection, acute kidney injury, and cardiovascular events. Adjunctive strategies, particularly intravenous iron and tranexamic acid, significantly reduce transfusion requirements safely. Conclusion: Management should prioritize a restrictive, symptom-guided transfusion policy integrated within a multimodal Patient Blood Management protocol. Preoperative optimization, blood conservation techniques, and targeted pharmacotherapy are essential to improve outcomes and minimize avoidable transfusions in this frail population.

Keywords

Hip Fracture, Anemia, Elderly, Blood Transfusion, Geriatrics, Patient Blood Management, Perioperative Care

1. Introduction

Hip fracture is a leading cause of morbidity, mortality, and significant healthcare expenditure among older adults globally [1]. With demographic shifts towards aging populations, the incidence of this injury is projected to rise, imposing substantial burdens on health systems [2]. A pivotal modifiable factor influencing outcomes is perioperative anemia, present in 40-46% of patients upon admission and often exacerbated by surgical intervention [3].

The etiology of anemia in this context is multifactorial, stemming from acute blood loss at the fracture site, surgical

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trauma, and frequently, pre-existing anemia due to chronic disease, nutritional deficiencies, or age-related decline in hematopoiesis [4]. Even mild anemia is a robust independent predictor of adverse outcomes, including increased 30-day and one-year mortality, longer hospital stays, higher incidence of postoperative delirium, and poorer functional recovery leading to greater institutionalization [5, 6].

Historically, allogeneic red blood cell transfusion was liberally employed to correct anemia, based on the physiological premise of improving oxygen delivery. However, contemporary evidence underscores that transfusion is not an innocuous intervention. Documented risks include transfusion-related immunomodulation, increased postoperative infection, acute kidney injury (AKI), cardiovascular complications, transfusion-associated circulatory overload (TACO), and elevated short- and long-term mortality [7, 8]. These risks are magnified in frail older adults with diminished physiological reserve.

Consequently, clinical guidelines have evolved to advocate for restrictive transfusion triggers and the adoption of integrated Patient Blood Management (PBM) programs [9]. Despite this, ambiguity persists in clinical practice regarding the optimal transfusion threshold and the hierarchy of alternative management strategies. This systematic review aims to synthesize the contemporary evidence (2016-2026) to address the central clinical question: In elderly patients with hip fracture and perioperative anemia, when is transfusion indicated, and which alternative strategies should be prioritized?

2. Methods

2.1. Search Strategy

A systematic literature search was performed in PubMed/MEDLINE, Embase, and the Cochrane Library for publications from January 1, 2016, to January 31, 2026. The search strategy utilized a combination of Medical Subject Headings (MeSH) and keywords: ("Hip Fractures" OR "femoral fracture") AND ("Anemia" OR "perioperative anemia") AND ("Blood Transfusion" OR "transfusion threshold" OR "restrictive transfusion") AND ("Aged" OR "Geriatrics" OR "elderly").

2.2. Eligibility Criteria

Inclusion criteria comprised:

1) Patients aged ≥65 years undergoing surgical repair of hip fracture;
2) Studies evaluating restrictive versus liberal transfusion strategies, intravenous (IV) iron, erythropoiesis-stimulating agents (ESAs), tranexamic acid (TXA), or other anemia-management interventions;
3) Reported outcomes including mortality, morbidity (infection, cardiac events, AKI, delirium), functional recovery, length of stay, and transfusion-related complications;
4) Study designs: randomized controlled trials (RCTs), prospective or retrospective cohort studies, systematic reviews, meta-analyses, and evidence-based clinical practice guidelines.

Exclusion criteria were:

1) Non-English or non-Spanish publications;
2) Case reports, editorials, and conference abstracts without peer-reviewed full text;
3) Studies focusing on non-geriatric populations or non-hip-fracture surgery.

2.3. Study Selection and Data Extraction

Two independent reviewers screened titles, abstracts, and subsequently, full-text articles. Discrepancies were resolved through consensus or consultation with a third reviewer. Data were extracted using a standardized form capturing study design, population characteristics, interventions, comparators, outcomes, and key findings.

2.4. Data Synthesis

Given the methodological heterogeneity across included studies, a formal meta-analysis was not feasible. Evidence was synthesized narratively and organized thematically:

1) Diagnostic criteria for anemia in older adults;
2) Epidemiology and clinical impact of perioperative anemia;
3) Risks associated with allogeneic transfusion;
4) Restrictive versus liberal transfusion strategies;
5) Adjunctive PBM interventions. Guideline recommendations were tabulated and compared.

3. Results

3.1. Diagnostic Criteria for Anemia in Older Adults

The World Health Organization (WHO) defines anemia as hemoglobin <13 g/dL in men and <12 g/dL in women, thresholds derived from younger populations [10]. For adults ≥65 years, a hemoglobin level <12 g/dL for both sexes is widely accepted for diagnosis [11]. Some experts propose a threshold of ≤11 g/dL for the very old or frail, recognizing that even mild anemia in geriatric patients correlates strongly with frailty, cognitive impairment, functional decline, and increased mortality [12].

3.2. Epidemiology and Impact of Perioperative Anemia in Hip Fracture

Approximately 40-46% of hip fracture patients present with anemia at admission [3]. Additional blood loss from surgery typically ranges from 500 to 1500 mL, with greater volumes associated with intertrochanteric and subtrochanteric fractures

[13]. Preoperative anemia is an independent predictor of:

(i) Increased 30-day and one-year mortality (adjusted odds ratio [aOR] 1.4-2.1) [5, 14];
(ii) Prolonged hospital length of stay [15];
(iii) Higher incidence of postoperative delirium (aOR 1.6-2.0) [16];
(iv) Poorer functional recovery and increased risk of discharge to institutional care [6].

Postoperative anemia exacerbates these risks and is linked to reduced mobility, higher infection rates, and increased hospital readmissions [17]. A recent multicenter study further confirmed admission hemoglobin as a significant predictor of mortality [18], and data from Qatar underscore its relationship with adverse outcomes in older patients [19].

3.3. Risks of Allogeneic Blood Transfusion

While transfusion rapidly increases hemoglobin concentration (approximately 1-1.5 g/dL per unit), it carries significant risks in older adults:

(i) Immunomodulation and infection: Transfusion-related immunosuppression increases the risk of postoperative infections, including surgical-site infection and pneumonia (relative risk [RR] 1.3-1.8) [20, 21];
(ii) Acute kidney injury (AKI): Transfusion is associated with a 2.8-fold increased risk of AKI in geriatric hip-fracture patients [22];
(iii) Cardiovascular events: Increased risk of myocardial infarction, heart failure, and stroke [23];
(iv) Pulmonary complications: Transfusion-associated circulatory overload (TACO) and transfusion-related acute lung injury (TRALI) [8];
(v) Mortality: Perioperative transfusion is linked to a 1.9-3.0-fold increase in 30-day and one-year mortality [22, 24].

A 2025 study identified pre-operative transfusion for chronic anemia as an independent risk factor for increased mortality [25], and a 2024 study explored the consequential thresholds of anemia in this population [26]. Furthermore, a 2025 analysis detailed the risk factors and outcomes associated with allogeneic transfusion [27].

3.4. Restrictive vs. Liberal Transfusion Strategies

High-quality RCTs and meta-analyses consistently demonstrate that a restrictive transfusion strategy (hemoglobin trigger <8 g/dL for asymptomatic patients) is non-inferior to a liberal strategy (trigger <9-10 g/dL) regarding mortality and functional recovery, while significantly reducing transfusion exposure and complication rates [28, 29].

Key trials include the FOCUS trial, which found no difference in 60-day mortality or functional outcomes between restrictive (Hb <8 g/dL) and liberal (Hb <10 g/dL) strategies, even in patients with cardiovascular disease or risk factors [30]. The TRIFE trial also showed non-inferiority of a restrictive strategy (Hb <9.7 g/dL) compared to liberal (Hb <11.3 g/dL) in patients aged ≥65 years, with fewer transfusions and no increase in complications [31]. A 2021 Cochrane review concluded that restrictive thresholds reduce the proportion of patients transfused by 43% without adversely affecting mortality, functional recovery, or length of stay [28]. A 2026 retrospective multicenter study provided real-world evidence on contemporary transfusion practices based on hemoglobin thresholds [32].

3.5. Clinical Guideline Recommendations

Current international guidelines strongly favor restrictive transfusion policies, as summarized in Table 1.

Table 1. *Guideline Recommendations for Transfusion in Geriatric Hip Fracture (2016-2026).*

Guideline (Year)	Recommended Threshold (Asymptomatic Patients)	Key Considerations
AAOS (2022) [33]	Hb <8 g/dL	Moderate evidence; symptom-guided approach
AABB (2016) [34]	Hb 7-8 g/dL	Strong recommendation; applies to hospitalized patients
Association of Anaesthetists (2020) [35]	Maintain Hb >9 g/dL in frail patients or those with cardiac disease	Individualize based on symptoms/comorbidities
Frankfurt Consensus (2019) [9]	Hb <8 g/dL (even in CVD unless symptomatic)	Integrate with Patient Blood Management
SCGIG (2021) [36]	Hb <8 g/dL + IV iron ± ESA	Comprehensive PBM bundle recommended
NICE (2020 update) [37]	Hb <8 g/dL	Consider symptoms; avoid routine transfusion

AAOS: American Academy of Orthopaedic Surgeons; AABB: Association for the Advancement of Blood & Biotherapies; SCGIG: Societat Catalana de Geriatria i Gerontologia; NICE: National Institute for Health and Care Excellence; CVD: cardiovascular disease; IV: intravenous; ESA: erythropoiesis-stimulating agent.

3.6. Adjunctive Patient Blood Management Strategies

3.6.1. Intravenous Iron Therapy

Pre- or postoperative IV iron reduces transfusion requirements by 30-50% and shortens hospital length of stay without increasing infection or mortality risk [38, 39]. A 2021 meta-analysis reported that IV iron decreased transfusion risk (RR 0.62, 95% CI 0.48-0.80) and length of stay by 1.2 days [38]. Recent trials confirm its efficacy and safety in reducing postoperative infections in severely anemic patients [40].

3.6.2. Tranexamic Acid (TXA)

TXA reduces perioperative blood loss by 200-400 mL and transfusion rates by approximately 30% in hip fracture surgery, without a significant increase in thromboembolic events [41-43].

3.6.3. Erythropoiesis-Stimulating Agents (ESAs)

ESAs combined with iron can reduce transfusion needs but are limited by cost and potential thrombotic risk [9, 44]. Their use is generally reserved for specific cases, such as patients with transfusion contraindications.

3.6.4. Comprehensive Geriatric Assessment (CGA)

Integrating frailty, cognition, and comorbidity burden into decision-making improves outcomes and helps tailor transfusion decisions [45]. Machine learning models are being developed to further personalize transfusion risk prediction [46].

3.6.5. Comprehensive PBM Bundles

The HiFIT trial demonstrated the effectiveness of combining IV iron and TXA to significantly reduce transfusion needs [47]. An overview of systematic reviews supports the role of multimodal interventions in reducing red cell transfusion [48]. Furthermore, a 2022 nationwide linked audit highlighted transfusion practices and outcomes [49].

4. Discussion

This review consolidates contemporary evidence indicating that perioperative anemia in elderly hip fracture patients is a potent, modifiable risk factor for poor outcomes [5, 6, 50]. However, correction via allogeneic transfusion introduces significant iatrogenic harm, arguing decisively against liberal transfusion policies [7, 8, 22].

The convergence of international guidelines around a restrictive hemoglobin threshold (<8 g/dL for asymptomatic patients) is supported by robust evidence [9, 28, 33, 34, 37]. This approach reduces transfusion exposure and complication rates without compromising survival or functional recovery [28, 29]. Crucially, a restrictive strategy is not synonymous with withholding transfusion; it emphasizes transfusion for clinical indications—such as symptomatic anemia (e.g., chest pain, dyspnea, unexplained tachycardia, hypotension) or hemodynamic instability—rather than an arbitrary laboratory value [35].

Clinical judgment remains paramount, especially in patients with active cardiovascular disease. While some guidelines suggest a higher threshold (e.g., Hb <9 g/dL) for this subgroup, evidence from the Frankfurt Consensus indicates that a restrictive approach is safe unless active symptoms are present [9].

Beyond transfusion triggers, a proactive PBM framework is essential. Key components include:

1) Preoperative optimization with rapid anemia screening and IV iron supplementation [38, 40];
2) Intraoperative conservation using TXA and meticulous surgical technique [41-43];
3) Postoperative reinforcement with continued iron therapy and minimized iatrogenic blood loss;
4) Multidisciplinary collaboration integrating geriatricians, surgeons, anesthetists, and hematologists [9, 48].

The HiFIT trial recently demonstrated the effectiveness of combining IV iron and TXA to significantly reduce transfusion needs [47]. IV iron and TXA emerge as cornerstone interventions, supported by high-level evidence for safety and efficacy [38, 41, 47]. Furthermore, studies show that surgery can often be safely conducted without transfusion even in patients with hemoglobin below 10 g/dL, provided they are hemodynamically stable and managed within a PBM protocol [51]. Anesthetic management also plays a crucial role in the overall perioperative strategy [52].

Limitations of the Evidence

Most landmark RCTs exclude patients with severe cardiac disease or acute coronary syndromes, creating an evidence gap for the highest-risk individuals. The assessment of "symptoms" can be challenging in cognitively impaired patients. Future research should focus on validated symptom-assessment tools, individualized triggers based on physiological reserve (e.g., point-of-care ultrasound), and the impact of early versus delayed surgery on hemoglobin dynamics, particularly in patients on anticoagulants.

5. Conclusions and Clinical Recommendations

Based on the synthesized evidence, the following conclusions and recommendations are proposed:

1) Perioperative anemia is highly prevalent and clinically significant, independently predicting mortality, delirium, prolonged hospitalization, and functional decline in elderly hip fracture patients.
2) Routine transfusion is not recommended for hemodynamically stable, asymptomatic patients with hemoglobin ≥8 g/dL.

3) A restrictive, symptom-guided transfusion strategy (Hb <8 g/dL) should be adopted. Decisions should be individualized for frail patients or those with cardiovascular disease.
4) Comprehensive Patient Blood Management protocols must be implemented, including preoperative anemia screening, IV iron supplementation, routine use of TXA (unless contraindicated), and multidisciplinary geriatric-orthopedic collaboration.
5) Alternatives to transfusion, particularly intravenous iron, should be prioritized to reduce transfusion exposure and improve patient outcomes.
6) Comprehensive Geriatric Assessment should be integrated into perioperative care to tailor management to the individual's frailty, functional status, and goals of care.

Adopting this evidence-based, conservative approach centered on PBM principles represents the optimal strategy for enhancing survival, functional recovery, and quality of life in older adults with hip fracture.

Abbreviations

AABB	Association for the Advancement of Blood & Biotherapies
AAOS	American Academy of Orthopaedic Surgeons
aOR	Adjusted Odds Ratio
AKI	Acute Kidney Injury
CGA	Comprehensive Geriatric Assessment
CI	Confidence Interval
ESA	Erythropoiesis-Stimulating Agent
Hb	Hemoglobin
IV	Intravenous
MeSH	Medical Subject Headings
NICE	National Institute for Health and Care Excellence
PBM	Patient Blood Management
RCT	Randomized Controlled Trial
RR	Relative Risk
SCGIG	Societat Catalana de Geriatria i Gerontologia
TACO	Transfusion-Associated Circulatory Overload
TRALI	Transfusion-Related Acute Lung Injury
TXA	Tranexamic Acid
WHO	World Health Organization

Author Contributions

Juan Rodrigo Tuesta-Nole: Conceptualization, Data curation, Formal Analysis, Investigation, Methodology, Project administration, Resources, Software, Validation, Visualization, Writing – original draft, Writing – review & editing

Conflicts of Interest

The author declares no conflicts of interest.

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