Patient Blood Management: Challenges and Approaches to Blood Health

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Summary

Anaemia is among the most common global health problems. When taking into account related blood health disorders such as blood loss and coagulopathies, the picture becomes even broader: According to recent estimates, more than 3 billion people worldwide are affected. Particularly in perioperative settings, patients with anaemia face a greater need for blood transfusions and increased risk of postoperative complications. The concept of Patient Blood Management (PBM) addresses these issues by providing therapeutic measures aimed at preserving valuable resources and enhancing patient safety. PBM is a multidisciplinary, patient-centred approach to optimizing blood health and rests upon three pillars: (1) (preoperative) anaemia management, (2) minimization of blood loss, and (3) rational use of blood products. Since anaemia has multifactorial causes, it is essential to consider expanding the existing treatment paradigm, which predominantly focus on iron deficiency therapy alone. An intersectoral and interdisciplinary approach – particularly involving primary care providers – is crucial to sustainably enhancing patient safety, quality of care, and resource efficiency.

Challenges to blood health

The high prevalence of anaemia, insufficient implementation of perioperative anaemia management, and liberal handling of blood transfusions pose significant challenges to health care systems worldwide. Global epidemiological data show that roughly 25% of the world's population is affected by anaemia. Approximately 1.9 billion people suffered from this disease in 2021 [1]. If other related blood health conditions like blood loss and coagulation disorders are factored in, the picture will become even broader: current estimates show that there are more than 3 billion people affected worldwide whose blood health is chronically or acutely impaired. This widespread blood health crisis has far-reaching effects on the global disease burden, the cost of health care, and the quality of life of those affected [2]. Anaemia is an especially important risk factor in the surgical context that can significantly affect the prognosis of patients undergoing surgery. Studies document that around 10–48 % of patients show signs of anaemia prior to surgery [3,4], which will be associated with significant risks if left untreated. A current study by Warner and Colleagues shows that anaemic patients (n = 1234) who undergo elective cardiac surgery have higher rates of postoperative acute renal failure (8 % vs. 18 %) and a prolonged stay in the hospital (5.8 days vs. 6.7 days) compared to non-anaemic patients [5].

There is currently a controversy as to whether the gender-specific haemoglobin cutoffs defined by the World Health Organisation (WHO) (men < 13 g/dl and women < 12 g/dl) are appropriate for defining anaemia. Earlier studies [6,7] as

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well as a more recent investigation by Netz et al. [8] suggest that adjusting the haemoglobin cutoff to <13 g/dl for women who are undergoing major surgical interventions is associated with a reduction in the need for transfusions and a lower rate of postoperative complications. Despite the known risks of allogeneic blood transfusions [9], anaemia not associated with a massive blood loss or life-threatening conditions is still frequently treated with red blood cell transfusion.

Early diagnostic evaluation, for instance by primary care physicians prior to the scheduled surgical intervention, combined with targeted causal therapy, can effectively reduce perioperative complications and significantly minimize the requirement for allogeneic blood transfusions. But this would urgently require a cross-sector treatment concept with clearly defined responsibilities and suitable reimbursement. The various aspects can be addressed and improved simultaneously through the targeted optimisation of blood health. Patient Blood Management (PBM) is a promising medical approach that focus on improving blood health in order to improve outcomes during the perioperative period. In spite of the WHO's call in recent years [2,10–12] for the comprehensive implementation of PBM, it has yet to be adequately put into practice [13–15].

What is Patient Blood Management?

PBM is a patient-oriented, evidence-based and multidisciplinary concept for optimising blood health [2] and increasing patient safety [16].

PBM measures are based on three pillars (Fig. 1) [17]:

1st Pillar: (Preoperative) anaemia management

2nd Pillar: Minimisation of blood loss

3rd Pillar: Rational use of blood products.

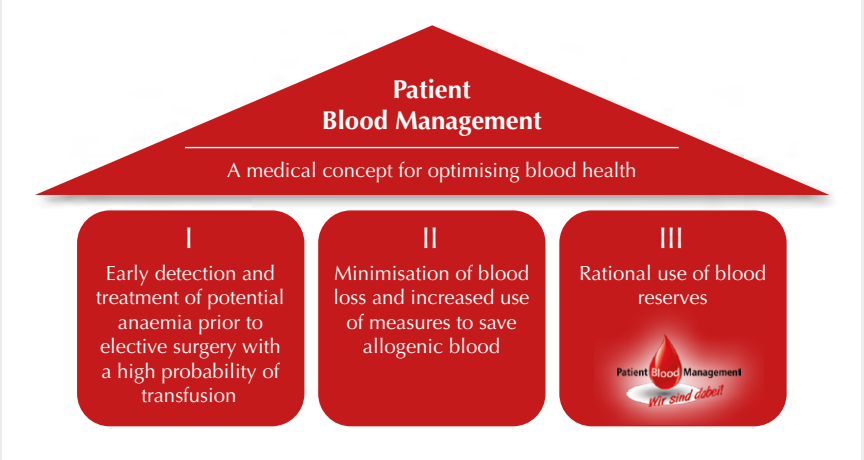
Pillar 1: (Preoperative) anaemia management

The first pillar of the PBM approach promotes patients' own haematopoiesis with the aim of raising the haemoglobin level in advance of planned surgical interventions. The focus is on the early diagnosis and treatment of preoperative anaemia. One of the main causes of anaemia is iron deficiency [18], which is generally easy to treat. Neef and colleagues showed that intravenous iron supplementation is most effective if it is administered at least ten days before surgery – ideally, treatment should be applied three to four weeks before surgery. This period of time enables an optimal rise in haemoglobin and allows for an additional iron supplementation if necessary [28]. In particular, various studies indicate that the correction of preoperative anaemia is associated with lower complication rates, a shorter stay in the hospital and a lower transfusion rate [4,19,20].

However, the latest studies show that a holistic concept for treating anaemia is necessary, and correcting iron deficiency only is not always sufficient. The causes of anaemia are multifactorial and, aside from iron deficiency, also include vitamin B12 and folic acid deficiency, chronic kidney disease, persistent inflammations, infections and, in rare cases, even genetic hemoglobinopathies (e.g. thalassemia, sickle cell anaemia) [21]. Furthermore, primary diseases such as primary osteomyelofibrosis, secondary bone marrow depression (e.g. after radiation) and toxic influences (e.g. poisoning) can trigger anaemia [22–24]. Spahn et al. developed a multimodal therapeutic approach in which cardiac surgery patients with (iron deficiency) anaemia received a combination therapy consisting of intravenous iron, erythropoietin alpha (EPO), vitamin B12 and folic acid before surgery. Even though the combination therapy is theoretically accompanied by risks such as thromboembolic events, infections and other complications, these did not occur more frequently during the course of the study. This multidimensional treatment concept led to a reduction in the need for transfusions [25].

Early diagnosis and therapy of anaemia in case of elective surgery should ideally be commenced in the primary care setting. In Germany, there is a structural gap in primary care when it comes to preoperative anaemia: Standardised diagnostics do not usually take place, which is attributable to a lack of legal requirements, unclear responsibilities and insufficient reimbursement. General practitioners, who are often the first point of contact before planned surgery, rarely perform relevant blood tests to determine iron deficiency parameters, such as ferritin or transferrin saturation. Furthermore, communication structures across sectors are lacking, and PBM has yet to be integrated at the national

Figure 1



Concept of Patient Blood Management (source modified: https://www.patientbloodmanagement.de).

level. Additionally, knowledge of the clinical significance and implementation of PBM has not yet been sufficiently embedded in training, continuing education, or everyday practice.

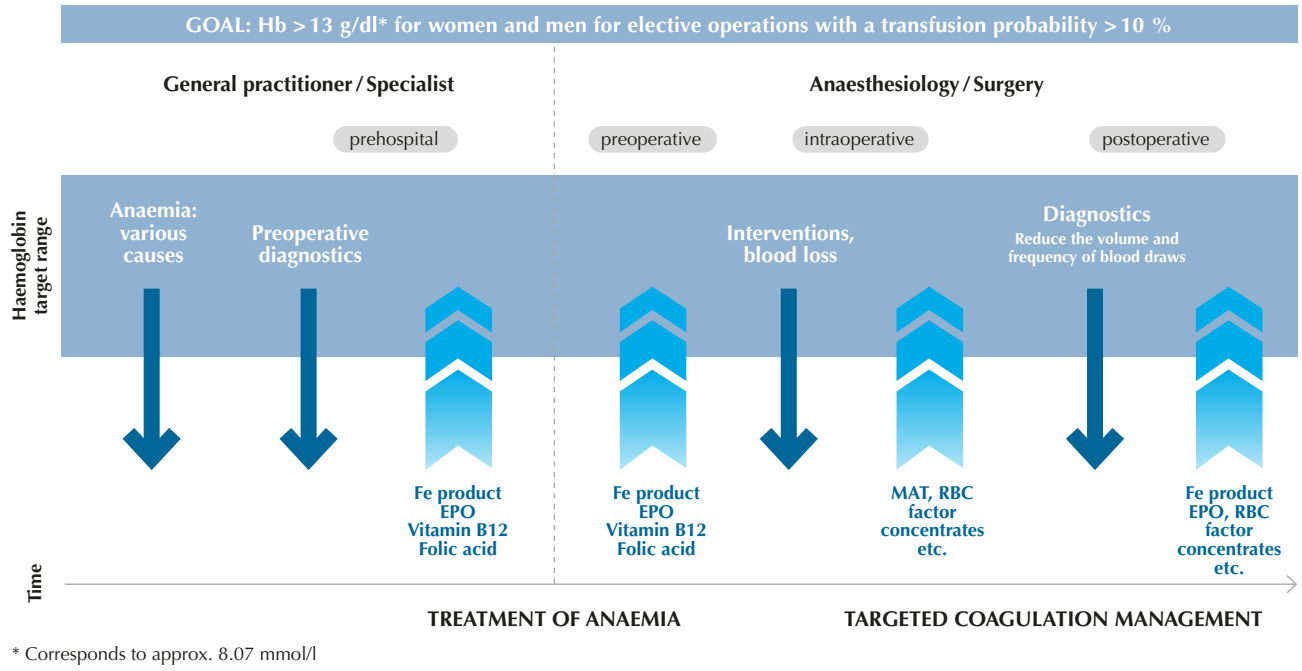
The general practitioner will play a central role in the future, as they usually care for the patients on a long-term basis, knows their pre-existing conditions and often is the first to notice symptoms of anaemia such as fatigue, decline in performance, heart palpitations or dyspnoea under exertion. The physician will usually have the most lab values on hand in chronological order, which can be used to detect changes in haematologic parameters at an early stage. In addition to early diagnosis, measures that can be taken by the general practitioner also include clarification of the causes and initiation of targeted therapy. Depending on severity, therapy can take place directly in the GP's practice, e.g. oral or intravenous supplementations of iron, vitamin B12 or folic acid preparations. This way, it can be ensured that the patients are optimally prepared for elective surgery. Close cooperation between the general practitioner and the treating hospital is also useful and desirable. Further clarification and treatment can be continued in a hospital equipped with interdisciplinary specialist departments, especially in more complex cases. Different forms of anaemia require different therapeutic approaches, ranging from dietary supplementation and erythropoiesis-stimulating agents to transfusion medicine and specialised treatment measures (Fig. 2).

Pillar 2: Minimisation of blood loss

The second pillar is composed of measures to reduce avoidable blood loss with the aim of maintaining the body's own blood reserves. For example, diagnostic-related blood loss can be associated with an unfavorable clinical course [26,27]. Frequent blood draws lead to a significant blood loss, which can reach up to 1,428 ml if the patient spends more than eleven days in the intensive care ward. Low-volume blood collection tubes and closed blood collection systems can significantly reduce the amount of blood loss needed for diagnostic purposes [28–30].

Another major aspect is a comprehensive coagulation management, which is supported by the careful correction of physiological parameters (body temperature, ionised calcium, pH value). The use of point-of-care diagnostics (POCD) is recommended for targeted therapy with coagulation factor concentrates, since it enables both a rapid and a bedside analysis [31]. Nonetheless, it must be kept in mind that POCD systems can have limitations despite their practical advantages. Their use is particularly valuable in situations in which rapid diagnostics are required – for example, when a central laboratory is not immediately available. The use of cell salvage

Figure 2



* Corresponds to approx. 8.07 mmol/l

The ups and downs of haemoglobin. Influencing factors and potential patient blood management (PBM) measures in the perioperative context (source: own illustration).

EPO: Erythropoietin; **RBCC:** RBC concentrate; **Fe product:** Iron product; **MAT:** Machine autotransfusion.

also makes a major contribution towards reducing the need for allogenic blood transfusions. A recent meta-analysis [32] showed that the use of cell salvage in surgery patients not only significantly reduces the need for allogenic blood transfusions by 39 %, but is also associated with a 28 % reduction in the risk of postoperative infection and a reduction of hospitalisation time by 2.31 days.

The implementation of various blood-saving methods, such as the use of low-volume blood collection tubes, closed blood collection systems, cell salvage, POCD as well as comprehensive coagulation management significantly improve haemoglobin levels and secure valuable blood reserves for emergencies (Fig. 2).

Pillar 3: Rational use of blood products.

The third pillar of the PBM concept consists of the rational use of blood products in compliance with the guidelines. The primary goal of a transfusion of allogenic blood products is to ensure an adequate oxygen supply to the tissue in order to avoid complications resulting from acute severe anaemia. However, it must be carefully considered whether the potential benefit of the transfusion outweighs the risks it entails. This decision should always be made considering individual patient factors. With patients in stable haemodynamic condition, even low haemoglobin values under 8 g/dl can often be tolerated without clinically relevant symptoms. Despite extensive studies, a significant benefit of a liberal transfusion practice (haemoglobin target values between 9 and 11 g/dL) compared to a rational strategy (haemoglobin target values between 7 and 9 g/dL) has not yet be seen in most clinical situations [33–35]. Therefore, a preventive approach is preferable [36].

Conclusion

The early diagnosis and treatment of preoperative anaemia by general practitioners is crucial, ideally in cooperation with specialists or specialised anaemia outpatient clinics. Comprehensive anaemia management which pays particular attention to iron, vitamin B12 and folic acid deficiencies makes a major contribution towards increasing patient safety, preventing perioperative complications and ensuring effective and sustainable patient care. An interdisciplinary approach is of central importance here. In individual cases with a short time frame, it should be considered whether to postpone elective surgery in order to enable adequate preoperative anaemia management. Just as important as interdisciplinary cooperation is the implementation of practicable measures in everyday primary care practice. These include structured recording of elective surgery, targeted requesting of relevant laboratory parameters (such as haemoglobin, reticulocyte-haemoglobin, ferritin and transferrin saturation) as well as cause-oriented therapy.

The integration of standardised processes – such as through short Standard Operating Procedures (SOPs), patient questionnaires or digital interfaces – also enables an efficient and permanent integration of preoperative anaemia management into the existing primary care processes.

Conflict of interest

KZ received fees for taking part in advisory board meetings from Haemonetics and CSL Vifor and received presentation fees from CSL Behring, Masimo, Pharmacosmos, Boston Scientific, Salus, iSEP, Edwards, HemoSonics and GE Healthcare. He is principal investigator in the EU-Horizon 2020 project ENVISION (intelligent digital plug and play tool for real-time monitoring of COVID19 patients and intelligent decision-making in intensive care units) and the Horizon Europe 2021 project COVend (biomarkers and AI-assisted FX06 therapy to prevent mild and moderately severe stages of COVID19 from progressing to severe stages) and partner for the EU Horizon 2023 project EDiHTA. KZ is CEO of the Christoph Lohfert Foundation and also heads the Stiftung für Gesundheit, Patientensicherheit und Patient Blood Management (PBM Foundation).

SC received fees for writing articles from the publishing house Thieme Verlag.

PM and his clinic received funding for research projects and clinical trials from the German Federal Ministry of Education and Research (BMBF, 01KG1815), the German Federal Ministry of Health (BMG, ZMVI1 2520DAT10E, ZMII2-2523FEP50A), CSL Behring and the German Research Foundation (DFG, ME 3559/1-1, ME 3559/3-1, ME 6094/3-2).

PM received presentation fees and reimbursement of travel expenses from CSL Behring, CSL Vifor, Pharmacosmos and Werfen. PM is a board member of the board of directors of the Stiftung für Gesundheit, Patientensicherheit und Patient Blood Management (PBM Foundation), the Network for the Advancement of Patient Blood Management, Haemostasis and Thrombosis (NATA) and a member of the standing work group of the scientific advisory board "Cross-sectional Guidelines for Therapy with Blood Components and Plasma Derivatives".

DM does not have any conflict of interest.

Literature

1. GBD 2021 Anaemia Collaborators: Prevalence, years lived with disability, and trends in anaemia burden by severity and cause, 1990-2021: findings from the Global Burden of Disease Study 2021. Lancet Haematol 2023;10:e713–e734
2. World Health Organization (WHO): Guidance on implementing patient blood management to improve global blood health status. World Health Organization 2024. URL: https://iris.who.int/handle/10665/380784. Lizenz: CC BY-NC-SA 3.0 IGO (Accessed on: März 2025)
3. Muñoz M, Gómez-Ramírez S, Campos A, Ruiz J, Liumbruno GM: Pre-operative anaemia: prevalence, consequences and approaches to management. Blood Transfus 2015;13:370–379
4. Triphaus C, Judd L, Glaser P, Goehring MH, Schmitt E, Westphal S, et al: Effectiveness of Preoperative Iron Supplementation in Major Surgical Patients With Iron Deficiency: A Prospective Observational Study. Ann Surg 2021;274:e212–e219

5. Warner MA, Hanson AC, Schulte PJ, Sanz JR, Smith MM, Kauss ML, et al: Preoperative Anemia and Postoperative Outcomes in Cardiac Surgery: A Mediation Analysis Evaluating Intraoperative Transfusion Exposures. Anesth Analg 2024;138:728–737
6. Ripoll JG, Smith MM, Hanson AC, Schulte PJ, Portner ER, Kor DJ, et al: Sex-Specific Associations Between Preoperative Anemia and Postoperative Clinical Outcomes in Patients Undergoing Cardiac Surgery. Anesth Analg 2021;132:1101–1111
7. Gombotz H, Schreier G, Neubauer S, Kastner P, Hofmann A: Gender disparities in red blood cell transfusion in elective surgery: a post hoc multicentre cohort study. BMJ Open 2016;6:e012210
8. Netz A, Hof L, Rumpf F, Blum LV, Neef V, Kerner A, et al: Adjusting Current Hemoglobin Thresholds: A Way to Improve Outcome in Women Undergoing Major Surgery. J Women's Health 2024;33:678–684
9. Carson JL, Triulzi DJ, Ness PM: Indications for and Adverse Effects of Red-Cell Transfusion. N Engl J Med 2017;377:1261–1272
10. World Health Organization (WHO): Global Forum for Blood Safety – Patient Blood Management: Concept Paper 2011. URL https://cdn.who.int/media/docs/default-source/biologicals/blood-products/document-migration/gfbs_01_pbm_concept_paper.pdf?sfvrsn=f189661_3 (Accessed on: 18.03.2025)
11. World Health Organization (WHO): The urgent need to implement patient blood management: policy brief 2021. URL: https://iris.who.int/bitstream/handle/10665/346655/9789240035744-eng.pdf?sequence=1 (Accessed on: 18.03.2025)
12. World Health Organization (WHO): Sixty-third World Health Assembly, WHA 63.12 (resolution). Availability, safety and quality of blood products; 2010. URL: https://apps.who.int/gb/ebwha/pdf_files/WHA63/A63_R12-en.pdf (Accessed on: 18.03.2025)
13. Gammon R, Jindal A, Dubey R, Shipp C, Tayal A, Rajbhandary S, et al: An international survey of patient blood management practices. Transfusion 2025;65:505–513
14. Agostini V, Masiello F, Vaglio S, Veropalumbo E, La Rocca U, Pupella S, et al: A survey on the implementation of Patient Blood Management programs in Italy. Blood Transfus 2024. Epub 28. März 2024
15. Füllenbach C, Schmitt E, Steinbicker AU, Hof L, Köhler S, Große Wortmann K et al: Umsetzung des Patient Blood Managements im klinischen Alltag (PBMCert). Anästh Intensivmed 2021;62:304–313
16. Meybohm P, Richards T, Isbister J, Hofmann A, Shander A, Goodnough LT, et al: Patient Blood Management Bundles to Facilitate Implementation. Transfus Med Rev 2017;31:62–71
17. Althoff FC, Neb H, Herrmann E, Trentino KM, Vernich L, Füllenbach C, et al: Multimodal Patient Blood Management Program Based on a Three-pillar Strategy: A Systematic Review and Meta-analysis. Ann Surg 2019;269:794–804
18. GBD 2015 Disease and Injury Incidence and Prevalence Collaborators: Global, regional, and national incidence, prevalence, and years lived with disability for 310 diseases and injuries, 1990-2015: a systematic analysis for the Global Burden of Disease Study 2015. Lancet 2016;388:1545–1602
19. Takashima J, Kobayashi H, Koizumi A, Shigehara F, Yamazaki K, Fujimoto D, et al: Impact of preoperative anemia and perioperative transfusion on short-term outcomes in colorectal cancer surgery: The role of iron supplementation. Ann Gastroenterol Surg 2024;9:288–297
20. Jain R, Farias MJ, Singh M, Pisani C, Nassar JE, Diebo BG, et al: Preoperative Iron Supplementation Mitigates the Risk Of Postoperative Complications Associated with Iron Deficiency Anemia Following Lumbar Spinal Fusion. Spine 2025. Epub 11. Februar 2025
21. Brittenham GM, Moir-Meyer G, Abuga KM, Datta-Mitra A, Cerami C, Green R, et al: Biology of Anemia: A Public Health Perspective. J Nutr 2023;153 Suppl 1:S7–S28
22. Gupta V, Harrison C, Hexner EO, Al-Ali HK, Foltz L, Montgomery M, et al: The impact of anemia on overall survival in patients with myelofibrosis treated with ruxolitinib in the COMFORT studies. Haematologica 2016;101:e482–e484
23. Li N, Liu X, Zhai F, Liu B, Cao X, Li S, et al: Association between dose-volume parameters and acute bone marrow suppression in rectal cancer patients treated with concurrent chemoradiotherapy. Oncotarget 2017;8:92904–92913
24. Feussner, JR, Shelburne JD, Bredehoeft S, Cohen HJ: Arsenic-induced bone marrow toxicity: ultrastructural and electron-probe analysis. Blood 1979;53:820–827
25. Spahn DR, Schoenrath F, Spahn GH, Seifert B, Stein P, Theusinger OM, et al: Effect of ultra-short-term treatment of patients with iron deficiency or anaemia undergoing cardiac surgery: a prospective randomised trial. Lancet 2019;393:2201–2212
26. Koch CG, Li L, Sun Z, Hixson ED, Tang AS, Phillips SC, et al: From Bad to Worse: Anemia on Admission and Hospital-Acquired Anemia. J Patient Saf 2017;13:211–216
27. Salisbury AC, Reid KJ, Alexander KP, Masoudi FA, Lai SM, Chan PS, et al: Diagnostic blood loss from phlebotomy and hospital-acquired anemia during acute myocardial infarction. Arch Intern Med 2011;171:1646–1653
28. Neef V, Himmele C, Piekarski F, Blum LV, Hof L, Derwich W, et al: Effect of using smaller blood volume tubes and closed blood collection devices on total blood loss in patients undergoing major cardiac and vascular surgery. Can J Anaesth 2024;71:213–223
29. Siegal DM, Belley-Côté EP, Lee SF, Hill S, D'Aragon F, Zarychanski R, et al: Small-Volume Blood Collection Tubes to Reduce Transfusions in Intensive Care: The STRATUS Randomized Clinical Trial. JAMA 2023;330:1872–1881
30. François T, Charlier J, Balandier S, Pincivy A, Tucci M, Lacroix J, et al: Strategies to Reduce Diagnostic Blood Loss and Anemia in Hospitalized Patients: A Scoping Review. Pediatr Crit Care Med 2023;24:e44–e53
31. Weber CF, Görlinger K, Meininger D, Herrmann E, Bingold T, Moritz A, et al: Point-of-care testing: a prospective, randomized clinical trial of efficacy in coagulopathic cardiac surgery patients. Anesthesiology 2012;117:531–547
32. Meybohm P, Choorapoikayil S, Wessels A, Herrmann E, Zacharowski K, Spahn DR: Washed cell salvage in surgical patients: A review and meta-analysis of prospective randomized trials under PRISMA. Medicine (Baltimore) 2016;95:e4490
33. Holst LB, Petersen MW, Haase N, Perner A, Wetterslev J: Restrictive versus liberal transfusion strategy for red blood cell transfusion: systematic review of randomised trials with meta-analysis and trial sequential analysis. BMJ 2015;350:h1354
34. Brunskill SJ, Millette SL, Shokoohi A, Pulford EC, Doree C, Murphy MF, et al: Red blood cell transfusion for people undergoing hip fracture surgery. Cochrane Database Syst Rev 2015: CD009699
35. Carson JL, Sieber F, Cook DR, Hoover DR, Noveck H, Chaitman BR, et al: Liberal

versus restrictive blood transfusion strategy: 3-year survival and cause of death results from the FOCUS randomised controlled trial. Lancet 2015;385:1183–1189

36. Bundesärztekammer: Querschnitts-Leitlinien zur Therapie mit Blutkomponenten und Plasmaderivaten – Gesamtnovelle 2020. URL: https://www.wbbaek.de/fileadmin/user_upload/_old-files/downloads/pdf-Ordner/MuE/Querschnitts-Leitlinien_BAEK_zur_Therapie_mit_Blutkomponenten_und_Plasmaderivaten-Gesamtnovelle_2020.pdf (Accessed on: 12.03.2025).

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