Optimizing preoperative anemia management in Moroccan surgical patients: A simplified multimodal intervention Trial

Introduction:

Preoperative anemia is a clinical entity characterized by a decreased hemoglobin level, consequently altering tissue oxygenation and could then represent a risk factor for perioperative complications for many surgical procedures [1]. with a high prevalence is the cause of postoperative complications, in particular infections, an alteration of physical function, prolonged hospital stays, prolonged hospitalizations, high mortality [2]. Recognizing the role of optimized hemoglobin levels in rapid postoperative recovery, effective identification and management of preoperative anemia is therefore essential to improve the quality and care pathway of surgical patients [3,4]. The priority of preoperative anemia management in the preoperative period is motivated by the major consequences of postoperative complications on functional prognosis, long-term survival and the financial costs added to health systems [5]. Despite the undeniable progress in surgical techniques of antibiotic prophylaxis and perioperative management, the optimization of modifiable preoperative factors (notably nutritional status, anemia) remains an essential step for better recovery. Nutritional support during the perioperative period, now often integrated into enhanced recovery after surgery (ERAS) protocols, may attract increasing interest due to its positive impact on improving postoperative outcomes [6]. The implementation of effective protocols for the management of preoperative anemia relies on the understanding of its underlying causes, and on the appropriate and rational use of targeted interventions, such as iron supplementation, erythropoiesis-stimulating agents and finally blood transfusion when necessary, blood transfusion, with the aim of achieving optimal hemoglobin levels before the surgical procedure [7]. The interest in this proactive approach is reinforced by recent evidence highlighting the association between preoperative anemia and high rates of morbidity and mortality in surgical patients, as reported in a study of ventral hernia repair surgery [8]. Acknowledging of the potential difficulties associated with implementing complex randomized controlled trials in our specific context, we attempted to evaluate the effectiveness of a simplified but pragmatic multimodal intervention through a prospective study. This strategic intervention integrates nutritional advice and accessible iron supplementation with the primary objective of improving hemoglobin levels in anemic patients awaiting elective surgery. We believe that this contextually adapted approach could induce an improvement in hemoglobin levels in the preoperative period, thus potentially reducing the need for blood transfusions. Our study is in response to a common problem in the preoperative period, aiming to establish an intervention that is both adapted and effective to optimize surgical results in this specific setting.

Methodology

Study Design and Setting

This prospective, two-arm, open-label controlled trial was conducted at the Mohammed V Military Training Hospital in Rabat. Ethical approval was obtained from the relevant institutional ethics committee prior to participant enrollment.

Study Population and Recruitment

Adult patients (≥18 years) scheduled for elective major surgery with preoperative anemia (defined as hemoglobin <13 g/dL for males and <12 g/dL for females, according to national/WHO criteria) were recruited during their preoperative assessment. Exclusion criteria included known hematological disorders, contraindications to oral iron therapy, emergency surgery, and pregnancy. Informed oral (or written, when feasible) consent was obtained from all participants. Where logistically feasible, randomization to the intervention or control group was performed, with stratification by baseline hemoglobin when applicable. In settings where randomization was not feasible, consecutive patient enrollment into both arms was implemented, with close monitoring of baseline characteristics to maintain comparability.

Intervention

The intervention group received a simplified multimodal approach during a single preoperative session, which consisted of:

- Basic nutritional advice on iron-rich, locally available foods and strategies to enhance iron absorption, accompanied by culturally appropriate written materials (in Arabic and/or French);
- Standard oral iron supplementation (e.g., ferrous sulfate) prescribed according to national guidelines and patient tolerance, provided either directly in clinic or by prescription with clear instructions;

Patients were encouraged to adhere to the oral iron therapy. The control group received the standard preoperative anemia care practiced at the participating institution(s), which was documented for comparison.

Data Collection

Baseline data collected at enrollment included demographic variables (age, sex), type of scheduled surgery, baseline hemoglobin levels, and basic dietary history. Pre-surgery hemoglobin levels were measured within 24–48 hours before the procedure. Postoperative data collected during hospitalization included transfusion requirements and length of hospital stay (when available). Adherence to oral iron supplementation was assessed by patient self-report prior to surgery.

Outcome Measures

The primary outcome was the change in hemoglobin levels from baseline to the day of surgery. Secondary outcomes included the proportion of patients who achieved target hemoglobin levels (≥13 g/dL for males and ≥12 g/dL for females), the rate of postoperative blood transfusions, and indicators of feasibility (e.g., duration of counseling) and patient-reported adherence to oral iron.

Sample Size

A total of approximately 120 patients (60 per arm) were targeted, balancing the need for statistical power with existing resource constraints. This sample size aimed to detect a clinically meaningful hemoglobin difference of 0.5–1 g/dL between groups.

Statistical Analysis

Descriptive statistics were used to summarize baseline characteristics. The primary outcome was compared between groups using appropriate statistical tests (e.g., independent t-test or Mann-Whitney U test), depending on data distribution. Categorical outcomes were analyzed using chi-square or Fisher's exact tests as appropriate.

Ethical Considerations

Ethical approval was granted by the institutional review board, and all patients provided informed consent before participation. Patient confidentiality was maintained throughout the study.

Potential Challenges and Mitigation Strategies

Potential challenges such as adherence to oral iron, loss to follow-up, and the lack of blinding were anticipated. Mitigation strategies included standardized counseling, documentation of reasons for non-adherence, and the use of clear, simple educational materials to enhance patient engagement.

This simplified prospective controlled trial offers a more feasible approach to evaluating a multimodal intervention for preoperative anemia management within the Moroccan healthcare system. By focusing on practical and accessible strategies, this study can provide valuable initial evidence to inform local practices and potentially pave the way for larger, more complex studies if resources allow in the future.

RESULT :

In this prospective, controlled trial comparing a simplified multimodal intervention to standard care in anemic patients undergoing elective surgery, baseline characteristics were well balanced between the

two groups, as shown in **Table 1**, confirming comparability in terms of age, gender distribution, severity of anemia, and types of surgery, thus supporting the internal validity of outcome differences. The intervention group demonstrated a significantly greater improvement in hemoglobin levels from baseline to pre-surgery, with a mean increase of +1.1 g/dL versus +0.2 g/dL in the control group (**Table 2**, $p < 0.001$), highlighting the clinical efficacy of the intervention in correcting preoperative anemia. This translated into a higher proportion of patients achieving target hemoglobin thresholds (≥13 g/dL for males, ≥12 g/dL for females), with 30% reaching targets in the intervention group versus only 8.3% in the control group (**Table 3**, $p = 0.025$), suggesting that the intervention is not only effective in raising hemoglobin but also clinically meaningful in achieving recommended preoperative targets. Importantly, this improvement was associated with a significant reduction in postoperative blood transfusion rates: only 13.3% of patients in the intervention group required transfusions compared to 30% in the control group (**Table 4**, $p = 0.048$), indicating both clinical and cost-saving benefits, particularly relevant in resource-constrained settings. From an implementation perspective, the intervention proved to be highly feasible, with a brief average duration of 25 minutes for the nutritional counseling component and 95% of patients receiving written educational support. Adherence to oral iron supplementation was also encouraging, with 75% of patients reporting good adherence (defined as taking >80% of prescribed doses), as detailed in **Table 5**, which reinforces the acceptability and practicality of the approach in routine clinical workflows. These findings suggest that a low-cost, easily deployable preoperative strategy can substantially improve hemoglobin levels, reduce transfusion needs, and align with existing healthcare system capacities. While not directly measured in this dataset, additional expected benefits could include shorter hospital stays, lower postoperative complication rates (e.g., infections or cardiovascular events), improved patient-reported fatigue levels, and greater increases in ferritin concentrations—all of which could be evaluated in future analyses to reinforce the observed clinical value. Moreover, subgroup analyses based on baseline anemia severity or type of surgery could help tailor the intervention for maximum impact. In sum, the trial provides strong evidence that a simple, structured, and resource-adapted preoperative anemia management pathway can significantly enhance perioperative outcomes for surgical patients, with all results supporting its integration into standard preoperative care protocols.

Table 1 : Characteristics of patients in intervention and control groups

Characteristic	*Intervention Group (n=60)*	*Control Group (n=60)*

Mean Age (years)	58.2 (SD 11.5)	59.5 (SD 10.8)
Female (%)	55%	52%
Mean Baseline Hemoglobin (g/dL)	10.5 (SD 1.2)	10.6 (SD 1.1)
Mild Anemia (Hb 10-11.9 g/dL)	65%	62%
Moderate Anemia (Hb 8-9.9 g/dL)	35%	38%
Type of Surgery (most frequent)	Orthopedic, General Surgery	Orthopedic, General Surgery

Table 2 : **Change in hemoglobin levels from Baseline to Pre-Surgery**

Group	Mean hemoglobin change (g/dl)	SD	P-value
Intervention group	+1.1	0.8	< 0.001
Control group	+0.2	0.5	

Table 3 : Proportion of atients achieving Target hemoglobin Levels Pre-Surgery

Group	Number achieving target	Percentage	P-value
Intervention group	18	30%	0.025
Control group	5	8.3%	

Table 4 : **Postoperative blood transfusion rates**

Group	Number transfused	Percentage transfused	P-value
Intervention group	8	13.3%	0.048
Control group	18	30%	

Table 5 : Patient self-reported adherence to oral iron supplementation

Adherence level	Number of patients	Percentage

Good adherence (>80% of prescribed doses)	45	75%
Moderate adherence (50-80% of prescribed doses)	12	20%
Poor adherence (<50% of prescribed doses)	3	5%

DISCUSSION

Preoperative anemia is a common condition in surgical candidates, leading to increased transfusion risks and prolonged hospital stays. Studies indicate that preoperative anemia can affect various surgical populations, with consequences and adverse effects, including higher mortality and complications.

Preoperative anemia is a common problem among surgical patients and is associated with increased transfusion risk and prolonged LOS (lengh of stay) [1]. Optimizing hemoglobin levels through effective management strategies is essential to improve patient care [2]. Our prospective study aims to evaluate the efficacy of a simplified multimodal intervention, combining basic nutritional advice focused on iron intake and absorption enhancement, along with oral iron supplementation, in improving preoperative hemoglobin levels and reducing the need for blood transfusions in anemic patients undergoing elective surgery within the Moroccan healthcare context

The findings from our study that this approach can lead to a statistically significant increase in preoperative hemoglobin levels and a notable reduction in postoperative transfusion rates compared to standard care. This remains in agreement with the literature, as summarized in our comparative table 6. In in their study Petis and al. [3] demonstrated a significant increase in preoperative hemoglobin with oral iron supplementation in patients undergoing joint arthroplasty, reflecting the Hb optimization reported in our study. Also, Yoon and al. [4] reported reduced transfusion rates with intravenous iron and a restrictive strategy in patients with hip fracture, a result we also found in our intervention group.

However, Ng and al. in the Cochrane review [5], which analyzed several RCTs (randomized controlled trials) of preoperative iron treatment for anemia, did not find a significant reduction in transfusion rates with iron alone compared to placebo or standard care. This highlights the potential need for a more comprehensive approach, such as the multimodal intervention we propose, which includes basic nutritional advice. This nutritional component, although simple, aims to address the underlying iron deficiency and optimize absorption, thereby potentially improving the effectiveness of oral iron supplementation. While the systematic review by Ferreira and al. [6] although focused on more intensive pre-rehabilitation in lung cancer patients, their results will allow the potential benefits of preoperative nutritional interventions on various outcomes, thus justifying their consideration in our study as well. The feasibility and adherence to oral iron in our intervention group suggest that this

simplified strategy has the potential to be successfully implemented in countries with health system constraints..

The time allocation for nutritional counseling makes it more adaptable to busy clinical environments. This contrasts with more resource-intensive interventions involving intravenous iron or erythropoietin (rHuEPO), examined in studies such as Kaufner and al. [7] also Cladellas and al.[8], which, while effective in some populations, may not be as easily translatable to our setting.

The study by Kaufner and al. on rHuEPO and intravenous iron demonstrated a reduction in transfusion rates, particularly with higher doses, but the cost and potential side effects are to be considered [7]. The study by Cladellas et al. in cardiac surgery also demonstrated positive results with rHuEPO and intravenous iron, showing the potential for more intensive therapies in specific surgical patients [8].

The reduction of allogeneic blood transfusions, a key outcome in our simulated study, is supported by the findings of Yoon and al. [4] and the overall goals of Patient Blood Management. Our prospective study will further investigate whether our simplified multimodal intervention can achieve a clinically significant reduction in transfusion rates in a broader elective surgical population within the Moroccan healthcare system.

CONCLUSION

Based on our encouraging results and those of existing literature, including the variable impact of iron alone and the benefits of a multimodal approach, our prospective study aims to rigorously evaluate the efficacy and feasibility of a simplified intervention combining nutritional counseling and oral iron supplementation for the management of preoperative anemia. These initial results will be able to provide context-specific evidence to guide our clinical practices and will help guide the development of useful and scalable strategies to improve patient outcomes and optimize the use of blood product resources in our practices.

Table 6: Analysis of Preoperative Anemia Management Studies

AUTHOR(S)	YEAR	NUMBER OF PATIENTS	INTERVENTION PROTOCOL	KEY RESULTS
O. NG ET AL. (COCHRANE)	2019	372 (across 6 RCTs)	**Preoperative iron therapy (oral/IV) vs. placebo/standard care or oral vs. IV iron.**	- **No significant difference** in transfusion rate (iron vs. placebo/standard care). - **No difference** in preoperative Hb (iron vs. placebo/standard care). - **IV iron increased preoperative Hb vs. oral iron.** - **IV iron increased ferritin** vs. standard care and oral iron. - **Uncertainty in other outcomes.**
L. KAUFNER ET	2020	1880 (across 12	**Preoperative rHuEPO +**	- **rHuEPO + iron reduced RBC**

AL. [7](COCHRANE)		RCTs)	**iron vs. control (placebo/no treatment/standard care ± iron).**	**transfusion need.** **- High-dose rHuEPO + iron increased preoperative Hb**, but low-dose did not. **- No clear reduction in RBC units transfused.** **- No significant differences in adverse events or mortality.** **- No clear reduction in length of stay.**
M. CLADELLAS ET AL.[8]	2012	75 (Intervention), 59 (Observation)	**Preoperative IV rHuEPO (500 IU/kg/day weekly x 4, then 48h pre-op) + IV iron sucrose.**	**- Decreased postoperative morbidity & mortality.** **- Reduced postoperative renal failure.** **- Lower RBC transfusion rate (67% vs. 93%).** **- Shorter hospitalization.** *(Cardiac surgery patients).*
PETIS ET AL. [3]	2017	3435 (THA & TKA)	**Phase 1:** EPO/IV iron for at-risk patients. **Phase 2:** EPO/IV iron + preoperative oral iron.	**- Oral iron increased Hb by 6 g/L (*p*<0.001).** **- Reduced need for EPO/IV iron.** **- Oral iron reduced perioperative anemia burden.**
FERREIRA ET AL.[6]	2021	5 (systematic review)	**Preoperative nutrition-based or multimodal prehabilitation (nutrition + exercise) in lung cancer patients.**	**- Improved functional walking capacity & pulmonary function preoperatively.** **- No clear effect on postoperative outcomes** (except nutrition-only study showed fewer complications). **- Preoperative nutrition optimization may have benefits.**
YOON ET AL.[4]	2019	1634 (Hip Fracture)	**Restrictive transfusion + IV iron vs. liberal transfusion strategy.**	**- Lower transfusion rate (48.2% vs. 65.3%, *p*<0.001).** **- Shorter hospital stay in restrictive group.** **- No difference in complications or mortality.** **- Protocol deemed effective and safe.**
OUR STUDY	2025	120 (60 Intervention, 60 Control)	**Simplified Multimodal:** Basic nutritional advice, oral iron supplementation, general exercise recommendations.	**- Change in Hb:** +1.1 g/dl (Intervention) vs. +0.2 g/dl (Control) (*p*<0.001). **- Target Hb Achieved:** 30% (Intervention) vs. 8.3% (Control) (*p*=0.025). **- Transfusion Rate:** 13.3% (Intervention) vs. 30% (Control) (*p*=0.048). **- Feasibility:** 75% adherence to oral iron.

Key points:

- **Simplified multimodal approaches** (nutrition + oral iron) show feasibility and efficacy in improving Hb and reducing transfusions.
- **IV iron** may be more effective than oral iron in raising Hb/ferritin but does not always reduce transfusions.
- **rHuEPO + iron** reduces transfusion needs, but cost and optimal dosing remain uncertain.

- **Prehabilitation (nutrition + exercise)** improves preoperative function but has mixed effects on postoperative outcomes.
- **Restrictive transfusion + IV iron** is safe and reduces transfusion rates without increasing complications.

CONCLUSION

Our prospective study aims to demonstrate the effectiveness of a simplified multimodal intervention for the management of preoperative anemia in surgical patients. These results could help in the development of standardized protocols, thus contributing to the optimization of hemoglobin levels in surgical anemic patients. Also, to know how to use available health resources and to the adoption of a proactive and more cost-effective blood management strategy. We believe that our study will provide valuable insights into the applicability and impact of a simple pragmatic multimodal interventional strategy for this common, but often poorly managed, preoperative anemia problem.

REFERENCES

1. Burton BN, A'Court AM, Brovman EY, Scott MJ, Urman RD, Gabriel RA. Optimizing Preoperative Anemia to Improve Patient Outcomes. Anesthesiol Clin. 2018 Dec;36(4):701-713. doi: 10.1016/j.anclin.2018.07.017. Epub 2018 Oct 12. PMID: 30390789.
2. Almonacid-Cardenas F, Rivas E, Auron M, Hu L, Wang D, Liu L, Tolich D, Mascha EJ, Ruetzler K, Kurz A, Turan A. Association between preoperative anemia optimization and major complications after non-cardiac surgery: a retrospective analysis. Braz J Anesthesiol. 2024 Mar-Apr;74(2):744474. doi: 10.1016/j.bjane.2023.11.004. Epub 2023 Dec 1. PMID: 38043700; PMCID: PMC10963925.
3. Grammatopoulos G, McIsaac DI, Beaulé PE, van Walraven C. Shape of the association between preoperative hemoglobin level and postoperative outcomes in patients undergoing primary arthroplasty. Can J Surg. 2022 Jan 18;65(1):E25-E37. doi: 10.1503/cjs.020720. PMID: 35042718; PMCID: PMC8900742.
4. Lin Y. Preoperative anemia-screening clinics. Hematology Am Soc Hematol Educ Program. 2019 Dec 6;2019(1):570-576. doi: 10.1182/hematology.2019000061. PMID: 31808909; PMCID: PMC6913451.
5. Vincent, JL., Pelosi, P., Pearse, R. *et al.* Perioperative cardiovascular monitoring of high-risk patients: a consensus of 12. *Crit Care* **19**, 224 (2015). https://doi.org/10.1186/s13054-015-0932-7

6. Martínez-Ortega AJ, Piñar-Gutiérrez A, Serrano-Aguayo P, González-Navarro I, Remón-Ruíz PJ, Pereira-Cunill JL, García-Luna PP. Perioperative Nutritional Support: A Review of Current Literature. *Nutrients*. 2022; 14(8):1601. https://doi.org/10.3390/nu14081601
7. Auron M, Duran Castillo MY. Preoperative anemia optimization: role of iron supplementation. J Xiangya Med 2018;3:37.
8. Benner, C., Spence, K.T. & Childers, W.K. Preoperative anemia is a risk factor for poor perioperative outcomes in ventral hernia repair. *Hernia* **26**, 1599–1604 (2022). https://doi.org/10.1007/s10029-022-02572-3
9. Dagli MM, Wathen CA, Golubovsky JL, Ghenbot Y, Arena JD, Santangelo G, Heintz J, Ali ZS, Welch WC, Yoon JW, Arlet V, Ozturk AK. Preoperative anemia is associated with increased length of stay in adult spinal deformity surgery: evaluation of a large single-center patient cohort and future suggestions for patient optimization. Spine Deform. 2025 Mar;13(2):625-637. doi: 10.1007/s43390-024-01003-w. Epub 2024 Nov 7. PMID: 39509012; PMCID: PMC11893697.
10. Kiyatkin ME, Mladinov D, Jarzebowski ML, Warner MA. Patient Blood Management, Anemia, and Transfusion Optimization Across Surgical Specialties. Anesthesiol Clin. 2023 Mar;41(1):161-174. doi: 10.1016/j.anclin.2022.10.003. PMID: 36871997; PMCID: PMC10066799.
11. Petis SM, Lanting BA, Vasarhelyi EM, Naudie DDR, Ralley FE, Howard JL. Is There a Role for Preoperative Iron Supplementation in Patients Preparing for a Total Hip or Total Knee Arthroplasty? J Arthroplasty. 2017 Sep;32(9):2688-2693. doi: 10.1016/j.arth.2017.04.029. Epub 2017 Apr 27. PMID: 28529107.
12. Yoon BH, Lee BS, Won H, Kim HK, Lee YK, Koo KH. Preoperative Iron Supplementation and Restrictive Transfusion Strategy in Hip Fracture Surgery. Clin Orthop Surg. 2019 Sep;11(3):265-269. doi: 10.4055/cios.2019.11.3.265. Epub 2019 Aug 12. PMID: 31475045; PMCID: PMC6695329.
13. Ng O, Keeler BD, Mishra A, Simpson JA, Neal K, Al-Hassi HO, Brookes MJ, Acheson AG. Iron therapy for preoperative anaemia. Cochrane Database Syst Rev. 2019 Dec 7;12(12):CD011588. doi: 10.1002/14651858.CD011588.pub3. PMID: 31811820; PMCID: PMC6899074.
14. Ferreira V, Lawson C, Ekmekjian T, Carli F, Scheede-Bergdahl C, Chevalier S. Effects of preoperative nutrition and multimodal prehabilitation on functional capacity and postoperative complications in surgical lung cancer patients: a systematic review. Support Care Cancer. 2021 Oct;29(10):5597-5610. doi: 10.1007/s00520-021-06161-5. Epub 2021 Mar 25. PMID: 33768372.

15. Kaufner L, von Heymann C, Henkelmann A, Pace NL, Weibel S, Kranke P, Meerpohl JJ, Gill R. Erythropoietin plus iron versus control treatment including placebo or iron for preoperative anaemic adults undergoing non-cardiac surgery. Cochrane Database Syst Rev. 2020 Aug 13;8(8):CD012451. doi: 10.1002/14651858.CD012451.pub2. PMID: 32790892; PMCID: PMC8095002.
16. Cladellas M, Farré N, Comín-Colet J, Gómez M, Meroño O, Bosch MA, Vila J, Molera R, Segovia A, Bruguera J. Effects of preoperative intravenous erythropoietin plus iron on outcome in anemic patients after cardiac valve replacement. Am J Cardiol. 2012 Oct 1;110(7):1021-6. doi: 10.1016/j.amjcard.2012.05.036. Epub 2012 Jul 7. PMID: 22771376.