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Peri-Operative Anemia and Blood Transfusion in Patients Undergoing Primary CABG Surgery: A Retrospective Study

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Abstract

Background: Pre-operative anemia is prevalent among patients undergoing coronary artery bypass grafting (CABG) and poses significant risks due to its impact on oxygen transport and surgical outcomes. This study investigates the incidence of pre-operative anemia in CABG patients and its association with peri-operative blood product transfusions. **Methods:** A retrospective review was conducted at Cleveland Clinic Abu Dhabi, analyzing medical records of 100 patients who underwent primary CABG from December 2023 to May 2024. Pre-operative hemoglobin levels were assessed, and anemia was classified per WHO criteria. We documented treatment strategies, intra-operative and post-operative blood product transfusions, and performed multivariate regression analysis to evaluate the impact of pre-operative anemia on post-operative hemoglobin levels. **Results:** The cohort comprised predominantly male patients (9:1 ratio), with 36% presenting with pre-operative anemia. Despite its prevalence, only 5.5% received pre-operative treatment. Post-operatively, 91% of patients remained anemic, increasing to 97% by discharge. Anemic patients had higher transfusion rates, with 36% receiving intra-operative packed red blood cells (PRBCs) compared to 6% of non-anemic patients. This trend continued post-operatively (44% vs. 19%). Non-PRBC blood product usage was also higher in non-anemic patients during surgery. **Conclusion:** The findings highlight a critical need for improved screening and management of pre-operative anemia in CABG patients. Addressing this issue could enhance patient outcomes and reduce transfusion-related complications. Implementing standardized anemia management protocols in pre-operative care pathways is essential for optimizing surgical results and resource utilization. Further research across multiple centers is warranted to validate these findings and enhance clinical practices.

Keywords

CABG, Anemia, Cardiac Surgery, Transfusion

1. Introduction

Pre-operative anemia, characterized by reduced levels of hemoglobin in the blood, is a prevalent and concerning issue in patients scheduled for primary coronary artery bypass grafting (CABG) surgery. Anemia, which impairs the blood's capacity to transport oxygen efficiently, poses significant risks for this high-risk surgical population. In the context of coronary artery disease (CAD), where patients often have compromised myocardial oxygen supply due to narrowed coronary arteries, anemia exacerbates the already delicate balance between oxygen demand and supply. The presence of pre-operative anemia can lead to increased intraoperative blood loss and a higher need for blood transfusions, both of which can complicate surgical outcomes and recovery [1]. Understanding the pathophysiology of anemia in CAD patients, including the roles of chronic inflammation, renal impairment, and nutritional deficiencies, is critical for developing effective strategies to manage anemia and optimize patient outcomes in CABG surgery.

Looking at the pathophysiology of the condition, Anemia in CAD patients is multifactorial and often involves a combination of chronic disease effects and specific physiological changes. One of the primary mechanisms is the reduced production of red blood cells due to inflammatory cytokines commonly elevated in CAD. These cytokines, such as tumor necrosis factor-alpha (TNF-alpha) and interleukin-6 (IL-6), can suppress erythropoiesis and lead to anemia of chronic disease (ACD) [2]. In ACD, iron metabolism is disrupted, with iron sequestered in macrophages and decreased availability for erythropoiesis, despite adequate or even elevated body iron stores.

Moreover, patients with CAD often have comorbid conditions such as chronic kidney disease (CKD), which further contributes to anemia. The kidneys produce erythropoietin, a hormone essential for red blood cell production. In CKD, impaired renal function leads to decreased erythropoietin levels, exacerbating anemia [3].

Additionally, nutritional deficiencies, such as iron, vitamin B12, and folate deficiencies, can also play a role. These deficiencies can result from poor dietary intake or malabsorption, complicating the anemia observed in CAD patients. The interplay between these factors can create a complex anemia scenario that affects the patient's overall health status and surgical risk [4].

In this study, we are describing the incidence of anemia in patients undergoing a primary CABG surgery in a tertiary hospital in the United Arab Emirates, as well as highlighting the current practice of peri-operative anemia management, and if that is affecting the intra- and post-operative blood products

transfusion.

2. Methods

This retrospective study was conducted at Cleveland Clinic Abu Dhabi (CCAD), a tertiary referral center specializing in cardiac surgery, to investigate the correlation between pre-operative anemia and the administration of blood products during and after primary CABG surgery. We reviewed the medical charts of 100 patients who underwent primary CABG surgery over a six-month period from December 2023 to May 2024. Inclusion criteria required patients to have undergone primary CABG surgery with complete pre-operative and post-operative medical records. Exclusion criteria excluded those who had re-operative CABG or major concurrent procedures, as well as patients with incomplete records affecting the study variables.

The data was extracted manually from EPIC (Verona, Wisconsin, United States) by the primary investigator, and revised by the data coordinator in the cardiac surgery department. Data extraction focused on several key variables such as intra- and post-operative use of blood products, hemoglobin levels at different perioperative phases, as well as detailed demographics (age, sex, body mass index, and body surface area). Pre-operative hemoglobin levels were recorded when the patients first had a blood test in preparation for surgery, and on the morning of surgery, and anemia was classified according to WHO criteria: hemoglobin < 13 g/dL for men and < 12 g/dL for women [5]. For patients identified with anemia, we documented the management strategy employed, which included iron supplementation, vitamin B12 and Folic acid supplements, erythropoietin administration, or no treatment. Additionally, we recorded any intra- or post-operative transfusion of blood products, including Packed Red Blood Cells (PRBCs), Fresh Frozen Plasma (FFP), platelets, Prothrombin Complex Concentrate (PCC), Fibrinogen, and other blood products.

Post-operative hemoglobin levels were documented immediately after surgery, before discharge from the Intensive Care Unit (ICU), and again before discharge from the hospital. Comparative analysis was done to compare pre- and post-operative hemoglobin levels. Associations between anemia treatment and blood product transfusion were assessed. Correlations between pre-operative hemoglobin levels and the type and amount of blood products administered were evaluated as well. All the collected data was then revised by a biostatistician from the hospital, a Fischer's test was used to obtain the statistical significance of the results, and a p-value < 0.05 was determined to be statistically significant.

The study was conducted in compliance with ethical standards approved by CCAD's Institutional Review Board (IRB), and written informed consent was obtained. Given the retrospective nature of the study, it was exempt from obtaining informed consent from individual patients. All patient data were de-identified to ensure confidentiality. Limitations of the study include its retrospective design and the potential lack of generalizability beyond the study setting.

3. Results

In our retrospective study, we found several noteworthy patterns. The study cohort predominantly consisted of male patients, with a notable ratio of 9:1 male to female. The age distribution varied, with 18% of patients being over 65 years old, 40% between 55 and 65 years, 33% between 45 and 55 years, and 9% under 45 years (Figure 1). The prevalence of obesity in the cohort was also significant: 25% of patients had a BMI ranging from 30 to 35, but only 3% had a BMI exceeding 35.

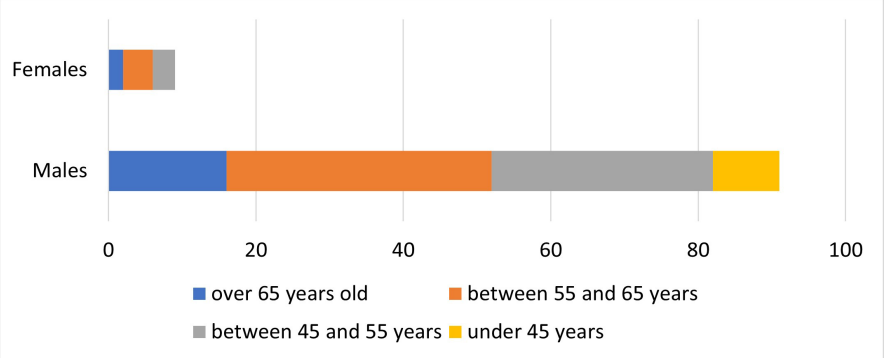

Figure 1. Demographic distribution chart showing the male-to-female ratio (9:1) and age distribution. This highlights the demographic characteristics of the cohort.

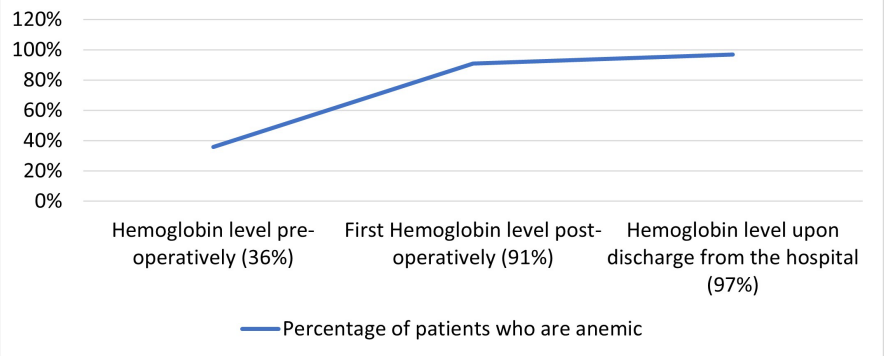

Figure 2. Progression of anemia in the patient cohort from the pre-operative to post-operative periods (immediately after surgery and at discharge).

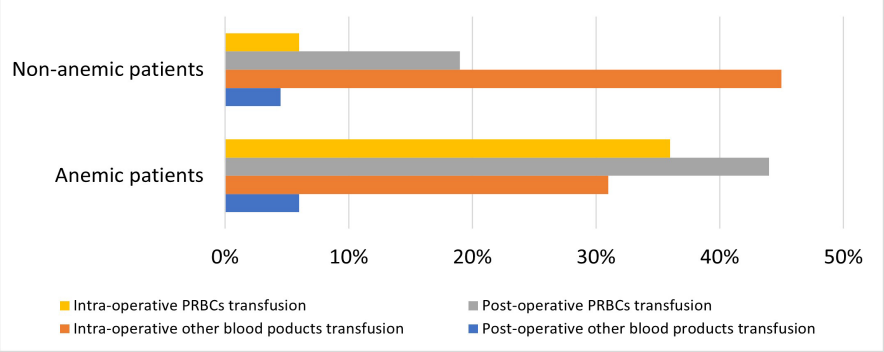

Figure 3. Grouped bar chart comparing intra-operative and post-operative PRBC and other blood products transfusion rates between anemic and non-anemic patients.

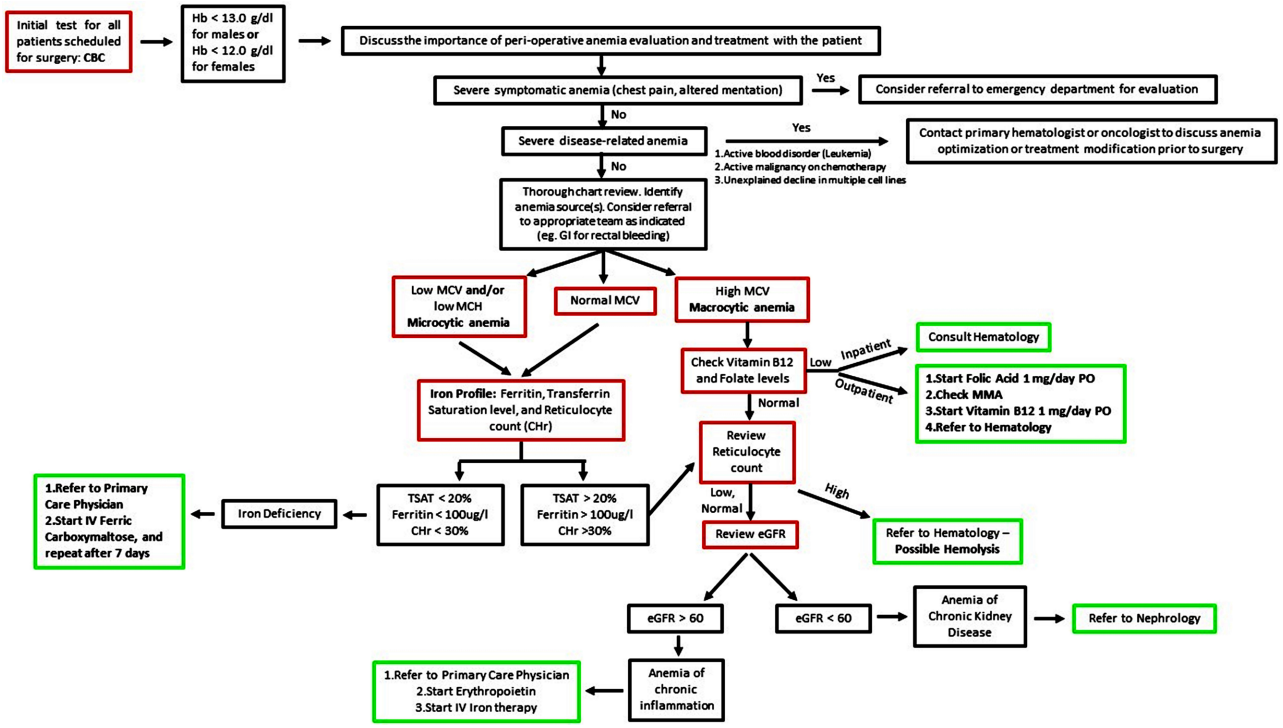

Figure 4. Suggested pre-operative anemia workup and management protocol.

A key finding was the high prevalence of pre-operative anemia, which affected 36% of the patients. Despite the recognized need for managing anemia prior to surgery, only 5.5% of the patients received any form of pre-operative treatment for anemia, which included iron supplements, erythropoietin, or vitamin B complex. Notably, no patient received a combination of all three treatment modalities. Consequently, this limited pre-operative management contributed to a high prevalence of anemia immediately following surgery, which was observed in 91% of patients. By the time of discharge, the prevalence of anemia had increased slightly to 97%, indicating that anemia was not effectively addressed during the post-operative period either (Figure 2). Post-operative treatment for anemia was provided to only 23% of patients, highlighting a potential area for improvement in anemia management.

The study also examined the relationship between anemia and blood product transfusion requirements. The data revealed a marked difference in intra-operative transfusion practices based on anemia status. Specifically, 36% of anemic patients received intra-operative packed red blood cell (PRBC) transfusions, compared to just 6% of non-anemic patients. This disparity continued into the post-operative period, where 44% of anemic patients required PRBC transfusions, in contrast to 19% of non-anemic patients. Using the Fischer's exact test, there was a statistically significant difference between both groups.

In addition to PRBC transfusions, we assessed the use of other non-PRBC blood products such as Fibrinogen, Platelets, Prothrombin Complex Concentrate (PCC), and Fresh Frozen Plasma (FFP). During the intra-operative phase, 31% of anemic

patients received non-PRBC blood products, whereas this was somewhat higher at 45% among non-anemic patients. This suggests a trend where non-PRBC blood product transfusions were more common in non-anemic patients during surgery, potentially due to differences in clinical management or protocols. However, post-operatively, the need for non-PRBC blood products was relatively low in both groups, with 6% of anemic patients and 4.5% of non-anemic patients receiving these products (**Figure 3**).

4. Discussion

This study highlights a significant prevalence of pre-operative anemia in patients undergoing primary coronary artery bypass grafting (CABG) at our tertiary center in the UAE, with 36% of patients affected. These findings align with existing literature that recognizes anemia as a critical factor influencing surgical outcomes in this high-risk population. For instance, studies have shown that pre-operative anemia is associated with increased morbidity and mortality following cardiac surgery [6].

Despite the known risks associated with anemia, only a small fraction (5.5%) of our patients received any pre-operative treatment. This underscores a substantial opportunity for improving patient care. Minimal interventions provided before surgery may explain the exacerbation of anemia post-operatively, where 91% of patients remained anemic immediately after surgery, increasing to 97% by discharge. Previous research has emphasized the need for systematic screening and timely therapeutic interventions, such as iron supplementation and erythropoietin administration, to improve outcomes for anemic patients [7]. However, this should always be tailored according to the urgency of the procedure, and the optimization opportunities available.

Our data reveal a striking correlation between pre-operative anemia and the requirement for blood transfusions. Anemic patients were significantly more likely to receive intra-operative packed red blood cell (PRBC) transfusions (36%) compared to their non-anemic counterparts (6%). This pattern persisted post-operatively, suggesting that anemia raises transfusion needs and may contribute to poorer recovery trajectories. Studies indicate that such transfusion practices are linked to extended hospital stays and increased healthcare costs [8].

Interestingly, our analysis showed that non-PRBC blood product utilization was higher in non-anemic patients during surgery, raising questions about the clinical decision-making processes guiding transfusion practices. This discrepancy may reflect variations in protocols or the underlying clinical conditions of the patients. Further exploration of these practices is warranted to find explanations for this part of the results, which can be re-visited in future follow-ups to this study.

The limitations of our study, including its retrospective design and focus on a single institution, must be acknowledged. This may affect the generalizability of our findings. Future prospective studies across multiple centers could help vali-

date our results and evaluate the effectiveness of standardized pre-operative anemia management protocols [9]-[11].

5. Conclusion

Our findings underscore the urgent need for enhanced anemia screening and management strategies in patients undergoing CABG. Addressing pre-operative anemia could not only improve patient outcomes but also reduce the reliance on blood transfusions, ultimately benefiting healthcare systems through more efficient resource utilization. As we move forward, an integrated anemia management protocol is described in this paper (**Figure 4**), and will be discussed in a multi-disciplinary meeting in the hospital in efforts to implement it.

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Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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Glossary of Terms

CABG	Coronary Artery Bypass Grafting
CAD	Coronary Artery Disease
UAE	United Arab Emirates
ACD	Anemia of Chronic Disease
CKD	Chronic Kidney Disease