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# The Impact of Preoperative Anemia on Postoperative Outcomes in Patients Undergoing Major Abdominal Surgery at Al-Hussein Teaching Hospital, Samawa, Iraq

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## Abstract

**Background:** Preoperative anemia is a global health issue and noted as an independent risk factor for increased postoperative morbidity and mortality among patients undergoing major surgery. However, there is still a lack of data related to specific preoperative anemia's impact in low-resource settings in the Middle East and Iraq. The objective of the present study was to evaluate the rate of preoperative anemia, as well as its effects on postoperative outcomes in patients who underwent major abdominal surgery at Al-Hussein Teaching Hospital, Samawa, Iraq. **Methods:** This was a prospective, observational cohort study conducted over 18 months. Adults undergoing major abdominal surgery were included within the study, and stratified into groups based on whether they were considered as having preoperative anemia as defined by World Health Organization criteria (hemoglobin <13 g/dL for males, <12 g/dL for females). Primary outcomes evaluated were surgical-site infections, pneumonia, acute kidney injury and 30-day mortality, as measured among each of the two groups. Secondary outcomes evaluated were lengths of hospital stay and rates of intensive care unit admissions among the study population. To evaluate any confounding variables, multivariable logistic regression analyses were conducted. **Results:** Among the 420 patients' charts reviewed, there were 210 patients (50%) with preoperative anemia. Patients with preoperative anemia experienced a significantly higher rate of complications overall (45.2% vs. 22.4%, $p < 0.001$), along with significantly greater incidence rates of surgical site infections (18.1% vs. 7.1%, $p = 0.001$), and significantly longer median lengths of hospital stay (9 days vs. 5 days, $p < 0.001$). Additionally, the 30-day mortality rate was also significantly higher in the preoperative anemic cohort (6.7% vs. 1.9%, $p = 0.021$). After adjusting for age, American Society of Anesthesiologists score, malignancy, and operating blood losses, preoperative anemia remained an independent predictor of decreased postoperative outcomes (Adjusted Odds Ratio: 2.45, 95% Confidence Interval: 1.58-3.80, $p < 0.001$). **Conclusions:** The current study demonstrates that preoperative anemia is prevalent in Samawa, Iraq, and is associated with being a strong independent predictor of postoperative morbidity and mortality following major abdominal surgery. Therefore, there is an urgent need for implementation of preoperative screenings and patient blood management programs in this area of the world.

## Keywords:

*Preoperative anemia; Major abdominal surgery; Postoperative complications; Patient blood management; Iraq.*

## Introduction

The World Health Organization characterizes Anemia as a Hemoglobin concentration of less than 13 grams/deciliter among men and less than 12 grams/deciliter among non-pregnant women. This medical condition is considered to be a considerable factor of public health worldwide; Anemia affects approximately a third of the world's population [1]. The prevalence of Preoperative Anemia within a Surgical Setting is highly common as rates among adults requiring Major Non-Cardiac Procedures fall between to 30% and 40%. Public health entails the prevention of illness within the community; precursors to prevent Anemia would be improvement of Neighborhoods with populations who have poor socioeconomic status and limited access to basic healthcare [2,3]. In the Preoperative phase of Surgery, Anemia affects the individual globally. The presence of Hemoglobin deficiencies at the time of surgery create a series of pathologies that could compromise patient safety. Therefore, the physiological basis for how Preoperative Anemia contributes negatively to the patient is related to how the body's ability to deliver oxygen compromised. The normal resting state of the human body has several ways in which mild to moderate Anemia can maintain adequate delivery of Oxygen, for example through tachycardia, increased cardiac output or increased oxygen extraction from tissues. When a patient experiences the metabolic stress caused by surgical procedures (i.e. surgical stress), there are tremendous physiological changes which will severely compromise these compensatory methods of Oxygen delivery [5].

There are many physiologic processes that explain why Preoperative Anemia leads to Increased Surgical Complications Postoperatively. Adequate oxygen supply to tissues is necessary to perform many cellular functions required for successful wound healing; adequate oxygen supply to tissues is also necessary for collagen production and oxidative killing of bacteria by neutrophils [6]. The lowering of hemoglobin levels below adequate levels leads to tissue hypoxia and prevention of proliferations of fibroblasts due to decreased hydroxylation of proline and lysine, two critical components in cross-linking collagen. This results in an increased risk of experiencing wound dehiscence and anastomotic leaks ([7]).

Furthermore, iron deficiency, the leading cause of anemia globally, negatively impacts the individual's immune system. Iron is necessary for ribonucleotide reductase, an enzyme needed for the production of DNA and the proliferation of cells, particularly T and B lymphocytic populations ([8]). Iron-deficient anemic patients have a lower cell-mediated immune response and nonfunctional phagocytes, placing them at an increased risk for developing SSI and full-blown sepsis after surgery ([9]).

The performance of major abdominal surgery creates a one-of-a-kind surgical group subject to severe stress on the patient. Major hepatic resections, pancreatectomies, total gastrectomies and complicated colorectal resections are representative procedures that regularly present with high levels of intraoperative blood loss, prolonged lengths of surgery and large volumes of fluid shifts ([10]). The abdomen contains many critical organs and is crucial for hematopoesis, protein synthesis and immune function. Therefore, surgical manipulation and resection of these types organs tend to exacerbate pre-existing anemias leading to a continuous downward spiral of physiological decline ([11]).

Historically, patients with preoperative anemia who undergo major abdominal surgery have had higher rates of postoperative complications than those who are not anemic. Landmark studies conducted using historical large, multicenter database populations have shown that even

mild levels of preoperative anemia are independently associated with a 30-day postoperative mortality rate that is similar to or in excess of major perioperatively occurring cardiovascular events ([12, 13]). Surgical infections, anastomotic leaks, and pneumonia are just a few of the specific complications that can be caused by preoperative anemia in relation to abdominal surgery. Acute Kidney Injury (AKI), is particularly problematic because the renal medulla lives on the edge of hypoxia during normal relative physiologic functioning. Anemia causes a decrease in the delivery of oxygen. Besides anemia, the other intraoperative factors that may induce AKI include hypotension, surgical stress, and others; therefore, all of these factors play a role in the development of AKI, which is an independent risk factor for both increased length of hospital stay and long-term mortality. Additionally, due to hypovolemia and anemia, the heart must work harder against a higher afterload, which increases the demand for myocardial oxygen while simultaneously reducing supply, thus creating an unhealthy equilibrium that can lead to perioperative ischemia of the heart, especially in older individuals, who have subclinical coronary artery disease.

Due to the large amount of published literature on this topic, many anaesthesia and surgical societies from around the world have endorsed the multi-disciplinary, evidence-based approach known as Patient Blood Management (PBM) programs in order to improve patient outcomes through managing and conserving patients' own blood. There are three components to PBM: (1) Pre-operatively increasing red cell mass using intravenous iron and/or erythropoietin-stimulating agents; (2) Minimizing intraoperative blood loss using blood conservation techniques (i.e. cell salvage, antifibrinolytics, exquisite surgical technique) and (3) Utilizing the physiological tolerance to anemia by employing restrictive transfusion thresholds. Additionally, in developed countries, PBM has been incorporated into Enhanced Recovery After Surgery (ERAS) protocols which have been proven to decrease the incidence of perioperative complications, decrease length of hospital stays and decrease overall healthcare expenditures. Globally, there is a widely accepted agreement that diagnosing and treating pre operative anaemia is an essential component of pre-operative preparation. However, the reality is that there is a vast difference between the prevalence of pre-operative anaemia in high-income countries compared to those in low and middle-income countries (LMICs). There are multiple reasons for the increased occurrence of pre-operative anaemia in LMICs, such as chronic malnutrition, parasitic infection, inadequate dietary intake of iron, a high prevalence of chronic diseases, and a lack of routine pre-operative anemic screening and optimization clinics [21]. In Iraq, as a developing, Middle Eastern country that has faced decades of violence, economic sanctions, and a severely disrupted healthcare system, provides a unique example of the challenges to pre operative anaemia management [22]. Historically, the healthcare system in Iraq has been largely focused on acute care and on managing the acute complications of violence, rather than on preventative health and chronic disease optimization [23].

Epidemiological data from various regions of Iraq have reported disturbingly high rates of iron deficiency anaemia in women of childbearing age and in children, highlighting the significant nutritional deficiencies and overall socio-economic challenges [24,25]. There is however a complete lack of literature focused specifically on the prevalence and impact of pre operative anaemia in the adult surgical population in Iraq. The majority of existing Iraqi surgical literature has focused on trauma outcome data or specific surgical technique data, leaving a large gap in addressing the systematic aspect of pre-operative patient optimization [26].Al-Hussein Teaching Hospital in Samawa is a tertiary referral hospital for a rural/agricultural population. The socio-demographic characteristics of the catchment area suggest that there is a high

prevalence of nutritional deficiency based on inadequate access to primary health care. Additionally, the prevalence of preoperative anemia should be high among the surgical population due to the factors noted above; therefore, preoperative anemia is expected to contribute significantly to the burden of surgery [27].

There is little local data available regarding preoperative anemia; therefore, the lack of evidence makes it difficult to justify the allocation of limited resources to support the establishment of PBM programs, procure intravenous iron, and delay elective surgery for preoperative anemia optimization [28]. Surgical and anesthetic providers in Samawa rely on empirical transfusion guidelines and often resort to transfusing allogeneic blood products whenever the hemoglobin level falls below the defined threshold intraoperatively or postoperatively. This practice does not address the underlying hypoxia associated with chronic anemia, and secondly, exposes the patient to inherent risks associated with blood transfusions including transfusion-related circulatory overload (TACO), transfusion-related acute lung injury (TRALI), and transfusion-related immunomodulation (TRIM); further increasing the risk for surgical site infection and cancer recurrence [29,30].

In that regard, this study will help fill the knowledge gap that exists. The primary aim of this study is to determine the prevalence of preoperative anemia for patients having major abdominal surgery at Al-Hussein Teaching Hospital Samawa, Iraq. Furthermore, the secondary aim of this study is to rigorously investigate the impact of preoperative anemia on postoperative outcomes such as 30-day mortality, incidence of major complications (Surgical site infection, anastomotic leak, pneumonia, acute kidney injury), need for postoperative admission to an intensive care unit (ICU) and total length of hospital stay. This preliminary local epidemiological and clinical evidence can serve as a basis to advocate for the inclusion of Patient Blood Management protocols as the standard of care for surgical practice in southern Iraq, thereby providing the opportunity to reduce perioperative morbidity and mortality within this vulnerable population.

## Methodology

This study on observational cohorts was performed over a duration of 18 months, between January of 2022-June of 2023 at the Department of General Surgery of Al-Hussein Teaching Hospital located in Samawa, Muthanna Governorate, Iraq. Al-Hussein Teaching Hospital is a tertiary care public hospital that provides free surgical care to the residents of Muthanna and surrounding provinces. Approval of the study protocol was received from both the Institutional Review Board as well as the Medical Ethics Committee located at Al-Hussein Teaching Hospital. Prior to entering the study, each patient (or representative where there was not sufficient time to receive written informed consent from them before an emergency surgery), signed a consent form agreeing to be part of the study prior to their participation in the study. This study complied with the Declaration of Helsinki and adhered to all of the guidelines set forth in that document.

All patients 18 years or older who were to undergo a major abdominal surgical procedure under general anesthesia where the estimated OR time would be > 2 hours and would require estimated EB > 500 mLs were included in the target population for this study. A major abdominal surgical procedure is defined as any laparotomy or extensive laparoscopic procedure involving the resection, repair, or bypass of any organ located inside the abdomen. This definition includes, but is not limited to, open and laparoscopic colectomy, anterior resection,

total or partial gastrectomy, Whipple procedure, hepatic resection, small bowel resection, exploratory laparotomy for either bowel obstruction or peritonitis, and radical nephrectomy.

Exclusion criteria have been carefully defined to reduce confounding variables. An example would be patients undergoing an emergency surgery where there was not sufficient time to perform preoperative laboratory testing.Additional criteria for exclusion involved patients who were diagnosed with chronic kidney issues/kidney disease stage 4 or stage 5 (like an estimated glomerular filtration rate of below 30 milliliters per minute per 1.73 square meters of body surface area) or those who regularly receive hemodialysis, which would consider the pathophysiology and management of anaemia at end-stage renal issues as different from other reasons for developing anaemia. Any patient who was experiencing any type of active pre-surgery bleeding (for example, heavy gastrointestinal bleeding) during the time that blood was drawn for analysis would be considered for exclusion from the study. In addition, patients who had known blood-related cancers, patients whose bone marrow was actively being suppressed by receiving chemotherapy treatment within the last 30 days prior to surgery, or known blood-related diseases such as thalassemia major and sickle cell disease should have been excluded so that the effect of gaining anaemia prior to the operation could be isolated. Finally, any patient who refused to have a blood transfusion because of their religious beliefs or because of other personal reasons (for example, a member of the Jehovah Witness religion) would not have been able to be included in the study because it would not be possible to implement logical and standard resuscitation protocols in such situations.

Data on patients before surgery were collected within 48 hours prior and consisted of a complete medical history taken as well as a full physical examination. All of the patients had their respective baseline demographic variables taken which included recording their age, sex, height/weight/bmi (body mass index) measurements. Comorbidity variables were documented in detail by utilising the Charlson Comorbidity Index (CCI) and the patients were classified by their physical status using the American Society of Anaesthesiologists' (ASA) Classification System (Class I- Class IV). Information about the specific type of surgical diagnosis if it was malignant or benign and what type of surgery was planned will be documented.

To assess the first (primary) exposure variable of anaemia preoperatively will have been collected through a complete blood count (CBC) using automated machines designed to test blood samples at the central testing labs located inside the hospital.Blood samples were collected through venous punctures ideally in the outpatient setting, however, in cases where this was not able to be performed, blood samples were taken on admission to the surgical ward prior to surgery. Patients were stratified into an Anemic group according to World Health Organisation (WHO) diagnostic criteria of anemia (less than 13.0 g/dL in males and less than 12.0 g/dL in non-pregnant females) or a Non-anemic (Control) group (hemoglobin levels greater than or equal to these thresholds). To sub-classify the anemia type the mean corpuscular volume (MCV) and the mean corpuscular hemoglobin concentration (MCHC) were used to classify the anemia into microcytic (MCV<80 fL), normocytic (MCV 80-100 fL) and macrocytic (MCV>100 fL). Due to available resources, however, more extensive iron studies (serum ferritin, transferrin saturation) and reticulocyte counts were not available for every patient and were not included in the primary analysis.

Intraoperative data were collected by an independent research assistant (not involved in the patient's clinical care) in order to eliminate bias. Intraoperative markers that were recorded included the type of anesthesia (general and regional combined versus general only), duration of surgery in minutes, estimated blood loss (EBL) estimated by the anaesthetist from the volume in the suction canisters and weight of the surgical sponges, and the amount of intravenous fluids administered.It was the responsibility of the attending anaesthetist and surgeon to decide whether or not to provide patients with an intra-operative allogeneic red blood cell (RBC) transfusion (a standard of practice in the institution). The transfusion of red blood cells was well documented, with respect to the number of units of RBC received.

For post-operative outcomes, data were collected for thirty days following the date of surgery or until the patient was discharged from the hospital (whichever happened first). Patients discharged from the hospital before thirty days had a structured telephone interview conducted to identify any complications that required management outside of the hospital. Medical records of patients with readmissions to Al-Hussein Teaching Hospital were also reviewed. The primary outcome variable was a composite of all major post-operative complications (Clavien-Dindo classification grades II and higher) over thirty days.The specific complications monitored included: 1) Surgical Site Infection (SSI)—as defined by the Centers for Disease Control and Prevention (CDC)—of either a superficial, deep or organ/space infection that developed within the first 30 days postoperatively; 2) Pneumonia was diagnosed with the presence of new/progressive pulmonary infiltrates (on chest X-ray) and signs of infection ( temperature > 100.4 degrees Fahrenheit, presence of purulent sputum, white blood count (WBC) > 12,000, or altered mental status); 3) Acute Kidney Injury (AKI)—as defined by the Kidney Disease: Improving Global Outcomes (KDIGO) as an increase in serum creatinine of >0.3 mg/dL within 48 hours or ≥1.5 times baseline within 7 days postoperatively; 4) Anastomotic Leak—either clinically through intra-abdominal drain output or radiologically through a contrast-enhanced CT scan or water-soluble enema in bowel resection and primary anastomosis patients; 5) 30-day all-cause mortality. Secondary outcome measures evaluated included total length of hospital stay (LOS)—number of days from surgery to discharge—and unanticipated postoperative ICU admission due to hemodynamic instability, respiratory failure or need for invasive hemodynamic monitoring.

Statistical analyses were performed utilizing the IBM Statistical Package for the Social Sciences (SPSS), version 26.0 (IBM Corporation; Armonk, NY; USA). Continuous variables' distributions of normality were evaluated both statistically via the Shapiro-Wilk test and visually via histogram. Normally distributed continuous variable means ± standard deviations (SD) were compared between anemic and non-anemic groups using an independent samples comparison using Student's t-test. Comparisons of non-normally distributed continuous variables (e.g., LOS and Operative Time), expressed as median (with an interquartile range [IQR]), utilized the Mann-Whitney U test. Categorical variables were expressed as frequencies (%) and were compared using either the Chi-square test ($\chi^2$) or Fisher's Exact test; determined by the expected number of counts in that category.

Multivariable logistic regression analyses assessed the independent effect of preoperative anemia on postoperative outcomes while controlling for confounding variables. The dependent variable was any major 30-day postoperative complication (Clavien-Dindo ≥ II). The covariates placed into the model included preoperative anemia status, age (< 60 years vs. ≥ 60 years), American Society of Anesthesiologists' (ASA) physical status (I-II vs. III-IV), malignant versus nonmalignant nature of pathology and intraoperative blood loss (< 500 ml vs.

≥ 500 ml). Logistic regression results were expressed as an adjusted odds ratios (AOR) – together with 95% confidence intervals (CI). A two-tailed p-value < 0.05 was considered statistically significant for all analyses. An a priori sample size estimate was performed using G*Power software at an expected complication rate of 20% In the non-anemic group and 35% in the anemic group, an alpha of 0.05, a power of 80%, and an allocation ratio of 1:1, the minimum sample size required to detect a difference between groups was 352 patients. To allow for potential loss to follow up or incomplete data, we planned to enroll 420 patients.

## Results

During the study period, a total of 450 patients were assessed for eligibility. Thirty patients were excluded based on the predefined criteria (12 due to chronic renal failure on dialysis, 8 due to emergency surgery without prior labs, 6 due to active preoperative bleeding, and 4 due to hematological malignancies). Consequently, 420 patients were enrolled and completed the 30-day follow-up, forming the basis of this analysis. The cohort was divided into two groups: the Anemic Group, comprising 210 patients (50.0%), and the Non-Anemic Group, comprising 210 patients (50.0%).

Table 1 demonstrates the baseline demographic and clinical characteristics of the study population. The mean age was similar between the Anemic Group (54.2 ± 14.1 years) and the Non-Anemic Group (52.8 ± 13.5 years) (p=0.342). The gender distribution showed a slight, but statistically insignificant, female predominance in the Anemic Group (54.8% vs. 45.2%, p=0.091). There were no significant differences in BMI or the prevalence of diabetes mellitus and hypertension between the two groups. However, patients in the Anemic Group had a significantly higher burden of advanced physical status, with 45.7% classified as ASA III or IV compared to 28.1% in the Non-Anemic Group (p<0.001). Furthermore, the proportion of patients undergoing surgery for malignant pathologies was significantly higher in the Anemic Group (61.9% vs. 38.1%, p<0.001).

**Table 1: Baseline Demographic and Clinical Characteristics of Patients Undergoing Major Abdominal Surgery (N=420)**

| Variable | Anemic Group (n=210) | Non-Anemic Group (n=210) | p-value |
|---|---|---|---|
| Age (years), Mean ± SD | 54.2 ± 14.1 | 52.8 ± 13.5 | 0.342 |
| Female Gender, n (%) | 115 (54.8%) | 95 (45.2%) | 0.091 |
| BMI (kg/m²), Mean ± SD | 25.4 ± 3.8 | 25.9 ± 3.5 | 0.158 |
| ASA Status III-IV, n (%) | 96 (45.7%) | 59 (28.1%) | <0.001 |
| Malignant Pathology, n (%) | 130 (61.9%) | 80 (38.1%) | <0.001 |
| Diabetes Mellitus, n (%) | 62 (29.5%) | 54 (25.7%) | 0.411 |
| Hypertension, n (%) | 78 (37.1%) | 71 (33.8%) | 0.498 |

BMI: Body Mass Index; ASA: American Society of Anesthesiologists; SD: Standard Deviation.

Table 2 outlines the intraoperative variables. The median operative duration was significantly longer in the Anemic Group (180 minutes, IQR 140-220) compared to the Non-Anemic Group (150 minutes, IQR 120-190) (p=0.002). Patients with preoperative anemia also experienced significantly higher estimated blood loss, with a median of 600 mL (IQR 400-850) versus 400 mL (IQR 300-600) in the control group (p<0.001). Consequently, the rate of intraoperative allogeneic red blood cell transfusion was markedly elevated in the Anemic Group (42.4% vs. 11.9%, p<0.001).

**Table 2: Intraoperative Variables Stratified by Preoperative Anemia Status**

| Variable | Anemic Group (n=210) | Non-Anemic Group (n=210) | p-value |
|---|---|---|---|
| Operative Duration (min), Median [IQR] | 180 [140 - 220] | 150 [120 - 190] | 0.002 |
| Estimated Blood Loss (mL), Median [IQR] | 600 [400 - 850] | 400 [300 - 600] | <0.001 |
| Intraoperative Transfusion, n (%) | 89 (42.4%) | 25 (11.9%) | <0.001 |

IQR: Interquartile Range.

The postoperative outcomes are detailed in Table 3. The primary outcome, the overall rate of major postoperative complications (Clavien-Dindo ≥ II), occurred significantly more frequently in the Anemic Group compared to the Non-Anemic Group (45.2% vs. 22.4%, p<0.001). Analyzing specific complications, the incidence of surgical site infections was 18.1% in the anemic cohort versus 7.1% in the non-anemic cohort (p=0.001). Acute kidney injury occurred in 14.3% of anemic patients compared to 5.2% of non-anemic patients (p=0.002). Pneumonia was also significantly higher in the presence of anemia (10.5% vs. 4.3%, p=0.018). Among the 198 patients who underwent bowel resection with primary anastomosis, the rate of anastomotic leak was 11.4% in the Anemic Group compared to 4.8% in the Non-Anemic Group (p=0.041). The 30-day all-cause mortality was significantly elevated in patients with preoperative anemia (6.7% vs. 1.9%, p=0.021). Secondary outcomes also demonstrated significant disparities; the median length of hospital stay was 9 days (IQR 6-14) for the Anemic Group compared to 5 days (IQR 4-8) for the Non-Anemic Group (p<0.001). Unplanned ICU admissions were required for 18.1% of anemic patients versus 7.1% of non-anemic patients (p<0.001).

**Table 3: Postoperative Outcomes According to Preoperative Anemia Status**

| Outcome | Anemic Group (n=210) | Non-Anemic Group (n=210) | p-value |
|---|---|---|---|
| Overall Complications (Clavien ≥ II), n (%) | 95 (45.2%) | 47 (22.4%) | <0.001 |
| Surgical Site Infection, n (%) | 38 (18.1%) | 15 (7.1%) | 0.001 |
| Acute Kidney Injury, n (%) | 30 (14.3%) | 11 (5.2%) | 0.002 |
| Pneumonia, n (%) | 22 (10.5%) | 9 (4.3%) | 0.018 |

| | | | |
|---|---|---|---|
| Anastomotic Leak*, n (%) | 15 (11.4%) | 7 (4.8%) | 0.041 |
| 30-Day Mortality, n (%) | 14 (6.7%) | 4 (1.9%) | 0.021 |
| ICU Admission, n (%) | 38 (18.1%) | 15 (7.1%) | <0.001 |
| Length of Stay (days), Median [IQR] | 9 [6 - 14] | 5 [4 - 8] | <0.001 |

*Calculated only for patients who underwent bowel resection with primary anastomosis (Anemic: n=132; Non-Anemic: n=146). ICU: Intensive Care Unit; IQR: Interquartile Range.

To account for the baseline imbalances, particularly the higher proportion of ASA III-IV patients and malignant pathologies in the Anemic Group, a multivariate logistic regression analysis was performed (Table 4). After adjusting for age, ASA status, malignancy, and intraoperative blood loss, preoperative anemia emerged as a strong independent predictor of postoperative complications, with an Adjusted Odds Ratio of 2.45 (95% CI: 1.58–3.80, p<0.001). Other independent predictors included ASA III-IV status (AOR: 2.12, 95% CI: 1.35–3.32, p=0.001) and intraoperative blood loss ≥500 mL (AOR: 1.89, 95% CI: 1.21–2.95, p=0.005).

**Table 4: Multivariate Logistic Regression Analysis for Predictors of Major Postoperative Complications**

| Predictor Variable | Adjusted Odds Ratio | 95% Confidence Interval | p-value |
|---|---|---|---|
| Preoperative Anemia (Yes vs. No) | 2.45 | 1.58 – 3.80 | <0.001 |
| Age ≥ 60 years | 1.34 | 0.86 – 2.09 | 0.193 |
| ASA Status III-IV | 2.12 | 1.35 – 3.32 | 0.001 |
| Malignant Pathology | 1.28 | 0.82 – 2.00 | 0.276 |
| Intraoperative Blood Loss ≥500 mL | 1.89 | 1.21 – 2.95 | 0.005 |

ASA: American Society of Anesthesiologists.

## Discussion

This cohort prospective research clearly establishes the rate of preoperative anemia in major abdominal surgery patients undergoing surgical procedures at Al-Hussein Teaching Hospital in Samawa, Iraq to be substantial with half of the patients in our study being diagnosed with this condition before having their surgery. The data also demonstrate that preoperative anemia is a very strong, independent, predictor of poor postoperative outcomes and increases a patient's risk for surgical site infections, acute kidney injury, pneumonia, anastomotic leaks, 30-day mortality, and longer hospital stays. The evident prevalence of preoperative anemia in this southern Iraqi cohort is significantly higher than reported rates (30% to 40%) found in European and North American – based surgical databases; however, similar rates of preoperative anemia in other low and middle income countries (LMICs), as well as in neighbouring Middle Eastern Countries have been documented [2, 31, 32]. The significant prevalence rate found in

preoperative patients at Al-Hussein Teaching Hospital is most likely a multifactorial consequence of the socio-economic context of Muthanna Governorate. The rural and agrarian communities located in this area face many challenges with regards to nutritional security; therefore, the populations typically do not consume adequate amounts of bio-available iron, vitamin B12, and folate. Furthermore, the high prevalence of chronic inflammatory diseases, the presence of parasitic infections and the overall delay of diagnosis of malignancies (which create anemia of chronic disease) have all contributed and collaborate together to create a major and significant baseline loss of hematological access prior to surgery [21, 24].

The strong independent association shown with this report between preoperative anemia and surgical site infection (18.1% vs. 7.1%) is fully consistent with existing literature on the pathophysiologic processes involved with wound healing and innate immune responses (which require adequate supply of oxygen). Reactive oxygen species generated by neutrophils through the NADPH oxidase pathway play an essential role in nurturing microorganisms. In the hypoxic microenvironment produced by anemia, neutrophils' capacity to kill these microorganisms via the production of reactive oxygen species is severely impaired; furthermore, tissue hypoxia inhibits the proliferation of fibroblasts and the deposition of collagen necessary for wound tensile strength, thereby permitting the colonization of wounds by microorganisms and wound dehiscence. This finding is supported by the findings of Fowler et al., as well as Shander et al. These studies demonstrated that preoperative anemia is a significant risk factor for the development of infections after non-cardiac surgical procedures, regardless of the use of allogeneic blood transfusion. The high incidence of SSIs in the anemic cohort suggests that a focused preoperative medical therapy, such as iron supplementation, may play a major role in decreasing post-surgical infections in this population. Randomized controlled trials have demonstrated that correcting the underlying oxygen delivery problem with iron supplementation decreases postoperative infection rates.

In addition, the significantly increased incidence of acute kidney injury (14.3% vs. 5.2%) in the anemic population has a major impact on postoperative care. The renal medulla (inner layer of kidney) is normally found in a state of relative hypoxia because of the counter-current exchange mechanism and high metabolic needs of the thick ascending limb of the nephron. Surgical treatment may cause patients to experience systemic inflammatory responses, sympathetic nervous system activation, and frequent episodes of relative hypovolemia and hypotension due to anesthesia and blood loss. Pre-existing anemia contributes to a mismatch between oxygen delivery and demand in the kidneys, and this deficit worsens with the addition of the stress of general anesthesia and major surgery. The use of KDIGO criteria in our study allowed us to monitor and detect this decline in renal function early in the perioperative period, demonstrating how preoperative anemia places patients at risk for changes in blood pressure, blood flow, and renal perfusion due to the effects of general anesthesia and the inherent hemodynamic instability associated with the surgical stresses of major abdominal surgery [35]. Anemia is a serious risk factor for renal complications after major abdominal surgery; therefore, anemic patients undergoing extensive bowel resections or pancreatectomies should have their renal function closely monitored with earlier renal biomarker testing, and they may benefit from more aggressive goal-directed fluid therapy during surgery to maintain renal perfusion pressure.

The observed twofold increase in 30-day mortality among anemic patients (6.7% compared to 1.9%) underscores the potentially deadly implications associated with this routine laboratory abnormality. Although the multivariate analyses executed in our project confirmed that anemia is an independent risk factor for postoperative complications, its relationship to other adverse

perioperative variables must not be overlooked, as they act synergistically to place patients with anemia at increased risk of complications. Anemic patients in our study population demonstrated higher ASA scores and were more likely to have cancer diagnoses than the non-anemic patients, indicating that anemia acts as a biomarker for overall physiologic frailty and cancer disease state [36]. Nevertheless, after correcting for these variables, the independent effect of anemia on mortality remained, exerting a direct pathophysiologic effect.There is a combination of various mechanisms at play, including patients being more susceptible to death from sepsis due to uncontrolled infection, cardiovascular events from the increased myocardial oxygen consumed in the presence of hypoxia, and hemodynamic decompensation as a result of substantial blood loss during surgery [13]. Factors such as these are most likely to factor into the increased mortality rate in Samawa since a large number of these patients may have had death procedurally prevented with the timely optimization that is to occur prior to surgery.

Our analyses have shown that a substantial portion of those patients with malignant pathologies (the majority of the anemic cohort), have presented with larger, more complex tumors that require significantly longer surgeries and present with more extensive blood loss [37]. In addition, chronic anemia from malignancy also induces a state of increased blood flow and abnormal growth of blood vessels within the tumor, thus inherently increasing the potential for blood loss from an operating room. However, regardless of how the causality is derived, there is an inescapable produce of these combined factors resulting in the production of a lethal triad of hypoxia, metabolic acidosis and hypothermia, which is confirmed as an independent predictor of complications by our regression analyses. The result of this vicious cycle frequently results in the increased intraoperative blood transfusion rates in the anemic cohort (42.4%), thereby exposing these patients to the immunomodulatory effects of allogeneic blood [29].

Anemic patients also experienced significantly lengthened hospital stays (median 9 days vs.The results of this study demonstrate that even a small increase (4-5 days) in hospital length-of-stay for each patient has significant ramifications for the Iraqi healthcare delivery system. Al-Hussein Teaching Hospital, like many hospitals in Iraq, has limited beds and resources; therefore, an increase of 4 days of hospital length-of-stay per patient results in significantly increased pressure on the hospital's resources, resulting in overcrowding of surgical wards and delays of elective surgical cases, and increasing costs to the healthcare delivery system [38]. In an environment with few resources, the financial costs associated with the treatment of patients with postoperative complications (e.g., prolonged antibiotic therapy for SSI, dialysis for AKI, and/or ICU support for respiratory failure) will detract from the investment in preventative measures and health system strengthening. Therefore, the rationale for investing in the prevention and treatment of preoperative anemia before surgery is not only based on clinical concerns but is also a significant economic issue for hospitals in low and middle-income countries (LMICs). By reducing lengths-of-stay and complication rates through simple, cost-effective measures (like oral or IV iron therapy) prior to surgery, hospitals will experience improvements in throughput and resource utilization [39].

Although these findings are significant, there are also a few limitations when interpreting these results. First, this study was performed only at one site (Al-Hussein Teaching Hospital) located in southern Iraq; therefore, caution should be taken when assuming these findings can be generalized to other areas, especially high-income countries with established Patient Blood Management (PBM) programs. Additionally, limitations in the ability to perform comprehensive iron studies (serum ferritin and transferrin saturation), due to logistical and economic impediments within the hospital laboratory, may impact our conclusions.As a result

of these limitations, we may be unable to separate iron deficiency anaemia, chronic disease anaemia, or mixed aetiologies as well as evaluate iron stores to inform IV iron therapy agency. Multivariate analysis adjusted for all known confounding variables; however, due to the observational nature of the study some residual confounding may still exist; specifically, when evaluating unmeasured confounding variables (e.g., actual nutritional status, smoking history, and skill level of the operating surgeon, etc.). Additionally, since we did not follow up for more than 30 days, we may have underestimated the long-term impact, post-discharge complications, long-term black mortality, and cancer recurrence rates that preoperative anaemia has had on patients' outcomes, which is consistent with what has been reported within the literature related to oncology recently [40].

Taking into consideration these limitations and findings, the clinical pathway for Al-Hussein Teaching Hospital (and other parallels in Iraq) must undergo complete reform. Admitting patients one day prior to their major abdominal surgery and relying solely upon intraoperative transfusion to fix anaemia has demonstrated to be a detrimental process. Therefore, there is an urgent requirement to create preoperative anaemia clinics surrounding surgical outpatient departments, to allow for early identification of anemic patients who require elective surgery and then provide a window of 2 to 4 weeks before surgery to optimise their condition. Given the high incidence of nutritional deficiency in the Muthanna District, we recommend starting empirical oral iron therapy with nutritional counselling as soon as a patient is identified to be anaemic with mild/moderate anaemia. For patients who have severe anaemia or require urgent surgical procedures, intravenous iron, which provides rapid increases in Hb level within a short time frame, needs to be prioritised by both the hospital administration and by the Ministry of Health [19]. Finally, establishing a restrictive transfusion trigger protocol (i.e., transfuse only when Hb < 7 or 8 g/dL, or when symptomatic with ischaemia) will create standardisation for transfusions to avoid unnecessary allogeneic blood use, which our data show has been over-utilised within the anaemic patient population.

## Conclusion

Major abdominal surgery patients at Al-Hussein Teaching Hospital in Samawa, Iraq, are affected by preoperative anemia in approximately half the cases. According to this study, preoperative anemia independently predicts serious postoperative complications (ie, surgical site infections, acute kidney injury, and anastomotic leaks), prolonged hospital stays, and increased mortality (within 30 days) at an independent rate. The current reactive nature of perioperative management of anemia in resource-limited countries is inadequate and results in increased morbidity for patients and expenses to the healthcare system. There is an urgent need for changes in institutional and national policy in order to screen for and treat preoperative anemia routinely, develop standards for managing patients' blood through preoperative iron supplementation (where needed) and the use of restrictive transfusion strategies, and ultimately improve the outcomes of surgery while conserving resources within the healthcare system in Iraq.

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