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COLLEGE OF HEALTH SCIENCES

DEPARTMENT OF ANESTHESIA

INCIDENCE AND ASSOCIATED FACTORS OF ANEMIA IN ELECTIVE SURGICAL PATIENTS ADMITTED TO A SURGICAL INTENSIVE CARE UNIT AT TIKUR ANBESSA SPECIALIZED HOSPITAL, ADDIS ABABA, ETHIOPIA, 2023.

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Declaration

In partial fulfillment of the requirements for the Master in Anesthesia, I, the undersigned, hereby declare this thesis is my original work.

I understand that plagiarism will not be accepted and all directly quoted material has been appropriately referenced

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Date of Submission: _____

This thesis result has been submitted for examination with my/our approval as Advisors and on the Master Science in Anesthesia

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Examiner

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Abstract

Introduction: Anemia is a frequently reported and commonly documented issue in intensive care units. In surgical intensive care units, more than 90 % of patients were found to be anemic. It is a hematologic factor that contributes to extended mechanical ventilation, sepsis, organ failure, longer hospitalizations in critical care units, and higher mortality. So, screening and identifying associated factors for the initiation of early treatment are recommended before intensive care unit discharge.

Objective: To assess the incidence and associated factors of anemia in elective surgical patients admitted to a surgical intensive care unit at Tikur-Anbessa Specialized Hospital, Addis Ababa, Ethiopia, from November 2022 to December 2022.

Method: A retrospective cohort involving 422 patients hospitalized to ICU after elective surgery at TASH, Addis Ababa, Ethiopia, was carried out between December 2019 and December 2022. Data was gathered from the patients' charts and study participants were chosen using methods of systematic random sampling. SPSS 26 (the statistical software for social science, version 26) was used to analyze the data. The binary logistic regression was used to examine associations between variables. Finally, variables are significant when their p-value is less than 0.05.

Result: The incidence of anemia in elective surgical patients admitted to the ICU was 69.9% (95% CI: 65.4% to 74.5%). ASA class III [AOR: 8.53, 95% CI: 1.92–13.8], renal failure [AOR: 2.53, 95% CI: (1.91, 5.81)], malignancy [AOR: 2.59, 95% CI: (1.31, 5.09)], thoracic surgery [AOR: 4.07, 95% CI: (2.11, 7.87)], urologic surgery [AOR: 6.22, 95% CI: (2.80, 13.80)], and neurosurgery [AOR: 4.51, 95% CI: (2.53, 8.03)] were significantly associated with anemia in ICU admitted surgical patients.

Conclusion and recommendation: More than 2/3rds of ICU-admitted surgical patients were anemic. ASA III, renal failure, malignancy, thoracic surgery, urologic surgery, and neurosurgery were significantly associated with it. Early identification helps to institute preventive and therapeutic measures.

Keywords: anemia, incidence, intensive care unit, Ethiopia.

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Acronyms and Abbreviations

AAU…… ……. Addis Ababa University

ACEIs……. Angiotensin-Converting Enzyme Inhibitors

ALI.....Acute Lung Injury

ASA …… The American Society of Anesthesiologists

CBC……. Complete Blood Count

CCBs…… Calcium Channel Blockers

DHS……. Demographic Health Survey

DM…… Diabetes Mellitus

GA……. General Anesthesia

Hb/HCT …… Hemoglobin/Hematocrit

ICU: Intensive Care Unit

NSAIDs……. Non-Steroidal Anti-Inflammatory Drugs

PBM…… Patient Blood Management

RBC (PRBC)…… Red blood cells (packed)

SPSS…….. Statistical Package for Social Sciences

TASH……. Tikur-Anbessa Specialized Hospital

USA……. ……... United States of America

WHO…….. World Health Organization

1.1. Background

The World Health Organization (WHO) defines anemia as having a hemoglobin (Hb) level less than 13 g/dL (hematocrit 39) in males and less than 12 g/dL (hematocrit 36%) in non-pregnant women. A reduced number of red blood cells will result in a decreased ability of the blood to transfer oxygen to the tissues because hemoglobin is essential for carrying oxygen (1).

For seriously ill patients hospitalized to intensive care units, anemia is a significant health burden. According to studies, 97% of patients whose stays in the ICU have been protracted noticeable anemia. About 67% (2/3) of patients admitted to the ICU on the day of admission have Hb less than 12 g/dl. However, according to WHO data, the overall prevalence of anemia is estimated to be 29% in industrialized countries and 43% in under-developed countries (3). Anemia was common in Ethiopia, affecting 18% of adult males and 23% of adult females, according to the Ethiopian Demographic and Health Survey (DHS). In rural regions, its magnitude is greater (4).

Factors contributing to anemia in the general population are multi-factorial, including sepsis, hemolysis (coagulopathies), blood loss, bone marrow suppression, decreased erythropoiesis, iron deficiency, poor nutrition, type of surgery, duration of surgery, prolonged stay in the ICU, and drugs (2, 5, 6).

Despite the above-listed contributing factors, 90% of anemia in ICU-admitted patients occurs in the immediate postoperative period after major surgery(5).

Anemia is also strongly associated with certain drugs that suppress erythropoietin release, like calcium channel blockers, chemotherapies, theophylline, ceftriaxone, diclofenac, quinidine, methyldopa, adrenergic blockers, angiotensin-converting enzyme inhibitors, and angiotensin-receptor blockers (2, 6).

The kind of anesthesia employed for surgery is also positively correlated with anemia and determines postsurgical transfusion. Patients who received neuraxial anesthesia had a decreased incidence of anemia and a decreased postsurgical transfusion requirement compared to those who received general anesthesia (7).

The prevalence and associated factors of anemia in both the pre-operative and intra-operative periods are studied in Ethiopia. But there are scarcities regarding the incidence of anemia and associated factors after the postoperative period in patients admitted to the surgical ICU in Ethiopia.

Therefore, this study aimed to provide up-to-date information regarding the incidence and risk factors of anemia in patients admitted to the surgical ICU.

1.2 Statement of the problem

Anemia is highly prevalent and frequently observed in ICU-admitted patients after surgery (2). In developing countries, the frequency of anemia is significant due to low socioeconomic status and inadequate healthcare services. Age, gender, co-morbidities, surgical indications, lifestyle, and socioeconomic status all affect its prevalence differently (8). It was also found to vary by residency; rural area residents were more anemic than urban area residents among apparently healthy people (9).

Different pieces of evidence proved that anemia after surgery in ICU-admitted patients is related with an increased risk of a negative patient outcome (10). ICU anemia is strongly linked to poor surgical patient outcomes, including a higher risk of oxygen depletion (reduced blood oxygen-carrying capacity), blood transfusion, extended ICU stay, surgical site infections, resource consumption, prolonged need for mechanical ventilation, more complicated surgery, and advanced treatment (10, 11). Furthermore, studies show increased requirements for re-intubation and weaning failure in those patients who are anemic (12).

Anemia in ICU-admitted patients poses challenges in both patient management and patient outcomes. This hematologic risk factor raises patient mortality and morbidity. Its adverse outcomes include congestive heart failure, respiratory failure, hypoxia, cardiac arrest, multi-organ failure, chronic kidney disease, failure of weaning from mechanical ventilator, prolonged hospitalization, infection, and a greater chance of dying (10, 13, 14).

Anemia is also a great burden for anesthetists, as hemoglobin is one of the clinical parameters that determine anesthesia choice and service delivery to the patient (15).

Different techniques were tried to cope with patients with anemia as part of the management plan. Most of the time, anemia in ICU-admitted patients is managed by transfusing packed red blood cells, which improves oxygen delivery to the tissue and decreases tissue hypoxia (16).

However, the transfusion of blood to critically ill patients is potentially dangerous and carries a risk. As blood-transfused patients are immune-compromised most of the time, they are at increased risk of blood transfusion-related complications. Some of the reported complications following transfusion include ALI (acute lung injury), organ dysfunction, systemic infections, and death (15, 16). Transfusion also increases hospital stays and resource consumption (17).

If anemia exists without obvious risk factors and if the patient is on certain medications, treatment can be done by withholding the drugs and putting the patient on corticosteroids (6).

But anemia is an illness that can be treated and prevented, and is frequently managed with fewer adverse effects without the need for blood transfusions, if it is identified early to decrease blood transfusion and transfusion-related complications (18).

Early recognition, screening, and treating anemia is not a major concern for most health professionals, specifically in the ICU, and attention is not given to screening and early detection of anemia in ICU patients. The major goal of early detection is to initiate management before deterioration, increase hemoglobin concentration, and improve patient health conditions to avoid hazards (19). Unfortunately, these studies are limited in our country, Ethiopia.

Identification of the various anemia-related causes and co-morbidities may help doctors and anesthetists lower the risk of transfusion, improve clinical care, and enhance the quality of anesthesia and operation. Therefore, the purpose of this research was to determine the incidence and factors contributing to anemia in adult patients admitted to the surgical ICU.

1.3 Significance of the study

As different previous studies stated, the incidence of anemia among surgical patients admitted to the surgical intensive care unit was high (2). Anemia in a critically ill patient will increase patient morbidity and adverse outcomes such as delayed emergence from anesthesia, failure to wean from a mechanical ventilator, surgical site infection, increased requirements for transfusion and transfusion-related complications, and respiratory, cardiac, and renal problems.

But if the incidence and risk factors are early identified, it helps to reduce patient morbidity and mortality, improve patient outcomes, increase patient safety, decrease resource utilization, and facilitate early recovery from the disease entity. Furthermore, it helps to decrease unnecessary prolonged hospital stays and hospital-acquired diseases.

Therefore, identifying the incidence and associated risk factors of anemia in ICU surgical patients enables health professionals to institute early therapeutic and preventive measures. Furthermore, it helps to weigh the risk-benefit analysis of blood transfusion for ICU patients, as it poses negative outcomes because most ICU patients are debilitated.

Although anemia is a common issue among patients who are admitted to the ICU, few research has been done in Ethiopia to determine its incidence and contributing variables. Therefore, determining the incidence and risk factors in patients admitted to the surgical ICU will help improve positive patient outcomes.

2. Literature Review

2.1. Incidence of Anemia in the ICU

Anemia is a serious problem in patients admitted to surgical intensive care unit. The global incidence of anemia on the day of admission among patients admitted to the surgical ICU was 67%, and it was about 97% within a week of admission (2).

Different studies were done in different European countries on the incidence of anemia in ICU-admitted patients. In Germany, a study conducted in 2019 found that among 378 ICU-admitted patients who are on mechanical ventilators, 98% showed a significantly lower Hb value (20); in Poland, among 494 ICU-admitted patients from January 2020 to December 2021, the incidence of anemia was present in 218 (58.8%) of patients (16); and in the United Kingdom, of 234 hospital admitted patients, the incidence of anemia was 30.7% (72/234), being more prevalent in females (33.3% versus 26.7% in males) (21). Among 303 hospitalized patients in Italy, a 2014 study indicated that the median hemoglobin concentration was 6.5 g/dL at the time of admission, 64 patients (21.1%) had a diagnosis Hb of less than 6.0 g/dL, and 11 of them (3.6%) had extremely severe anemia (Hb of less than 5 g/dL) (22), and in Greece, the median Hb concentration at the time of admission was 6.5 g/dL. Of 58 patients (38 males and 20 females), 25 (43.1%) had anemia at ICU admission during their study in 2015 (23).

Similarly, different prospective and retrospective studies were conducted in American countries on the incidence of anemia in ICU-admitted patients. Of the 5925 patients admitted during the study period in the United States in 2010, 1833 (30.9%) had a critical care unit blood transfusion; at least once, the hemoglobin levels were under 9 g/dl in 57.6% of patients (11), and in Canada, among the 7273 patients on ICU admission, 67.0% of patients had a median Hb of 9 g/dL or less throughout their ICU stay (24).

In Asian countries, the incidence of anemia was stated. In India, among 100 admitted surgical patients to the intensive care unit, 68% were found to be anemic during the study period (25). A multicenter observational study was done in five Spanish hospitals, with 142 patients in all, 71.83 percent men and 28.17 percent women. Anemia occurred in 66.9% of the sample without an iatrogenic diagnosis of anemia in 2022 during their ICU stay (5). 2,588 patients were

incorporated in the retrospective cohort study in Japanese ICU admitted patients; of these 909 (35.1%) of these patients had anemia, which was indicated by hemoglobin levels of 10.4 g/dL for women and 10.9 g/dL for men (26), and 615 were studied prospectively in Chinese ICU admitted patients; 48.27% were found to be anemic subjects in 2021 (27). In another Chinese study, a retrospective analysis of 465 patients who underwent pulmonary surgery revealed that 274 patients underwent video-assisted thoracic surgery (VATS) and 191 patients underwent open thoracotomies. A postoperative anemia diagnosis was made in 75.3 percent of patients in the ICU (28).

Different studies are also available in our continent, Africa. A study conducted in Malawi from 2016 to 2018 using a prospective cohort observational study comprised 359 of the 499 patients admitted to the intensive care unit. The median hemoglobin concentration (Hb) upon ICU admission was 9 g/dl; 61 (19%) patients had Hb 7.0 g/dL and 195 (62%) had Hb 9.0 g/dL (17). Of the 283 patients studied retrospectively in Niger ICU admitted patients in 2021, 246 patients (86.9%) had anemia, and 55 (19.4%) received transfusions (29). Furthermore, a retrospective cohort study was done involving 165 patients, 74 males, and 91 females, in Egypt at Cairo University between January 2015 and December 2018 in ICU admitted patients. The mean hemoglobin was 8.28 g/dl for the survivors' group and 8.27 g/dl for the non-survivors from 103 anemia cases, and from those, 62.5% were responding to transfusion and 37.5% were not (30).

In our country, Ethiopia, although the incidence of anemia in surgical ICU-admitted patients is limited, the magnitude of preoperative anemia was 36.8% in 185 patients scheduled for surgery (31). Furthermore, a study conducted in TASH intra-operatively reported that 88 (22.7%) patients had hemoglobin levels less than 11 g/dl and were indicated for transfusion among 387 elective surgical patients (32).

2.2. Associated Risk Factors

Different studies have been done regarding socio-demographic characteristics in association with anemia. Age is strongly associated with anemia. Increased age increases the risk of anemia as pro-inflammatory cytokines become dysregulated with age and harm hemopoiesis by either inhibiting erythropoietin synthesis or impairing erythropoietin receptor activity (33). Males were discovered to be more anemic than females in research done on five Spanish ICU patients (5). On the contrary, at reproductive age, non-pregnant women are at increased risk of developing anemia, according to research done in Saudi Arabia (34).

Anemia in ICU-admitted elective surgical patients was related to ASA physical status (35, 36), hypertension (37), renal failure (38, 39), malignancies (40, 41, 42, 43), diabetes (44), heart failure (45), RVI (46), history of two or more disease, and certain medication histories: beta blockers, chemotherapies, calcium channel blockers, HAARTs, and ACEIs, and patients taking more than two medications were related to anemia (2, 47, 48). Moreover; patients on prolonged mechanical ventilation have an increased risk of anemia than patients in non-mechanically ventilated patients, as evidenced by research in Malawi (12). Duration of surgery and a prolonged stay in the ICU was contributing factor too (49).

Due to traumatic or operative blood loss, anemia is also directly linked to major surgeries, including thoracic surgery (28), urologic surgery (50, 51), and neurologic surgery (52, 53). Following surgery, the release of inflammatory cytokines (IL-1, interferon, and TNF) can inhibit erythropoietin synthesis, iron sequestration in macrophages, gastrointestinal iron absorption, and erythroid response to erythropoietin. Despite appropriate iron storage in the bone marrow macrophages, this results in less iron being accessible for erythropoiesis. Particularly in patients who have been brought to the ICU, all of these factors play a role in the worsening of postoperative anemia (14).

2.4. Conceptual framework

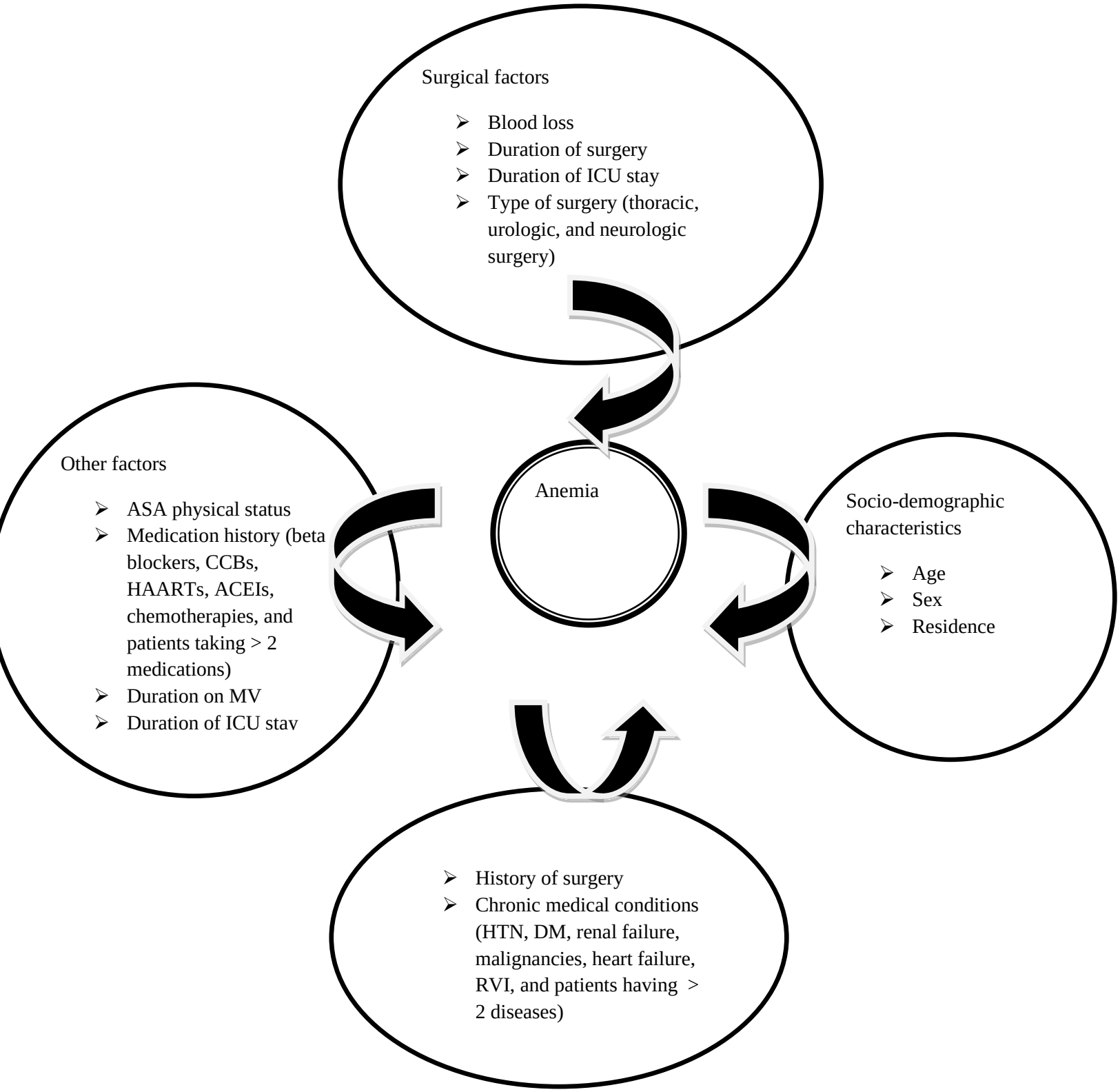

Figure 1: Schematic presentation of conceptual framework

3. Objectives

3.1. General Objective

- To assess the incidence and associated factors of anemia in elective surgical patients admitted to the surgical ICU in TASH, Addis Ababa, Ethiopia, from November 2022 to June 2023.

3.2 Specific Objectives

- To determine the incidence of anemia in elective surgical patients admitted to the surgical ICU in TASH, Addis Ababa, Ethiopia, from November 2022 to June 2023.
- To identify factors associated with anemia in ICU-admitted elective surgical patients in TASH, Addis Ababa, Ethiopia, from November 2022 to June 2023.

4. Methods

4.1. Study Area

The study was conducted at Tikur Anbessa Specialized Hospital in Addis Ababa, Ethiopia. Ethiopia's capital city, Addis Ababa, is situated 2355 meters (7726 feet) above sea level. The city's total population in 2023 is 5.4 million (5,461,000).

Tikur-Anbessa Specialized Hospital was established in 1972 and is the largest referral hospital in the country, with 700 beds. It has a catchment population of more than 5 million. Six medical and six surgical ICU beds are available in the Tikur-Anbessa specialized hospital.

The average number of surgical patients admitted to the surgical ICU monthly is 40–45 patients. So, on average, 480 to 540 patients are admitted to the surgical ICU annually.

4.2. Study Design and Period

- A retrospective cohort from December 2019 to December 2022.

4.3. Population

4.3.1. Source population

- All adult patients undergoing elective surgery at TASH

4.3.2. Study population

- All elective adult surgical patients admitted to the ICU at TASH during the study period

4.4. Inclusion and Exclusion Criteria

4.4.1 Inclusion Criteria

- All patients who underwent elective surgery and were admitted to the surgical ICU who were 18 years of age or older have been included.

4.4.2 Exclusion Criteria

- Hemolytic anemia as a primary factor in ICU admission
- Absence of baseline hemoglobin or hematocrit records
- Congenital causes of anemia such sickle cell
- Patients receiving anemic therapies, such as iron supplements, were not included in the study

4.5. Study Variables

4.5.1. Dependent Variable

- Anemia (Yes/No).

4.5.2. Independent Variables

Socio-demographic variables:

- Age
- Sex
- Residence (rural or urban).

Clinical characteristics were:

- ASA physical status
- Co-morbidities: DM, hypertension, malignancies, renal failure, retroviral disease, heart failure, and patients having two or more diseases.
- Type of surgery: thoracic, abdominal, urologic, neurologic, head & neck, and vascular surgeries.
- Type of anesthesia
- Previous surgical history
- Duration of surgery
- Duration on mechanical ventilator
- Length of ICU stay
- Blood loss, and
- Drugs: ACE inhibitors, calcium channel blockers, beta blockers, chemotherapies, highly active anti-retroviral therapies, and patients on treatments

4.6 Sample size

The incidence of anemia in patients admitted to the surgical ICU and its related risk factors were not known in the research area. The sample size was calculated using the single population formula, assuming a 0.5 incidence of anemia in ICU-admitted surgical patients and a 5% margin of error at a 95% confidence interval:

$$n = \frac{\frac{za^2}{2}\, p(1_{-p})}{w^2}$$

When the following parameters are present: n = sample size, z = 1.96, p = 0.5, CI = 95%, and w = margin of error = 0.05, n = $(1.96)^2$ 0.5 (1 -0.5)/ $(0.05)^2$ = 384

In order to account for the non-response rate, we added 10% of the n (i.e., 384 + 38 = 422); as a result, 422 surgical patients who were admitted to the ICU were included in the study.

4.7 Sampling Technique

The study was conducted at TASH surgical ICU. The average number of surgical patients admitted to the surgical ICU monthly is 40–45 patients. So, on average, 480 to 540 patients are admitted to the surgical ICU annually. Three years of data were taken retrospectively to establish the incidence of anemia and to search out the risk factors. So, the total number of patients admitted to the surgical ICU was 1530 on average within three years.

The sampling interval was based on systematic random sampling, and it was 1530/422=4. Therefore, the first patient selected was 2 randomly, and subsequently, every fourth patient was picked up to be included in the study.

4.8. Data Collection Tools and Procedures

Data has been collected from the patient's chart by using a structured checklist prepared in English. Demographic, clinical, and laboratory data were retrieved from patient chart records. Hemoglobin and hematocrit measurements have been gathered by chart review from the patient's medical records from CBC.

The questionnaire was created to gather information on socio-demographic factors (age, sex, and residency), hematologic measurements (hemoglobin and hematocrit), previous surgery, medical status (hypertension, diabetes mellitus, renal failure, cancer, RVI, and heart failure), and drug history (Beta-blocker, calcium channel blocker, ACEIs, HAARTs, and chemotherapies). Blood loss, duration of surgery, duration on a mechanical ventilator, duration of ICU stay, and type of anesthesia employed was also investigated in patients' medical chart.

4.9. Data Quality Assurance

To guarantee the validity of the findings, 42 patients, or 10% of the sample size, undertook a pretest at Tikur Anbessa Specialized Hospital. The goal of the study, the confidentiality of the information acquired, and the inclusion and exclusion criteria were all covered in training for data collectors. The lead investigator kept a careful eye on the data gatherers throughout the study. The collected information has been reviewed for clarity, accuracy, and completeness.

4.10. Data Processing and Analysis

Before being exported to SPSS version 26 for analysis, the data was first verified, coded, and entered into Epidata version 4.6. The Hosmer-Lemeshow test (0.46) was used to assess the model's fitness. To define categorical variables, multicollinearity was examined utilizing collinearity diagnosis (variance inflation factors (VIF) and tolerance). Binary logistic regression was used to examine associations between variables. In order to determine the strength of the connection, variables with a p-value of less than 0.2 in bivariable regression are entered into multivariable logistic regression. Finally, p-values less than 0.05 are regarded as significant for variables. The mean and standard deviation were shown for the continuous variables. Means and percentages have been used to express the categorical data. The analyzed data were displayed using graphs and charts.

4.11. Operational Definitions

Adult patient: Both sexes must be at least 18 years old (11).

Hematocrit: Is a measurement of a person's blood's proportion of red blood cells. Healthy adults typically have hematocrits between 36% and 48% for women and 39–52% for men (54).

Hemoglobin: is a protein that contains iron in RBCs and is responsible for providing oxygen to the cells. It ranges from 13–17 for males and 12–16 for females (54).

Prolonged ICU stay: patients with ICU admissions who stay for longer than 8 days (49).

Post-surgery: the period starting from the immediate termination of surgery and till discharge (55).

Postsurgical anemia: The World Health Organization defines anemia following surgery as a decrease in hemoglobin (Hb 13 g/dL for men and 12 g/dL for women (1).

Post-surgical anemia in the ICU: Anemia at any point of time during ICU stays (56).

4.12. Ethical Considerations

Ethical clearance was obtained from Addis Ababa University (AAU) by the ethical review board. Tikur-Anbessa Specialized Hospital has received approval and a letter of collaboration from the Department of Anesthesia. The medical center's privacy as well as the study participants' records was protected.

5. Results

5.1 Socio-Demographic Variables

This study comprised a total of 422 patients who were admitted to the ICU for elective surgery. Of these, 174 men (41.2%) and 248 women (58.8%) were present. The patients mean age was 48 (30.3-65.7) years. 229 (54.3%) of the patients were from rural areas, while 193 (45.7%) were from urban.

Table 1: Elective surgical patients admitted to the surgical ICU in TASH at Addis Ababa, Ethiopia, between November 2022 and June 2023 (n = 422).

Variables	Categories	Frequency (n)	Percent (%)
Sex	Males	174	41.2%
	Females	248	58.8%
Residence	Urban	193	45.7%
	Rural	229	54.3%

Variable	Mean ±Standard deviation(SD)
Age	48±17.7

5.2. Clinical Features of Study Subjects

The mean time used to finish surgery was 5.13 (4.28-6.38) hours. The mean time of surgical patients waiting on mechanical ventilators and in the ICU was 8.0 (2-14) and 8.9 (2.3-15.5) days, respectively. The average volume of blood loss during the surgical procedure was 1380 (525-2235) milliliters.

Table 2: Clinical features of elective surgical patients admitted to the ICU in TASH, Addis Ababa, Ethiopia, from November 2022 to June 2023 (n = 422).

Variable	Mean ± Standard deviation (SD)
Duration of surgery in hours	5.13± 1.25
Duration on a mechanical ventilator in Days	8.0± 6.0
Duration of ICU stay in Days	9± 6.6
Blood loss in ml	1380 ± 855
Hb at admission in g/dl	9.8 ± 2.4
Hb at 3rd day in g/dl	9.3 ± 1.6
Hb on the 7th day	9.2 ± 1.4
Hb at discharge	10.3 ± 1.7

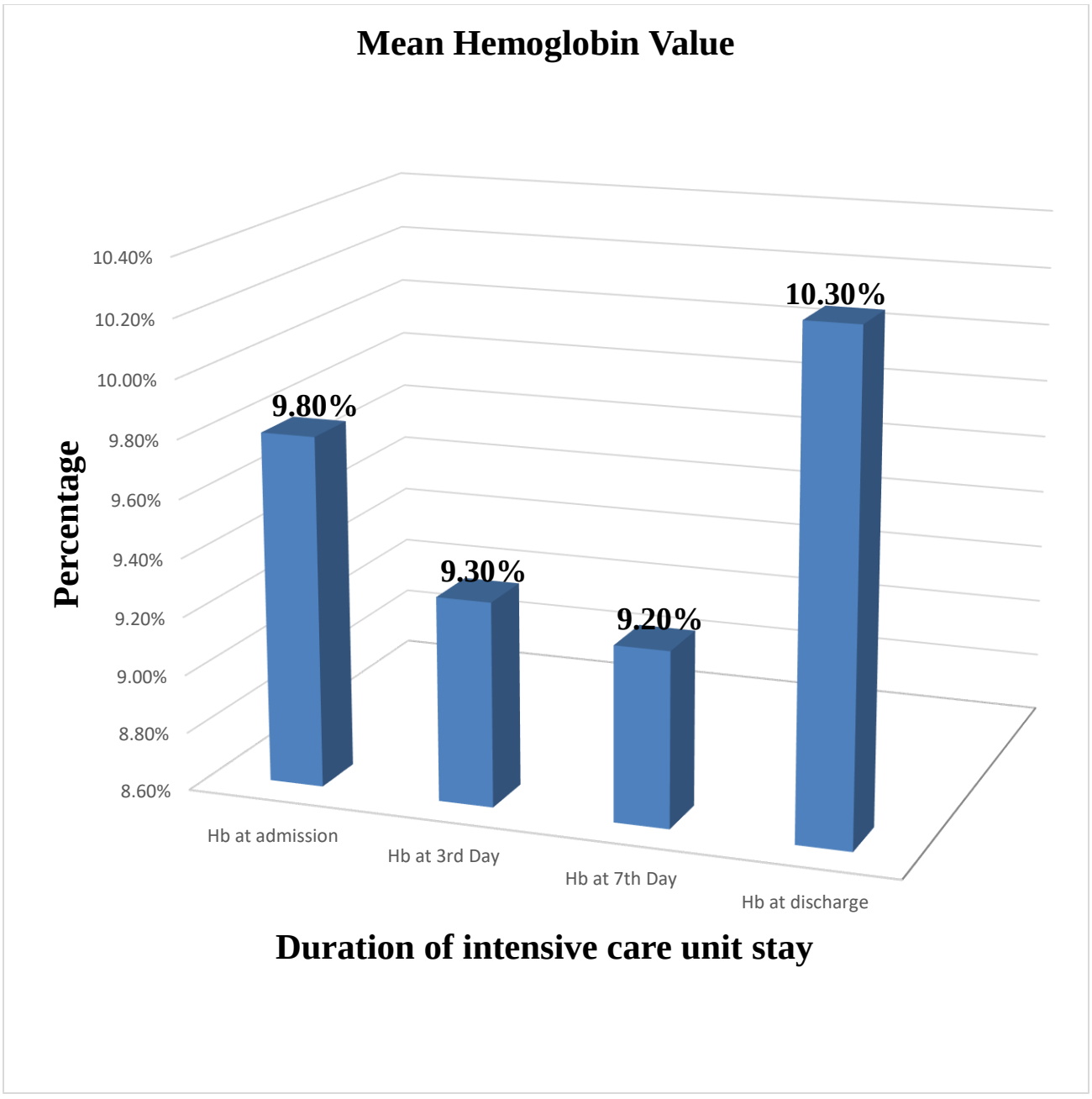

Figure 2: Bar graph showing mean hemoglobin value of ICU admitted surgical patients in TASH, Addis Ababa, Ethiopia, from November 2022 to June 2023 (n = 422)

All patients who were included in this study were under GA (100%). From these, 69.9% of patients were found to be anemic.

In this study, 247 (58.5%) and 100 (23.7%), were ASA 2 and ASA 3, respectively. From this, 166 (67.2%) of ASA 2, 83 (83%) of ASA 3, and 46 (61.3 %) of ASA 1 developed anemia (Figure 2).

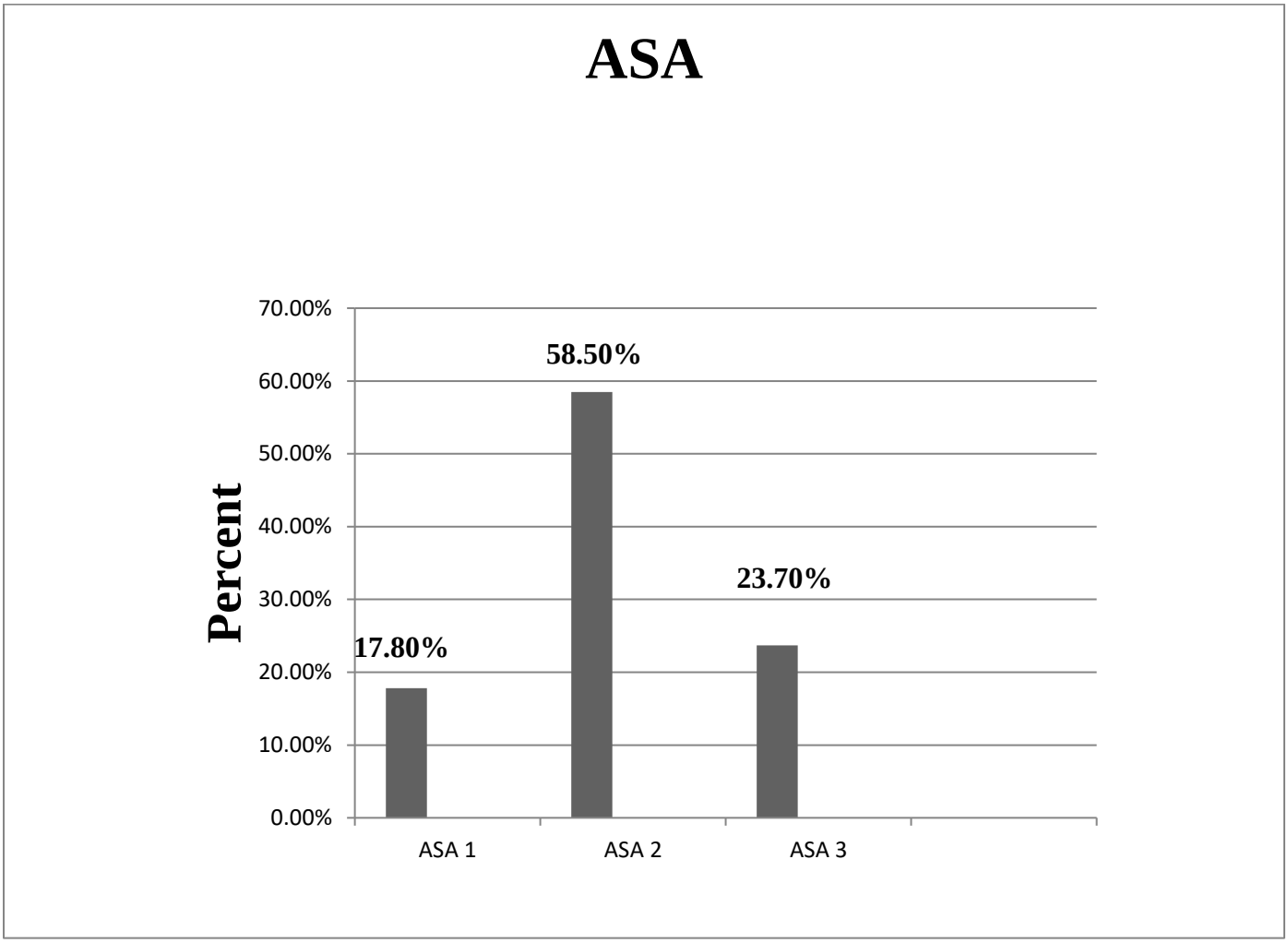

Figure 3: Bar graph showing the percentage of ASA physical status among anemic ICU admitted surgical patients at TASH, Addis Ababa, Ethiopia, from November 2022 to June 2023 (n = 422)

In all, 148 (35.1%), 90 (21.3%), and 84 (19.9%) study participants had histories of hypertension, cancer, and two or more diseases, respectively.

Regarding treatment factors, 107 (25.4%), 102 (24.2%), 96 (22.7%), and 71 (16.8%) had histories of two or more two medications, ACEIs, calcium channel blockers, and chemotherapies, respectively.

Of those surgical patients, (123 (29.2%), 93 (22.0%), and 84 (19.9%) admitted to the ICU were undergoing neurologic, thoracic, and abdominal surgery, respectively.

From 422 ICU-admitted surgical patients, 220 (52.1%) had a previous history of surgery, and the remaining 202 (47.9%) cases had no history of surgery (table 3).

Table 3: Clinical characteristics of elective surgical patients admitted to the surgical ICU at TASH, Addis Ababa, Ethiopia, from November 2022 to June 2023 (n = 422).

Variables	Categories	Total (n)	Percent (%)
Hypertension	Yes	148	35.1
	No	274	64.9
Diabetes mellitus	Yes	34	8.0 %
	No	388	91.9 %
Renal failure	Yes	39	9.2 %
	No	383	90.8 %
Malignancy	Yes	90	21.3%
	No	332	78.7 %
RVI	Yes	30	7.2 %

	No	392	92.8 %
Heart failure	Yes	44	10.4 %
	No	378	89.6 %
Two and above disease	Yes	84	19.9 %
	No	338	80.1 %
Beta blocker	Yes	32	7.6 %
	No	390	92.4 %
Calcium channel blocker	Yes	96	22.7 %
	No	326	77.3 %
ACE inhibitor	Yes	102	24.2 %
	No	320	75.8 %
Chemotherapy	Yes	71	16.8 %
	No	351	83.2 %
HAART	Yes	30	7.2 %
	No	392	92.8 %
More than two treatment	Yes	107	25.4 %
	No	315	74.6 %
Thoracic	Yes	93	22.0 %
	No	329	78.0 %
Abdominal	Yes	84	19.9 %
	No	338	80.1 %

Urologic	Yes	64	15.2 %
	No	358	84. 8 %
Neurologic	Yes	123	29.2 %
	No	299	70.8 %
Vascular	Yes	20	4.7 %
	No	402	95.3 %
Head and Neck	Yes	44	10.4 %
	No	378	89.6 %
Previous surgical history	Yes	220	52.1 %
	No	202	47.9 %

5.3 Incidence of Anemia in ICU Surgical Patients

According to this study, 69.9% (95% CI: 65.4% to 74.5%) of elective surgery patients admitted to the surgical ICU had anemia.

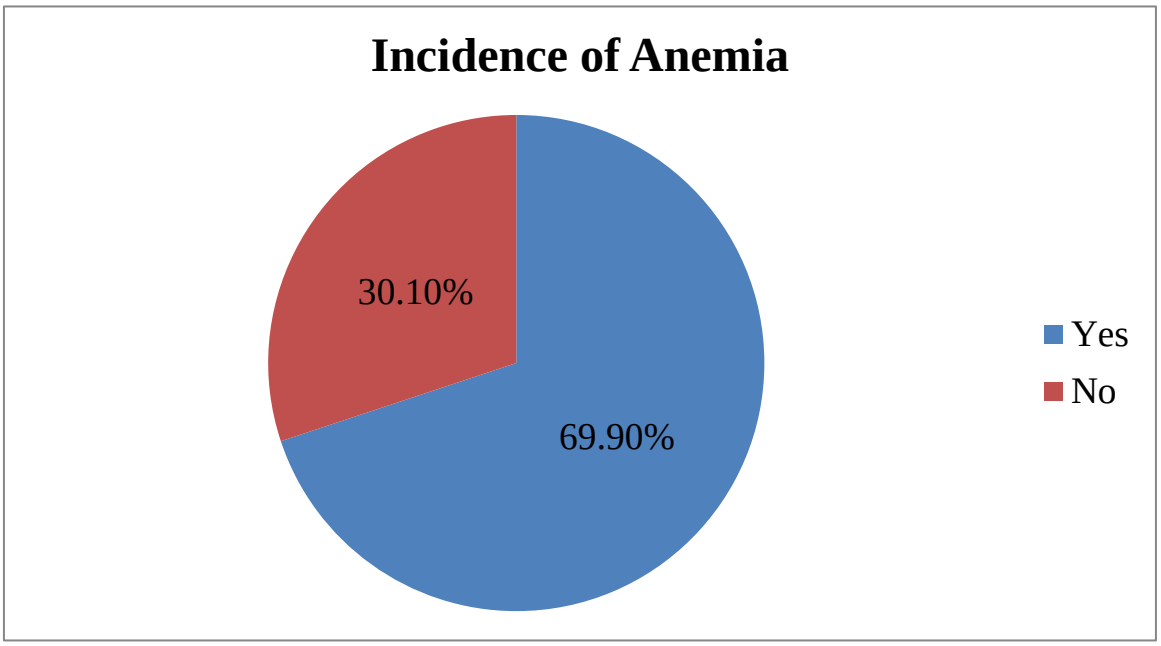

Figure 4: Pie chart showing the incidence of anemia in elective surgical patients admitted to the surgical ICU at TASH, Addis Ababa, Ethiopia, from November 2022 to June 2023 (n = 422).

5.4 Anemia-related risk factors for elective surgical patients admitted to surgical intensive care unit

Bivariable and multivariable logistic regression were used to examine the association between anemia and the independent factors. In a bivariable study, ASA class, hypertension, renal failure, malignancy, heart failure, calcium channel blockers, ACE inhibitors, chemotherapy, thoracic surgery, urologic surgery, neurologic surgery, and previous surgical history were found to be positively associated with anemia with a p-value < 0.2 and were candidates for multivariable logistic regression.

In multivariate logistic regression, anemia in ICU-admitted elective surgical patients was significantly associated with ASA class III, renal failure, malignancy, thoracic surgery, urologic surgery, and neurologic surgery.

Compared to patients with ASA levels I and II, those with ASA status III had about 8.5 times (AOR: 8.53, 95% CI: 1.92-13.8) higher risk of developing anemia. Patients with renal failure had ICU anemia 2.5 times more frequently (AOR: 2.53, 95% CI: 1.91-5.80) than patients without a history of renal failure. In comparison to non-cancer patients, those with cancer were 2.6 times (AOR: 2.59, 95% CI: 1.31-5.09) more likely to experience anemia in the ICU.

Patients who underwent thoracic surgeries were more likely to get ICU anemia four times (AOR: 4.07, 95 percent CI: 2.11-7.87) than patients who did not have thoracic surgery. Patients who had urologic surgery were 6.2 times (AOR: 6.22, 95 percent CI: 2.80-13.8) more likely than non-patients to experience anemia in the intensive care unit. Neurosurgical patients had anemia 4.5 times (AOR: 4.51, 95% CI: 2.53-8.03) more frequently than non-neurologic surgery patients in ICU admissions for surgical patients.

Table 4: Factors related with anemia among elective surgical patients admitted to the surgical ICU at TASH, Addis Ababa, Ethiopia, from November 2022 to June 2023, according to bi-variable and multivariable binary logistic regression analysis (n = 422).

Variables	Categories	Anemia		COR(95% CI)	AOR(95% CI)	P-value
		Yes (n=295)	No (n=127)			
ASA Status	ASA I ASA II ASA III	46 (10.9%) 166 (39.3%) 83 (19.7%)	29 (6.9%) 81 (19.2 %) 17 (4%)	I 1.29 (0.76-2.21) 3.08 (1.53-6.2)	I 1.47 (0.82-2.64) 8.53 (1.92-13.8)**	 0.20 0.005
Previous surgical history	Yes No	161(38.1%) 134 (31.8%)	59 (14.0%) 68 (16.1%)	1.39 (0.91-2.10) I	1.21 (0.75-1.95 I	0.45
Renal failure	Yes No	37 (8.8%) 258 (61.1%)	2 (0.5%) 125 (29.6%)	8.96 (2.13-13.8) I	2.53(1.91-5.81)** I	0.01
Malignancy	Yes No	77 (18.2%) 218 (51.7%)	13 (3.1%) 114 (27.0%)	3.09 (1.65-5.85) I	2.59(1.31-5.09)** I	0.008
Calcium channel blocker	Yes No	80 (20.0%) 215 (50.9%)	16 (3.8%) 111 (26.3%	2.58 (1.44-4.63) I	2.23 (0.94-5.23) I	0.09
ACEIs	Yes No	83 (19.7%) 212 (50.2%)	19 (4.5%) 108 (25.6%)	2.23 (1.28-3.86) I	1.48 (0.65-3.39) I	0.4
Thoracic surgery	Yes No	52 (12.3%) 243 (57.6%)	41 (9.7%) 86 (20.4%)	1.90 (1.07-3.39) I	4.07(2.11-7.87)** I	0.001
Urologic surgery	Yes No	55 (13.1%) 240 (56.8%)	9 (2.1%) 118 (28.0%)	3.01 (1.44-6.29) I	6.22(2.80-13.8)** I	0.001
Neurologic surgery	Yes No	99 (23.5%) 196 (46.4%)	24 (5.7%) 103 (24.4%)	2.17 (1.31-3.59) I	4.51(2.53-8.03)** I	0.001

** Significant in the multivariable binary logistic regression (p-value 0.05), AOR stands for adjusted odds ratio, COR for crude odds ratio, CI for confidence interval, and I for reference.

6. Discussion

In this study, we found that the incidence of anemia in elective surgical ICU-admitted patients was 69.9%. This shows how frequently anemia occurs in surgical ICU-admitted patients. In this study, we found approximately a mean hemoglobin and hematocrit level of 9.8 g/dl (28.6%) on the day of ICU admission. Further, hemoglobin and hematocrit levels were decreasing as the number of ICU stay days increased. It was 9.3 g/dl (28.6%) on the 3rd day, 9.2 g/dl (27.6%) on the 7th day and 10.3 g/dl (31.9%) on the day of discharge.

This study was similar with other studies in Germany showing that 66.9% of ICU-admitted surgical patients had anemia during their ICU admission, with a mean hemoglobin/hematocrit level of less than 10 g/dl (30.0%) and further decrement as the ICU stay increased (57).

Similarly, according to a study conducted in Poland, up to 66% of patients were anemic on the day of admission to the ICU, and almost all became anemic during the first 3 days of ICU admission (16). The impact of the first 3 days of ICU admission on hemoglobin concentration is also present in our study, where we noted the largest decreases in hemoglobin during the first 3 days of ICU admission and decreased onwards.

On the contrary, the incidence of anemia at admission in our study was higher than in studies conducted in Greece (43.1%) (23), in five Spanish hospitals (63.31%) (5), in Western European ICUs (63%) (42), in the United States (57.8%) (11), and in Canada (61.3%) (24). These differences might happen as a result of the fact differences in sample size and socio-demographic characteristics.

The incidence of anemia in this study was lower than in studies in India, reaching 97% within a week of ICU admission with hemoglobin or hematocrit levels below 12 g/dl (36%) (2). This difference might have occurred because they used a large sample size; they included septic patients, patients with coagulative defects, and patients on treatment for anemia, from which we were excluded.

Further reports in Germany show the frequency of anemia in ICU-admitted patients was 98%, which is too high (20). This variety has occurred because the study participants they included in this investigation were all on mechanical ventilators.

In Niger, the frequency of anemia in the surgical ICU was 86.9% (29). This was also high as compared with our result. This difference occurred because they used all patients who were admitted to the surgical ICU, irrespective of the type of case (elective or emergency), from which we excluded emergency cases.

According to this study, ASA physical status III, renal failure, cancer, thoracic, urologic, and neurologic surgery were significantly associated with the incidence of anemia.

Compared to those with ASA I and II, patients with ASA status III had 8.5 times increased risk of developing anemia. Other studies confirmed the ASA physical status class with preexisting co-morbidities increases adverse postoperative surgical outcomes (44, 45). As the physical status class of ASA increases, postoperative adverse events like morbidity and mortality increase too (35, 36).

According to this study, the odds of developing ICU anemia after surgery were 2.5 times greater among patients with renal failure than among those without a history of renal failure. Different studies proved that anemia was the commonest complication in patients with renal failure, depending on the severity of renal impairment (38). It has been observed in our study that hemoglobin concentrations decrease in patients with chronic renal failure. This conclusion is consistent with research gained by other authors. Although anemia can occur at various stages of CKD, the incidence of anemia and the severity of CKD are strongly correlated (39).

Renal hormones such as erythropoietin, which regulates the bone marrow's production of red blood cells, are thought to play a role in renal failure. As kidney disease progresses, other factors that lower red cell survival and inhibit marrow erythropoiesis may also contribute to renal failure (39).

In the intensive care unit, anemia was 2.6 times more likely to develop in patients having history of malignancy than patients who hadn't history of malignancy. Similar studies demonstrated that individuals admitted to the ICU with cancer had a higher frequency of anemia. There were a total of 4,426 patients from the United States (Southern California) who had cancer and underwent chemotherapy. 3,962 (89.5%) patients with cancer experienced anemia while undergoing chemotherapy (40). Even anemia rates among cancer patients were greater in studies of gynecologic malignancies in Asian nations (40).

Several mechanisms have been proposed. Inflammation brought on by cancer reduces the production of red blood cells in the first place. Following inflammation, the release of inflammatory cytokines (IL-1, interferon, and TNF-) can impair erythropoietin synthesis, iron sequestration in macrophages, gastrointestinal iron absorption, and erythroid response to erythropoietin. Despite appropriate iron storage in the bone marrow macrophages, this results in less iron being accessible for erythropoiesis. Second, metastatic cancer that has spread to the bone may result in secondary myelofibrosis, which results in the immediate release of prothrombotic extraordinarily large von Willebrand factor multimers, which, by binding to the glycoprotein 1b-IX complex, promote coagulation and platelet aggregation. Third, it has been suggested that intraluminal fibrin thrombi or emboli from blood vessel malignancies may directly cause red cell fragmentation. Fourth, most patients with cancer are on chemotherapeutic agents, which are myelosuppressive and reduce red blood cell production (41, 42, 58).

ICU anemia was more frequently encountered in patients undergoing thoracic surgery four times than in those patients not undergoing thoracic surgery. There are studies in line with our findings. In a retrospective analysis of 465 patients who underwent pulmonary surgery in China found that 274 patients underwent video-assisted thoracic surgery (VATS) and 191 patients underwent open thoracotomies. A postoperative anemia diagnosis was made in 75.3 percent of patients in the ICU (28).

Patients who had undergone urologic surgery were 6.2 times more likely to develop anemia in the ICU than those who had not undergone urologic surgery. According to different studies, anemia is significantly associated with urologic surgery, and the magnitude is even higher in renal transplant surgeries (50, 51).

ICU anemia was frequently encountered in patients undergoing neurologic surgery, 4.5 times more frequently than in those who hadn't undergone neurologic surgery. As evidenced by different published reports, anemia is a common scenario in patients undergoing neurologic surgery after ICU admission. This is supported by a study(52, 53).

The possible postulated mechanisms of anemia after surgery are described below. Anemia during surgery is a typical clinical scenario. Anemia that develops postoperatively resembles chronic illness anemia and is likely due to the impact that inflammatory mediators generated both before and after surgery have on the growth and survival of RBCs (59, 60).

7. Strengths and limitations of the study

7.1 Strength

- Most of the studies on anemia were pre-operative and cross-sectional studies, so this study identifies the incidence and associated factors of anemia postoperatively after patients have been admitted to the surgical ICU using cohort studies.
- It provides insights and clues about the incidence and risk factors of anemia in ICU-admitted elective surgical patients for future research; as such studies are limited in our country, Ethiopia.

7.2. Limitations

- It is secondary data, and as a result, some important information regarding factors associated with anemia was not found (e.g., nutritional status and living conditions).

8. Conclusions

Among surgical patients admitted to the ICU, anemia was present 69.9% of the time. Furthermore, ASA physical status class III, renal failure, cancer, thoracic surgery, urologic surgery, and neurologic surgery all significantly increased the likelihood of anemia in surgical patients who were hospitalized to the intensive care unit (ICU).

Anemia increases the risk of mortality and morbidity. Preventing the need for a transfusion is one of the most important strategies to increase a patient's surgical success because this medical procedure might lead to unintended problems.

The idea of a more effective and optimum method of treating postoperative anemia in the ICU has the promise of lowering medical costs and potential difficulties that our patients might encounter, adding to the already stressful period in their lives following their operation.

9. Recommendations

For the surgery team and anesthesia

- The incidence of anemia is too high; early screening and the institution of therapeutic measures are necessary.
- Preoperative screening of ASA physical status, medical conditions, and surgical history
- Treating patients with those co-morbidities, such as renal failure and malignancies before patients undergoing surgery.
- Minimize modifiable risk factors, such as duration of ICU stay, duration of surgery, and blood loss, as much as possible.

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11. Annexes

Annex 1: Consent Form

Addis Ababa University

College of Medicine and Health Sciences

Department of Anesthesia

Introduction: I am Habtie Bantider. ---------- a graduating MSC student in the department of anesthesia working on research entitled ‘’Incidence and associated risk factors of anemia in patients admitted to surgical ICU: A retrospective study design’’.

I have received permission from the Department of Anesthesia at Addis Ababa University.

The objective of this study is to determine the incidence and associated risk factors of anemia in patients admitted to the surgical ICU.

By participating in this research, you will provide valuable data for future scientific practice in the area of the study.

Anything will be kept confidential regarding the institution’s privacy. Everything will be confidential in a secure way.

The results that we find will be used as baseline data for further actions to solve problems and future scientific studies in the area.

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Annex 2: Research Questionnaires

Section 1: Socio-demographic characteristics

Variable	Possible responses
Sex	1. Male 2. Female
Age	……..Years.
ASA physical status	ASA I ASA II ASA III
Residence	Urban Rural

Section 2: Co-morbidities

Disease entity	Response	Disease entity	Response
Hypertension	Yes No	Malignancy	Yes No
DM	Yes No	Heart failure	Yes No
	Yes No	RVI	Yes No
Renal failure	Yes No	Having greater than two co-morbidities	Yes No

Section 3: treatment factors

Drugs	Response	Drugs	Response
Beta-blockers	Yes No	Chemotherapy	Yes No
ACE inhibitors	Yes No	HAART	Yes No
Calcium channel blockers	Yes No	Taking more than 2 medications	Yes No

Section 4: Surgical factors

Variables	Response	Variables		Response
Previous surgical history	Yes No	Type of surgery	Thoracic surgery	Yes No
Type of anesthesia	GA SA		Abdominal surgery	Yes No
Duration of surgery	----hrs.		Urologic surgery	Yes No
Blood loss in ml	-------ml		Neurologic surgery	Yes No
			Vascular surgery	Yes No
			Head and neck surgery	Yes No

Section 5: ICU and MV duration

Variable	Response
Duration of ICU stay	…….days
Duration on a mechanical ventilator	……days

Section 6: Hematologic factor

Variable	Response
Hemoglobin	At admission---------- At 3rd day---------- At 7th day---------- At discharge…….g/dl
HCT	At admission---------- At 3rd day---------- At 7th day---------- At discharge……. %

Annex 3: Collinearity Diagnosis

Table 5: Multicollinearity test using VIF and tolerance for independent variables.

Variable	VIF	1/VIF (tolerance)
ASA	1.28	0.782
Previous history of surgery	1.14	0.877
Hypertension	1.92	0.521
Renal failure	1.43	0.698
Malignancy	1.37	0.732
Heart failure	1.81	0.553
Calcium channel blockers	1.12	0.893
ACEIs	1.23	0.813
Chemotherapy	1.46	0.685
Thoracic surgery	1.58	0.633
Urologic surgery	1.71	0.585
Neurologic surgery	1.32	0.758