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The effects of preoperative anaemia on postoperative complications in patients undergoing thoracic surgery: A prospective descriptive study

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ABSTRACT

Objective: Preoperative anaemia is a risk factor for an increased requirement for blood and blood-product transfusions in patients undergoing thoracic surgery. Our aim was to study the association between preoperative anaemia and adverse outcomes in patients undergoing thoracic surgery.

Material and Methods: This was a prospective descriptive study of adult patients undergoing thoracic surgery. Patients were classified into preoperative anaemia (Group A: Hb <13 g/dL in males, <12 g/dL in females) and non-anaemia (Group B). Collected data included demographics, intraoperative parameters, laboratory values, and postoperative outcomes, including complications, transfusion requirements, intensive care unit stay, and length of hospital stay. Statistical analyses were conducted to assess differences between the groups.

Results: A total of 104 patients were included: 29 with preoperative anaemia (Group A) and 75 with normal haemoglobin levels (Group B). Both groups were predominantly male. Patients with preoperative anaemia experienced significantly higher rates of intraoperative bleeding and perioperative crystalloid use, greater chest tube drainage volumes and longer durations, and increased postoperative pRBC transfusion requirements. Complications were more frequent in Group A than in Group B (31% vs. 8%, p=0.005) and hospital stays were longer (9.6±5.5 days vs. 7.7±4.7 days, p=0.014).

Conclusion: This study highlights the significant impact of preoperative anaemia on patients undergoing thoracic surgery. Preoperative anaemia was associated with increased intraoperative bleeding, higher complication rates, and longer hospital stays. These findings emphasise the need for thorough preoperative evaluation and optimisation of anaemia to improve surgical outcomes.

Keywords: Preoperative anaemia, thoracic surgery, postoperative complications

INTRODUCTION

Preoperative anaemia is a common and significant condition associated with various complications (1). The estimated prevalence of preoperative anaemia ranges from 16% to 54% (2). Retrospective studies involving large patient cohorts have demonstrated that preoperative anaemia is linked to an increased risk of 30-day postoperative mortality, highlighting its role as a critical risk factor for poor perioperative outcomes (3).

The World Health Organization (WHO) defines anaemia as haemoglobin (Hb) levels below 13.0 g/dL in males and below 12.0 g/dL in females (4). However, it remains unclear whether the adverse impact of anaemia on postoperative outcomes is directly attributable to low Hb levels, underlying risk factors, or blood transfusion-related effects.

A meta-analysis of cardiac surgery patients found that preoperative anaemia was associated with a significant 2.7-fold increased risk of mortality (2). Furthermore, anaemia is frequently linked to comorbidities such as coronary heart disease, diabetes mellitus, or cirrhosis (3). Research has also indicated that preoperative

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anaemia is associated with a a 3.13-fold increased risk of acute kidney injury and a 2.65-fold increased risk of infections (2).

Experimental studies have confirmed that anaemia reduces oxygen delivery, leading to hypoxia in multiple organs, including the brain and kidneys, and ultimately causing organ dysfunction (5). Hypoxia caused by anaemia has been directly associated with acute kidney injury and heightened risks of postoperative infections. Additionally, preoperative anaemia is associated with an increased likelihood of allogeneic blood transfusion, which can suppress cellular immunity and thereby increase the risk of surgical-site infection (6-8).

Secondary analyses of the European Surgical Outcomes Study have further evaluated the impact of abnormal preoperative Hb levels (3). Patients with anaemia experienced longer hospital stays, more frequent intensive care unit (ICU) admissions, greater reliance on mechanical ventilation within the first 24 postoperative hours, and increased use of inotropes or vasopressors (3).

The aim of this study was to determine whether preoperative anaemia, which has been established as a risk factor for postoperative morbidity and mortality in major surgery, is similarly associated with adverse outcomes in patients undergoing thoracic surgery.

MATERIAL and METHODS

Study Design, Setting and Eligibility Criteria

This was a prospective descriptive study of adult patients undergoing thoracic surgery. Patients aged 18 years or older who underwent open thoracic or thoracoscopic surgery under general anaesthesia at our university hospital between 2018 and 2019 were included. Excluded patients were paediatric patients younger than 18 years; patients with a known bleeding disorder, chronic kidney disease, hepatic failure, or congestive heart failure; and patients undergoing emergency surgery who were not assessed preoperatively in the anaesthesia assessment clinic.

This study received approval from the Marmara University Clinical Research Ethics Committee (decision number 09.2018.137, dated 2 February 2018). Written informed consent was obtained from all included participants. The study was registered in the ANZCTR Clinical Trials Registry (ACTRN12619000043134).

Anaesthesia Management

Preoperative preparation was conducted in the anaesthesia assessment clinic. Comorbid conditions were identified, and relevant laboratory tests and imaging evaluations were reviewed. Blood preparation was completed for all patients, and the need for postoperative intensive care was assessed based on comorbidities and the complexity of the surgery. Patients with Hb levels below 12 g/dL for females and below 13 g/dL for males, as defined by the WHO (4), were categorised as the anaemia group (Group A), whereas those with levels above these thresholds were categorised as the non-anaemic group (Group B).

The same thoracic anaesthetist attended all surgeries. Routine monitoring included electrocardiogram, peripheral oxygen saturation (SpO_2), and non-invasive blood pressure, with baseline values recorded. Radial artery cannulation with a 20-G cannula and central jugular cannulation were performed after induction of anaesthesia. Induction was achieved with propofol (2 mg/kg), rocuronium bromide (0.6 mg/kg), and fentanyl (2 µg/kg), using a gas mixture of 80% oxygen and 20% air. Anaesthesia was maintained with 2% sevoflurane, and remifentanil was initiated at 0.5 µg/kg/min after intubation and continued at 0.25 µg/kg/min.

Mechanical ventilation settings were adjusted to maintain an end-tidal carbon dioxide ($EtCO_2$) value of 35-40 mmHg. To prevent hypothermia, patients were warmed intraoperatively using air-warming systems (Bair Hugger Warming System, Augustine Medical, Eden Prairie, MN, USA), with body temperature monitored via an oral temperature probe. Balanced electrolyte solutions were administered for intravenous fluid maintenance, with additional boluses of colloids [Gelofusine 4%, Braun, Sheffield, UK; Hydroxyethyl Starch (Voluven) 6%, 130/0.4, Fresenius, Bad Hamburg, Germany] given as needed. In cases of persistent hypotension despite adequate fluid replacement, intravenous vasopressors or inotropes, such as norepinephrine (0.02-0.2 µg/kg/min) or dopamine (5-10 µg/kg/min), were administered.

Data Collection and Variables

Demographic data, including age, sex, body weight, and the American Society of Anesthesiologists physical status classification, were documented for all patients. Vital parameters such as mean arterial pressure, heart rate, SpO_2, body temperature, $EtCO_2$, and central venous pressure were monitored and recorded. Blood gas analyses included measurements of lactate, pH, base excess, bicarbonate (HCO_3), sodium, potassium, and glucose. Arterial blood gas samples were analysed hourly using the Radiometer ABL800 Flex (Radiometer, Copenhagen, Denmark).

Intraoperative data collected included blood loss, blood transfusions, crystalloid and colloid administration, surgical and anaesthetic durations, and urine output. Preoperative and postoperative Hb, platelet count, creatinine, and international normalized ratio (INR) levels were documented for both groups. Postoperative parameters included 24-hour chest tube drainage volume, total drainage amount, drain removal time, ICU length of stay, and total hospital stay. Blood transfusions in the ward were also recorded.

Transfusion management aimed to maintain Hb levels >9 g/dL, guided by blood gas analyses and the European Society of Anaesthesiology recommendations for intraoperative bleeding management.

Outcomes

The outcomes of this study include 1) postoperative complications; 2) need for perioperative or postoperative blood or blood product transfusions; 3) ICU length of stay; and 4) hospital length of stay.

Statistical Analysis

Numerical data were summarised as mean ± standard deviation for normally distributed variables or as median and interquartile range for non-normally distributed variables. Group comparisons for normally distributed numerical data were conducted using the Student's t-test, while the Mann-Whitney U test was used for skewed data. Categorical data were presented as frequencies and percentages, with hypotheses tested using Pearson's chi-squared test or Fisher's exact test as appropriate. We reported exact p-values, with p-values <0.05 considered statistically significant. All statistical analyses were performed using IBM SPSS Statistics version 22.

RESULTS

Table 1 outlines the demographic characteristics of the study participants. A total of 104 patients were included, with 29 patients having preoperative anaemia (Group A) and 75 patients presenting with normal Hb levels (Group B). Both groups predominantly comprised male patients. The mean age of participants was higher in Group A than in Group B (60.5±11.7 years vs. 52.7±16.6 years). The durations of surgery and anaesthesia were comparable between the two groups. Most patients underwent lobectomy (n=50); other procedures included wedge resection (n=32), pleurectomy for mesothelioma (n=12), thymectomy (n=3), pneumonectomy (n=2), tracheal resection (n=2), thymic cystectomy (n=1), chest wall tumour resection (n=1), and oesophageal resection (n=1).

Table 1. Demographic characteristics of the participants

Variable	Level	Group A (n=29)	Group B (n=75)	p-value
Sex, n (%)	Female	9 (31%)	21 (28%)	0.948
	Male	20 (69%)	54 (72%)	
Age (years)		60.5±11.7 (64)	52.7±16.6 (58)	0.031
BMI (kg/m^2)		27.7±5.5 (26.4)	27.8±5.2 (26.7)	0.786
ASA physical status, n (%)	ASA 1	1 (3%)	6 (8%)	0.269
	ASA 2	24 (83%)	65 (87%)	
	ASA 3	4 (14%)	4 (5%)	
Anaesthesia duration (min)		258.1±89.2 (240)	249.3±95.8 (225)	0.506
Surgery duration (min)		210±81.1 (185)	201.7±88.6 (180)	0.450

Values are given as mean ± standard deviation (median), BMI: Body mass index, ASA: American Society of Anesthesiologists.

Table 2 highlights the preoperative and postoperative laboratory values. Preoperative and postoperative creatinine and INR levels were comparable between the two groups. Platelet counts were consistently higher in Group A than in Group B. A postoperative drop in Hb levels was observed in both groups, with Group A experiencing a mean reduction of 1.9 g/dL compared to 2.3 g/dL in Group B.

Table 3 summarises the observed study outcomes. Complications were significantly more frequent in Group A (31%) than in Group B (8%) (p=0.005). Among these, seven patients developed pneumonia, three required re-exploration, two experienced subcutaneous emphysema, and one patient each experienced prolonged chest tube drainage, a prolonged air leak, or death after discharge. The only death observed in this study occurred in Group A. Among the pneumonia cases, one patient also developed a pulmonary embolism and another developed critical myopathy, both of whom were in Group A.

Mean intraoperative blood loss was higher in Group A than in Group B (435.2±331.6 mL vs. 343.2±513 mL; p=0.008). Patients in Group A exhibited higher chest tube drainage volumes both at 24 hours and in total, as well as longer chest tube durations (Table 3). Although the ICU length of stay was similar between the groups, Group A patients had significantly longer hospital stays than Group B patients (9.6±5.5 days vs. 7.7±4.7 days, respectively; p=0.014).

Table 2. Preoperative and postoperative laboratory values

Variable	Group A (n=29)	Group B (n=75)	p-value
Preoperative Hb (g/dL)	11.4±0.9	14.4±1.2	0.001
Preoperative platelet (x10^3)	318±101 (325)	246±78 (236)	0.001
Preoperative creatinine (mg/dL)	0.96±0.44 (0.99)	0.87±0.18 (0.88)	0.398
Preoperative INR	1.09±0.51 (1.04)	0.97±0.19 (1)	0.251
Postoperative Hb (g/dL)	9.5±1.3	12.1±1.8	0.001
Postoperative platelet (x10^3)	349±166 (329)	252±108 (222)	0.002
Postoperative creatinine (mg/dL)	0.85±0.44 (0.72)	0.75±0.25 (0.72)	0.619
Postoperative INR	1.13±0.2 (1.12)	1.09±0.1 (1.09)	0.030

Values are presented as mean ± standard deviation (median), Hb: Haemoglobin, INR: International normalised ratio.

Table 4 provides data on perioperative and postoperative blood and blood product transfusions. A significantly higher proportion of patients in Group A received perioperative crystalloids than in Group B. While perioperative packed red blood cell (pRBC) and fresh frozen plasma use was similar in both groups, postoperative pRBC transfusion requirements on the ward were higher in Group A (0.86±1.46 mL) than in Group B (0.13±0.48 mL). Table 5 summarises the distribution of postoperative complications by group.

DISCUSSION

This study examined the association between preoperative anaemia and adverse outcomes in patients undergoing thoracic surgery. Patients with preoperative anaemia (Group A) demonstrated significantly higher volumes and longer durations of chest tube drainage, increased intraoperative bleeding, greater perioperative crystalloid fluid administration, and higher postoperative pRBC transfusion requirements in the ward compared to those without anaemia (Group B). Furthermore, the hospital length of stay was notably longer in Group A.

The complication rate was notably higher in Group A (31%) than in Group B (8%) (p=0.005). This aligns with existing literature, in which preoperative anaemia has been associated with increased postoperative complications, particularly in cardiac surgery patients (2,9,10). Alan et al. (1) observed that severe anaemia increased 30-day complication rates, such as acute kidney injury and surgical-site infections, among cranial surgery patients. Similarly, Janssen et al. (6) reported that blood transfusion significantly increased the risk of surgical site infections, urinary tract infections, and pneumonia in patients undergoing lumbar spine surgery.

Our study also observed that the mean age of patients in Group A was higher than that in Group B, suggesting that age-related comorbidities may contribute to the higher incidence of anaemia. This is consistent with findings of Ranucci et al. (11), who noted an association between advanced age and postoperative complications among anaemic patients undergoing cardiac surgery. In contrast, Musallam et al. (9) reported that age and sex did not influence postoperative complications among anaemic patients. The EuroSCORE (12), the European System for Cardiac Operative Risk Evaluation, is a universal risk-scoring system that does not currently include preoperative anaemia as a risk factor. However, based on our findings, we propose that preoperative anaemia should be considered a significant risk factor in such scoring systems to improve patient preparation and risk assessment.

According to the cell-based coagulation model, platelets play a crucial role in the formation of the clot core during the initial phase of haemostasis. An increased platelet count is generally considered protective, reducing the risk of uncontrolled bleeding from vascular injury during surgery. In our study, despite a higher platelet count in the preoperative anaemia group (Group A), both intraoperative bleeding and postoperative drainage were

Table 3. Summary of study outcomes between groups

Variable	Group A (n=29)	Group B (n=75)	p-value
Postoperative complications, n (%)	9 (31%)	6 (8%)	0.005
Intraoperative bleeding (mL)	435.2±331.6 (350)	343.2±513 (200)	0.008
Perioperative urine output (mL)	393.1±249.9 (320)	347.1±277.1 (250)	0.241
24-hour chest tube drainage (mL)	361±163.3 (350)	322±207.5 (300)	0.113
Total chest tube drainage (mL)	1276±522 (1300)	979±520 (900)	0.001
Chest tube duration (days)	7±3.2 (6)	5.5±3.6 (5)	0.006
ICU stay (days)	0.21±0.41 (0)	0.31±1.15 (0)	0.546
Hospital stay (days)	9.6±5.5 (8)	7.7±4.7 (7)	0.014

Values are given as mean ± standard deviation (median), ICU: Intensive care unit.

Table 4. Perioperative and postoperative blood and blood product transfusions

Variable	Group A (n=29)	Group B (n=75)	p-value
Perioperative crystalloid use (mL)	1538±506 (1500)	1357±648 (1200)	0.018
Perioperative colloid use (mL)	378±383 (500)	337±399 (100)	0.485
Perioperative FFP use (mL)	0.1±0.56 (0)	0.07±0.38 (0)	0.904
Perioperative pRBC use (mL)	0.1±0.41 (0)	0.12±0.84 (0)	0.341
Postoperative FFP use (mL)	0.03±0.19 (0)	0.07±0.38 (0)	0.674
Postoperative pRBC use (mL)	0.86±1.46 (0)	0.13±0.48 (0)	0.001

Values are given as mean ± standard deviation (median), FFP: Fresh frozen plasma, pRBC: Packed red blood cell.

Table 5. Distribution of postoperative complications by group		
Complication	**Group A (anaemia, n=29)**	**Group B (non-anaemia, n=75)**
Pneumonia, n	4	3
Re-exploration for bleeding, n	1	2
Subcutaneous emphysema, n	1	1
Prolonged chest tube drainage, n	1	0
Prolonged air leak, n	1	0
Pulmonary embolism, n	1	0
Critical myopathy, n	1	0
Mortality, n	1	0

significantly greater in this group. This finding may be explained by the lateral migration theory (13). According to this theory, during bleeding, erythrocytes migrate to the centre of blood vessels, pushing other cells such as leucocytes and platelets towards the blood vessel walls. In patients with anaemia, the reduced number of erythrocytes may impair this hydrodynamic interaction, preventing platelets from effectively reaching the vessel wall and forming clots. This mechanism may explain the increased bleeding observed in Group A, despite higher platelet counts. In the anaemia group, a higher proportion of complex surgical procedures was observed; this may have contributed to increased intraoperative bleeding. Furthermore, most thoracic surgical interventions in our cohort were performed for malignant disease. Malignancy-related inflammatory changes, including elevated platelet counts, are well known to predispose to both thromboembolic events and bleeding complications. These factors should therefore be considered when interpreting the association between preoperative anaemia and perioperative bleeding observed in our study.

Preoperative anaemia was also linked to prolonged hospital stays, consistent with Muñoz et al. (14), who found that preoperative anaemia in colectomy patients increased length of stay and worsened postoperative outcomes. Wu et al. (10) reported higher mortality rates and cardiac complications in patients with low preoperative haematocrit levels undergoing non-cardiac surgery. Similarly, Kılıç et al. (15) reported that preoperative anaemia was a prognostic marker in patients undergoing pneumonectomy for non-small-cell lung cancer and associated with adverse postoperative outcomes. Based on these findings, we hypothesise that preoperative anaemia contributes to prolonged chest tube duration and hospitalisation.

Our data reveal a smaller drop in Hb levels in the anaemia group (Group A). A possible explanation for this finding is that patients in the anaemia group had lower baseline Hb values; therefore, the absolute perioperative decline in Hb was numerically smaller, despite similar transfusion rates and greater intraoperative blood loss. Moreover, perioperative fluid administration and haemodilution might have contributed to different extents across groups, potentially masking the true extent of blood loss as measured by decreases in Hb concentration. Although intraoperative blood loss was higher in the anaemia group, similar transfusion rates between groups may have partially compensated for the decline in haemoglobin. Additionally, low baseline Hb levels in Group A could have led to a smaller relative reduction compared with Group B, where patients started from higher baseline levels.

Study Limitations

Our study has several important limitations that merit acknowledgement. First, the anaemia group had a significantly higher mean age than that of the non-anaemia group (60.5±11.7 vs. 52.7±16.6 years). Advanced age is independently associated with both the comorbidity burden and postoperative complications, and may therefore confound the observed relationship between preoperative anaemia and adverse outcomes. Future larger multicentre studies with prospectively collected comorbidity and frailty indices are warranted to confirm the independent effect of preoperative anaemia on postoperative complications and to determine whether targeted preoperative anaemia management modifies this risk.

Chest tube duration is influenced by multiple factors, particularly the underlying lung parenchymal status and the type of surgical procedure. In our study, the limited number of events did not allow for a robust multivariate analysis to adjust for these variables; therefore, our observation regarding the association between preoperative anaemia and longer chest tube duration should be interpreted as exploratory rather than definitive.

CONCLUSION

This study highlights the significant impact of preoperative anaemia on patients undergoing thoracic surgery. Preoperative anaemia was associated with increased intraoperative bleeding, greater volume and longer duration of chest tube drainage, increased postoperative pRBC transfusion requirements, and longer hospital stays. Moreover, the complication rate was markedly higher among anaemic patients. These findings emphasise the need for thorough preoperative evaluation and optimisation of anaemia to improve surgical outcomes. Additionally, integrating preoperative anaemia as a risk factor in scoring systems may enhance patient risk stratification and perioperative planning. Future research should address the limitations of this study to validate and expand upon our results.

Ethics

Ethics Committee Approval: This study received approval from the Marmara University Clinical Research Ethics Committee (decision number 09.2018.137, dated 2 February 2018). The study was registered in the ANZCTR Clinical Trials Registry (ACTRN12619000043134).

Informed Consent: Written informed consent was obtained from all included participants.

Footnotes

Author Contributions

Concept A.S., G.Ç., E.Y., K.Ç.Y., B.Y., M.Y., Z.A.; Design - A.S., G.Ç., E.Y., K.Ç.Y., B.Y., M.Y., Z.A.; Data Collection or Processing - A.S., G.Ç., B.Y., M.Y., Z.A; Analysis or Interpretation - A.S., G.Ç., B.M.A.; Literature Search - B.M.A., E.Y., K.Ç.Y.; Writing - A.S., G.Ç., B.M.A., E.Y., K.Ç.Y., B.Y., M.Y., Z.A.

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