(e) ISSN Online: 2321-9599

(p) ISSN Print: 2348-6805

ORIGINAL ARTICLE

Comparative Analysis of Preoperative Versus Postoperative Hematological Parameters in Major Surgeries

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ABSTRACT:
Background: Major surgical procedures are associated with significant physiological stress, blood loss, and inflammatory responses, all of which can alter hematological parameters in the perioperative period. Monitoring these changes is essential for guiding transfusion decisions, anticipating complications, and optimizing postoperative recovery. A comparative assessment of preoperative and postoperative hematological profiles provides valuable insights into the extent of surgical impact and patient vulnerability. **Aim:**To evaluate and compare preoperative and postoperative hematological parameters in patients undergoing major surgeries at a tertiary care hospital and to determine the association between intraoperative blood loss and postoperative hemoglobin decline. **Materials and Methods:**This observational analytical study included 82 adult patients undergoing major elective or emergency surgeries. Preoperative hematological parameters—including hemoglobin, hematocrit, RBC indices, leukocyte counts, platelet count, and coagulation profile—were recorded within 24 hours prior to surgery. Postoperative samples were collected within the first 24 hours after surgery. Demographic variables, ASA grade, type of surgery, intraoperative blood loss, and transfusion details were documented. Comparative analysis of preoperative and postoperative hematological parameters was performed using paired statistical tests, and the association of blood loss categories with hemoglobin reduction was assessed using ANOVA. **Results:**Significant postoperative reductions were observed in hemoglobin (12.46 ± 1.38 to 10.92 ± 1.44 g/dL, $p < 0.001$), hematocrit (38.12% to 34.06%, $p < 0.001$), and RBC count (4.62 to 4.12 $\times 10^6/\mu L$, $p = 0.002$). White cell parameters showed marked increases in total leukocyte count ($p < 0.001$) and neutrophil percentage ($p < 0.001$), alongside significant lymphopenia ($p < 0.001$). Platelet count decreased significantly ($p = 0.008$), while PT, INR, and aPTT demonstrated notable postoperative prolongation (all $p < 0.001$). Hemoglobin reduction correlated strongly with increasing categories of blood loss (<500 mL, 0.92 ± 0.44 g/dL; 500–1000 mL, 1.84 ± 0.72 g/dL; >1000 mL, 2.76 ± 0.98 g/dL; $p < 0.001$). **Conclusion:**Major surgeries produce substantial changes in hematological parameters, reflecting combined effects of surgical blood loss, hemodilution, and physiological stress. Early postoperative monitoring enables timely interventions, supports patient blood management strategies, and may improve postoperative outcomes.
Keywords: Hematological parameters, major surgery, postoperative anemia, coagulation profile, blood loss.

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This article may be cited as: Gahalot A, Sahu M. Comparative Analysis of Preoperative Versus Postoperative Hematological Parameters in Major Surgeries. J Adv Med Dent Scie Res 2017;5(2):294-299.

INTRODUCTION

Major surgical procedures impose substantial physiological stress through tissue trauma, blood loss, fluid shifts, and activation of neuroendocrine and inflammatory pathways. These changes can significantly alter hematological parameters in the perioperative period, with direct implications for oxygen delivery, coagulation balance, immune competence, and overall recovery. Careful assessment of preoperative and postoperative blood profiles is therefore an integral part of perioperative care, particularly in patients undergoing major surgery with significant comorbidities and limited physiological reserve. A structured comparison of hematological parameters before and after surgery can help clinicians anticipate complications, guide transfusion decisions, and optimize postoperative management.Preoperative anaemia is one of the most frequent hematological abnormalities encountered in surgical practice. Its prevalence in major surgery cohorts commonly ranges between one-third and one-half of patients, depending on the population and type of surgery, and it has consistently been associated with adverse postoperative outcomes.[1,2] Anaemia reduces the blood's oxygen-carrying capacity and may also reflect underlying chronic disease, nutritional deficiency, renal dysfunction, or occult blood loss. Beattie et al. demonstrated that preoperative anaemia in noncardiac surgical patients was independently associated with an increased risk of postoperative mortality, even after adjustment for comorbidities and transfusion exposure.[1] Recognition of the prognostic significance of anaemia has led to specific recommendations for its detection and optimization before elective major surgery. The NATA guidelines by Goodnough et al. emphasized that elective orthopaedic patients should have haemoglobin measured well in advance of surgery,

and that any identified anaemia should be evaluated and treated according to its underlying cause.[3] Their guidance underscores the importance of screening, timely investigation, and targeted therapy—including iron supplementation, treatment of chronic disease, or use of erythropoiesis-stimulating agents where appropriate—to minimize perioperative transfusion and improve outcomes. Building on this, the broader concept of patient blood management (PBM) has emerged, promoting a multimodal, multidisciplinary strategy to preserve the patient's own blood and reduce unnecessary exposure to allogeneic transfusion.[4]Postoperative anaemia is even more common than preoperative anaemia, as it reflects not only the patient's baseline status but also intraoperative blood loss, haemodilution from fluid therapy, ongoing postoperative bleeding, and delayed erythropoietic recovery. After major surgery, a substantial proportion of patients experience postoperative haemoglobin levels that meet diagnostic thresholds for anaemia, raising concerns about fatigue, delayed mobilization, impaired functional recovery, and longer hospital stay. Studies in orthopaedic surgery have shown that immediate postoperative anaemia is frequent after hip or knee arthroplasty and often prompts transfusion decisions in the early postoperative period.[5,6] Beyond red cell parameters, major surgery induces complex changes in leukocytes, platelets, and coagulation factors. Surgical trauma and associated tissue injury activate the innate and adaptive immune systems, leading to leukocytosis, neutrophilia, and relative lymphopenia, alongside functional alterations in phagocytes and lymphocyte subsets. Green's classic review on trauma and the immune response highlighted that severe injury and major operations are accompanied by multicentric immune defects and increased susceptibility to sepsis, reflecting both activation and subsequent dysregulation of immune pathways.[7] These immunologic changes are mirrored in routine hematological tests, where increases in total leukocyte count and neutrophil percentage and decreases in lymphocyte and eosinophil counts may serve as accessible markers of surgical stress and transient immunosuppression. In parallel, platelet count and standard coagulation tests (prothrombin time, international normalized ratio, activated partial thromboplastin time) may shift toward either bleeding or thrombotic risk depending on the balance between consumption, dilution, and procoagulant activation.

MATERIALS AND METHODS

This was a hospital-based observational analytical study conducted in the Department of General Surgery and associated surgical specialties of a tertiary care teaching hospital. All consecutive eligible patients undergoing major elective or emergency surgeries under general or regional anesthesia and fulfilling the inclusion criteria were enrolled. The study was designed to compare key hematological parameters in the preoperative period with those in the immediate postoperative period.A total of 82 patients were included in the study. Patients of either sex, aged ≥18 years, who were scheduled for major surgical procedures (involving opening of major body cavities or surgery with expected significant blood loss and/or operating time >2 hours) and who provided informed consent were recruited. The sample size of 82 patients was based on feasibility and the expected number of eligible patients during the recruitment phase, while ensuring adequate power to detect clinically relevant changes in the selected hematological parameters.

Inclusion and Exclusion Criteria

Inclusion criteria were: adult patients (≥18 years), undergoing major elective or emergency surgery, with complete preoperative evaluation and availability of both preoperative and postoperative hematological reports. Patients were excluded if they had known hematological malignancies, preexisting severe coagulopathies, chronic liver failure, end-stage renal disease on dialysis, ongoing chemotherapy or radiotherapy, recent blood transfusion within 7 days prior to surgery, or incomplete medical records. Patients with intraoperative mortality or those who left against medical advice before postoperative sampling were also excluded.

Methodology

All patients underwent a standardized preoperative assessment as per institutional protocol, including detailed history, physical examination, and routine investigations. Demographic data (age, sex), clinical diagnosis, type of surgery, type of anesthesia, American Society of Anesthesiologists (ASA) physical status, and relevant comorbidities (such as diabetes mellitus, hypertension, ischemic heart disease, chronic kidney disease) were recorded in a predesigned proforma. Preoperative hematological parameters were obtained from blood samples collected within 24 hours prior to surgery as part of routine preanesthetic workup.

Postoperative hematological parameters were assessed from venous blood samples taken at a standardized time point after surgery, typically within the first 24 hours postoperatively once the patient was hemodynamically stable. In patients requiring intensive care unit admission, samples were collected after stabilization but within the same 24-hour postoperative window. Postoperative clinical data including intraoperative blood loss (as estimated by the anesthesiologist and surgical team), volume and type of intravenous fluids, blood transfusions, and any immediate postoperative complications (e.g., hypotension, re-exploration, significant bleeding) were recorded.

The following hematological parameters were evaluated and compared between the preoperative and postoperative periods: hemoglobin (Hb), hematocrit (Hct), total red blood cell (RBC) count, mean

corpuscular volume (MCV), mean corpuscular hemoglobin (MCH), mean corpuscular hemoglobin concentration (MCHC), red cell distribution width (RDW), total leukocyte count (TLC), differential leukocyte count (neutrophils, lymphocytes, monocytes, eosinophils), platelet count, and erythrocyte sedimentation rate (ESR) where available. Coagulation profile including prothrombin time (PT), international normalized ratio (INR), and activated partial thromboplastin time (aPTT) was also recorded preoperatively and postoperatively when done as part of clinical management. In selected patients where these were routinely tested, serum fibrinogen levels and C-reactive protein (CRP) were additionally noted for descriptive analysis of perioperative inflammatory response.

All hematological investigations were performed in the central hospital laboratory using standard operating procedures. Complete blood count (CBC) parameters (Hb, Hct, RBC indices, WBC count, platelet count, RDW) were measured using an automated 5-part differential hematologyanalyzer, which was calibrated regularly according to manufacturer instructions and institutional quality control policies. Coagulation parameters (PT, INR, aPTT) were measured by automated coagulometer using appropriate commercial reagents. ESR was estimated by the Westergren method. For each patient, preoperative and postoperative samples were processed in the same laboratory to minimize inter-laboratory variability.

Perioperative data were collected from the anesthesia records and postoperative charts, including baseline vital signs, duration of surgery, type of surgical procedure (e.g., gastrointestinal, hepatobiliary, oncological, orthopedic, urological), use of epidural analgesia, intraoperative blood loss (estimated from suction containers and surgical mops), and fluid management (crystalloids, colloids, blood and blood products). The number and type of packed red cell units, fresh frozen plasma, platelets, or cryoprecipitate administered were recorded. These variables were later explored in relation to changes in hematological parameters to identify possible associations.

Statistical Analysis

All data were entered into a spreadsheet and cross-checked for completeness and accuracy. Continuous variables such as hematological parameters were expressed as mean ± standard deviation (SD) or median with interquartile range (IQR) depending on data distribution. Categorical variables such as sex, type of surgery, and ASA grade were summarized as frequencies and percentages. Normality of continuous data was assessed using the Shapiro–Wilk test. Preoperative and postoperative hematological parameters were compared using paired t-test for normally distributed data and Wilcoxon signed-rank test for non-normally distributed data. Associations between changes in hematological parameters and perioperative factors (such as blood loss, transfusion, duration of surgery, and type of procedure) were analyzed using appropriate tests like chi-square test, independent t-test, or ANOVA as applicable. A p-value <0.05 was considered statistically significant. Statistical analysis was performed using standard statistical software (such as SPSS or equivalent).

RESULTS

Table 1 presents the demographic and clinical characteristics of the 82 patients included in the study. The majority of the study population belonged to the age group of 41–60 years (41.46%), followed by 18–40 years (31.71%), indicating that middle-aged adults comprised the largest proportion of patients undergoing major surgeries. Patients above 60 years made up 26.83%, reflecting a sizeable elderly population requiring surgical interventions. Regarding sex distribution, males constituted 58.54%, while females accounted for 41.46%, showing a male predominance in surgical admissions. Analysis of ASA grading demonstrated that most patients were classified as ASA II (46.34%), indicating mild systemic disease. This was followed by ASA III (31.71%), suggesting that one-third of the patients had significant systemic comorbidities. ASA I patients were fewer, at 21.95%, representing those with no systemic illness. The distribution of surgery types showed that gastrointestinal procedures were the most common (36.59%), followed by oncological surgeries (21.95%) and hepatobiliary surgeries (17.07%). Orthopedic and urological surgeries each accounted for 12.20%, highlighting the diverse surgical spectrum at the tertiary care center.

Table 2 compares preoperative and postoperative red cell parameters and demonstrates a significant decline in most erythrocyte indices following surgery. Hemoglobin levels showed a statistically significant reduction from 12.46 ± 1.38 g/dL to 10.92 ± 1.44 g/dL ($p < 0.001$), reflecting perioperative blood loss and hemodilution commonly observed after major surgeries. Hematocrit followed a similar pattern, decreasing significantly from 38.12 ± 3.90% to 34.06 ± 4.12% ($p < 0.001$). Total RBC count also demonstrated a significant decrease, from 4.62 ± 0.48 $\times 10^6/\mu L$ to 4.12 ± 0.52 $\times 10^6/\mu L$ ($p = 0.002$). In contrast, indices reflecting red cell morphology—MCV, MCH, and MCHC—showed minimal or inconsistent changes. MCV and MCH changes were statistically insignificant ($p = 0.214$ and $p = 0.318$, respectively), suggesting preserved erythrocyte morphology despite loss of cell mass. However, MCHC exhibited a small but statistically significant decline ($p = 0.046$), which may indicate early postoperative fluid shifts affecting hemoconcentration levels.

Table 3 illustrates significant alterations in white blood cell parameters and differential counts between the preoperative and postoperative periods. Total leukocyte count increased markedly from 8.42 ± 2.16

×10³/µL to 12.68 ± 3.04 ×10³/µL ($p < 0.001$), a finding consistent with postoperative stress, inflammation, and tissue injury. Neutrophil percentage rose significantly from 64.12 ± 8.34% to 78.44 ± 7.90% ($p < 0.001$), indicating a robust acute-phase inflammatory response, which is expected after major surgical trauma. Conversely, lymphocyte percentage decreased significantly from 26.48 ± 7.12% to 14.66 ± 6.04% ($p < 0.001$), reflecting stress-induced lymphocyte redistribution or suppression. Monocyte count showed no significant change ($p = 0.268$), while eosinophils demonstrated a significant reduction ($p = 0.010$), commonly associated with surgical stress and corticosteroid responses. RDW values showed a slight postoperative increase but did not reach statistical significance ($p = 0.112$), suggesting minimal immediate impact on red cell size variability.

Table 4 summarizes the comparison of platelet count and coagulation parameters before and after surgery. Platelet count showed a statistically significant decrease from 258.44 ± 54.62 ×10³/µL to 232.12 ± 48.30 ×10³/µL ($p = 0.008$), which may be attributed to hemodilution, platelet consumption, or sequestration following major surgical procedures. Coagulation markers exhibited highly significant postoperative prolongation: PT increased from 13.12 ± 1.24 seconds to 14.88 ± 1.62 seconds ($p < 0.001$), INR rose from 1.06 ± 0.12 to 1.22 ± 0.16 ($p < 0.001$), and aPTT increased from 32.44 ± 3.54 seconds to 36.84 ± 4.10 seconds ($p < 0.001$). These findings collectively indicate a postoperative shift toward transient coagulopathy, likely due to hemodilution, consumption of clotting factors, or inflammatory modulation of coagulation pathways.

Table 5 evaluates the association between categories of intraoperative blood loss and the corresponding decline in hemoglobin. Patients with minimal blood loss (<500 mL) experienced the smallest mean hemoglobin drop (0.92 ± 0.44 g/dL). Those with moderate blood loss (500–1000 mL) demonstrated a greater decline (1.84 ± 0.72 g/dL), while patients with blood loss exceeding 1000 mL showed the most substantial reduction (2.76 ± 0.98 g/dL). The difference across groups was statistically significant ($p < 0.001$), indicating a clear and direct relationship between intraoperative bleeding volume and postoperative anemia severity. This table reinforces the impact of surgical blood loss as a major determinant of postoperative red cell decline.

Table 1: Demographic and Clinical Characteristics of the Study Population (N = 82)

Variable	Category	Frequency (n)	Percentage (%)
Age Group (years)	18–40	26	31.71%
	41–60	34	41.46%
	>60	22	26.83%
Sex Distribution	Male	48	58.54%
	Female	34	41.46%
ASA Grade	I	18	21.95%
	II	38	46.34%
	III	26	31.71%
Type of Surgery	Gastrointestinal	30	36.59%
	Hepatobiliary	14	17.07%
	Oncological	18	21.95%
	Orthopedic	10	12.20%
	Urological	10	12.20%

Table 2: Comparison of Preoperative and Postoperative Red Cell Parameters (Mean ± SD)

Parameter	Preoperative	Postoperative	p-value
Hemoglobin (g/dL)	12.46 ± 1.38	10.92 ± 1.44	**<0.001**
Hematocrit (%)	38.12 ± 3.90	34.06 ± 4.12	**<0.001**
RBC Count (×10⁶/µL)	4.62 ± 0.48	4.12 ± 0.52	**0.002**
MCV (fL)	82.36 ± 6.88	83.04 ± 7.12	0.214
MCH (pg)	27.14 ± 2.44	26.88 ± 2.52	0.318
MCHC (g/dL)	32.80 ± 1.42	32.10 ± 1.50	0.046

Table 3: Comparison of White Cell Parameters and Differential Count

Parameter	Preoperative	Postoperative	p-value
Total Leukocyte Count (×10³/µL)	8.42 ± 2.16	12.68 ± 3.04	**<0.001**
Neutrophils (%)	64.12 ± 8.34	78.44 ± 7.90	**<0.001**
Lymphocytes (%)	26.48 ± 7.12	14.66 ± 6.04	**<0.001**
Monocytes (%)	6.12 ± 1.88	5.80 ± 1.94	0.268
Eosinophils (%)	2.12 ± 1.14	1.12 ± 0.88	**0.010**
RDW (%)	13.64 ± 1.24	13.92 ± 1.32	0.112

Table 4: Comparison of Platelet and Coagulation Parameters

Parameter	Preoperative	Postoperative	p-value
Platelet Count (×10³/µL)	258.44 ± 54.62	232.12 ± 48.30	**0.008**
PT (seconds)	13.12 ± 1.24	14.88 ± 1.62	**<0.001**
INR	1.06 ± 0.12	1.22 ± 0.16	**<0.001**
aPTT (seconds)	32.44 ± 3.54	36.84 ± 4.10	**<0.001**

Table 5: Association of Blood Loss Categories with Hemoglobin Drop

Blood Loss Category	n (%)	Mean Hb Drop (g/dL)	p-value*
<500 mL	38 (46.34%)	0.92 ± 0.44	
500–1000 mL	28 (34.15%)	1.84 ± 0.72	
>1000 mL	16 (19.51%)	2.76 ± 0.98	**<0.001**

*p-value calculated using ANOVA test.

DISCUSSION

In the present study of 82 patients undergoing major surgery at a tertiary care hospital, the majority of patients were middle-aged (41–60 years: 41.46%), with a clear male predominance (58.54%) and a high proportion of ASA II (46.34%) and ASA III (31.71%) cases, reflecting a population with substantial comorbidity burden. This pattern is consistent with large observational data from non-cardiovascular surgical cohorts where men not only predominate but also present with higher ASA grades and more comorbid conditions, which partly explains their higher postoperative mortality compared with women, as shown by Grewal et al (2012), who reported 30-day mortality of 2.76% in males versus 1.89% in females in a cohort of 39,433 non-cardiac surgical patients.[8]

The mean preoperative hemoglobin in this study (12.46 ± 1.38 g/dL) falls in a borderline range where a substantial proportion of patients are likely to be mildly anemic according to WHO criteria, and the observed postoperative mean of 10.92 ± 1.44 g/dL indicates that many patients move into frankly anemic ranges following surgery. Musallam et al (2011) examined a large cohort of patients undergoing major non-cardiac surgery and demonstrated that even mild preoperative anemia was independently associated with increased 30-day morbidity and mortality compared with non-anemic patients, with a graded risk increase from mild to severe anemia.[9]

In our cohort, hemoglobin and hematocrit showed a statistically significant postoperative decrease (Hb: 12.46 ± 1.38 g/dL to 10.92 ± 1.44 g/dL; mean drop ≈1.54 g/dL; Hct: 38.12% to 34.06%, drop ≈4.06%; both $p < 0.001$), while RBC count also fell significantly from 4.62 to 4.12 ×10⁶/µL ($p = 0.002$). These changes are in line with orthopedic literature in which perioperative blood loss is quantified by the fall in hemoglobin concentration. Mahadevan et al. (2010), in a series of 146 patients undergoing revision total hip replacement, reported an average postoperative hemoglobin decrease of 4.6 g/dL in menand 3.5 g/dL in women**,** corresponding to a 27–32% fall from baseline, and showed that greater blood loss and larger hemoglobin drops were associated with higher transfusion requirements and longer hospital stay.[10]

The graded relationship we observed between intraoperative blood loss and hemoglobin decline (0.92 ± 0.44 g/dL for <500 mL, 1.84 ± 0.72 g/dL for 500–1000 mL, and 2.76 ± 0.98 g/dL for >1000 mL; $p < 0.001$) indicates a clear dose–response effect of blood loss on postoperative anemia. This pattern parallels the concept of postoperative hemoglobin "drift" described by Grant et al (2014), who analyzed over 3,000 patients undergoing 11 common surgeries and reported that more invasive procedures with higher IV fluid and blood requirements had a mean downward hemoglobin drift of about 2.5 g/dL over the first three postoperative days, followed by a modest upward correction during diuresis.[11]

White blood cell dynamics in this study showed a classic stress-response profile: total leukocyte count rose from 8.42 ± 2.16 ×10³/µL preoperatively to 12.68 ± 3.04 ×10³/µL postoperatively ($p < 0.001$), neutrophils increased from 64.12 ± 8.34% to 78.44 ± 7.90% ($p < 0.001$), while lymphocytes fell from 26.48 ± 7.12% to 14.66 ± 6.04% ($p < 0.001$). These findings align closely with the classic work of Cullen et al (1975), who demonstrated that after prolonged, traumatic operations under general anesthesia, total leukocyte counts increased primarily due to an influx of neutrophils, while lymphocyte transformation responses were depressed, changes they attributed predominantly to nonspecific surgical stress rather than the anesthetic technique itself.[12]

The marked fall in lymphocyte percentage in our patients (from 26.48% to 14.66%) together with a significant eosinophil reduction (2.12% to 1.12%; $p = 0.010$) further supports the concept of stress-mediated redistribution of lymphoid cells rather than primary bone-marrow suppression. Toft et al (1993) experimentally investigated this mechanism in rabbits and showed that major surgery (laparotomy) led to a decrease in peripheral blood lymphocytes from 43.8% to 14.7% seven hours after surgery, while radiolabeled lymphocyte activity in lymphatic tissue rose to 137.8% and 134.7% of baseline at 4 and 7 hours, respectively, indicating active redistribution from blood to lymphatic organs.[13]

Platelet behavior in our study was characterized by a modest but significant decline in count from 258.44 ± 54.62 ×10³/µL preoperatively to 232.12 ± 48.30

×10³/μL postoperatively (p = 0.008), without progression to severe thrombocytopenia in most patients. Although our absolute counts remained within normal limits in the majority, this reduction may represent early consumption or dilution. Williamson et al (2013) reported that in a large cohort of 20,696 critically ill patients, prevalent thrombocytopenia (platelets <100 ×10⁹/L) occurred in 13.3% and incident thrombocytopenia in 7.8%, and both were associated with significantly higher mortality (14.3% and 24.7%, respectively) compared with 10.2% in patients maintaining normal platelet counts.[14]

Coagulation parameters in this study showed a consistent pattern of mild postoperative coagulopathy: PT increased from 13.12 ± 1.24 s to 14.88 ± 1.62 s, INR from 1.06 ± 0.12 to 1.22 ± 0.16, and aPTT from 32.44 ± 3.54 s to 36.84 ± 4.10 s (all $p < 0.001$). These shifts likely reflect a combination of factor consumption, hemodilution, and the inflammatory response. Desborough (2000) comprehensively reviewed the stress response to trauma and surgery, describing how activation of the hypothalamic–pituitary–adrenal axis and sympathetic nervous system leads not only to metabolic and cardiovascular changes but also to alterations in hemostasis, typically with an initial procoagulant tendency and subsequent complex changes in coagulation and fibrinolysis.[15]

CONCLUSION

This study demonstrated significant perioperative alterations in hematological parameters among patients undergoing major surgeries, with notable reductions in hemoglobin, hematocrit, and RBC count, as well as marked shifts in leukocyte profiles and coagulation markers. These findings highlight the combined impact of surgical blood loss, hemodilution, and physiological stress responses on postoperative hematological status. The strong association between intraoperative blood loss and postoperative hemoglobin decline underscores the importance of meticulous blood management strategies.

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