Scholars Journal of Applied Medical Sciences
Abbreviated Key Title: Sch J App Med Sci
ISSN 2347-954X (Print) | ISSN 2320-6691 (Online)
Journal homepage: https://saspublishers.com

OPEN ACCESS

Medicine

Predictive Factors and Prognostic Impact of Blood Transfusion in Surgical Intensive Care: A Retrospective Observational Study

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DOI: https://doi.org/10.36347/sjams.2025.v13i08.007 | **Received:** 16.06.2025 | **Accepted:** 06.08.2025 | **Published:** 19.08.2025

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Abstract | **Original Research Article**

Introduction: Blood transfusion is frequently administered in surgical intensive care units, primarily to correct anaemia or coagulopathy. However, it is associated with an increased risk of complications. ***Objective:*** to identify predictive factors for the use of blood transfusion in surgical intensive care and to assess its impact on clinical outcomes. ***Methods:*** We conducted a retrospective observational study at a single centre. This study included 100 postoperative patients admitted to the surgical intensive care unit of Ibn Sina University Hospital Center, Rabat, Morocco. Factors associated with transfusion were analysed using univariate and multivariate regression models. ***Results:*** Among the 100 patients included, 64 required a blood transfusion, mainly due to poorly tolerated anaemia (77%) or haemorrhagic shock (23%). Preoperative anaemia was identified as the main predictive factor for transfusion ($p < 0.001$). Transfused patients had a longer ICU stay (7.2 ± 6.9 days vs 4.4 ± 2 days; $p = 0.004$) and a higher rate of postoperative complications (35.9% vs 5.5%; $p = 0.06$). Mortality was also higher among transfused patients (10.9% vs 5.56%), although this difference was not statistically significant ($p = 0.367$). ***Conclusion:*** Blood transfusion is common in surgical intensive care. Preoperative anaemia is its main predictive factor. Transfusion is associated with a higher rate of postoperative complications and prolonged length of stay.

Keywords: Blood transfusion; surgical intensive care; morbidity; risk factors; prognosis.

I. INTRODUCTION

Blood transfusion is a common therapeutic intervention in intensive care, particularly following major surgical procedures. It is indicated to correct anaemia, coagulopathy, or thrombocytopenia, with the aim of ensuring adequate tissue perfusion and optimising oxygen delivery. According to some reports, approximately one-third of patients admitted to intensive care units (ICUs) receive a transfusion during their stay [1]. However, numerous studies have shown that transfusion is not without risks, and may be associated with increased morbidity, mortality, and length of ICU stay.

Identifying the predictive factors for perioperative transfusion is essential to improve risk stratification, optimise transfusion practices, and minimise potential adverse effects. Several variables have been explored in the literature, including biological parameters, preoperative clinical characteristics, and the nature of the surgical procedure.

In this context, we conducted a retrospective study in the surgical intensive care unit of the Ibn Sina University Hospital in Rabat, with the following

Objectives:

1. To identify predictive factors for blood transfusion in postoperative patients admitted to surgical intensive care;
2. To assess the prognostic impact of transfusion on morbidity, mortality, and length of ICU stay.

II. MATERIALS AND METHODS

1. Study design and setting

This was a monocentric, observational, retrospective study conducted in the surgical intensive care unit of Avicenne Hospital, part of the Ibn Sina University Hospital Centre in Rabat.

2. Study population

The study included 100 patients admitted to surgical intensive care following elective surgery. All

included patients had a documented transfusion status (transfused vs non-transfused).

3. Inclusion and exclusion criteria

Inclusion criteria:

- Admission to surgical ICU following elective surgery;
- Complete availability of clinical and biological data.

Exclusion criteria:

- Incomplete or non-usable medical records;
- Transfusion administered exclusively in the preoperative period, outside the ICU setting;
- Death within the first 24 hours postoperatively (to avoid bias related to early mortality not attributable to transfusion).

4. Data collection

Data were extracted from medical records and included:

- **Demographic and clinical variables:** age, sex, comorbidities, and type of surgery (visceral, vascular, thoracic);
- **Preoperative biological parameters:** haemoglobin (g/dL), platelet count ($\times 10^3/mm^3$), prothrombin time (%), serum creatinine (mg/L), total bilirubin (mg/L);
- **Transfusion status:** timing (intraoperative or postoperative), type of blood products administered (red blood cell concentrates [RBCs], fresh frozen plasma [FFP], platelet concentrates), and transfusion volumes;
- **Clinical outcomes:** ICU length of stay (days), duration of mechanical ventilation (days), postoperative complications, and death.

5. Endpoints

- **Primary endpoint:** blood transfusion and identification of its predictive factors;
- **Secondary endpoints:** ICU length of stay, postoperative morbidity, and ICU mortality.

6. Operational Definitions

- Postoperative respiratory complications included: bronchopneumonia, atelectasis requiring bronchoscopic aspiration, hypoxaemia (PaO_2/FiO_2 ratio < 300), or pleural effusion requiring drainage.
- Acute kidney injury was defined as an increase in serum creatinine ≥1.5 times the baseline value or urine output <0.5 mL/kg/h for more than 6 hours.
- Septic shock was defined according to the Sepsis-3 criteria: infection-related organ dysfunction with persistent hypotension requiring vasopressors to maintain a mean arterial pressure ≥65 mmHg.

7. STATISTICAL ANALYSIS

Statistical analysis was performed using Jamovi software (version 2.6, The Jamovi Project, 2024).

Quantitative variables were expressed as mean ± standard deviation or median depending on distribution; qualitative variables were expressed as percentages.

In the first step, the population was divided into two groups according to transfusion status (transfused vs non-transfused). Comparisons were made to identify factors associated with transfusion (univariate analysis).

In the second step, the two groups were compared in terms of 30-day mortality, postoperative morbidity, and ICU length of stay to assess the prognostic consequences of transfusion.

The following statistical tests were used:

- Student's t-test or Mann–Whitney U test for quantitative variables;
- Chi-square test or Fisher's exact test for qualitative variables.
- Factors associated with transfusion and clinical outcomes were then included in a multivariate binary logistic regression model. A two-tailed p-value < 0.05 was considered statistically significant.

8. Ethical Considerations

This study was conducted in accordance with the ethical principles of the Declaration of Helsinki. It was based on clinical data retrospectively collected from medical records, anonymised and without any intervention on patient management. This study adheres also to the STROBE guidelines for the reporting of observational studies (Strengthening the Reporting of Observational Studies in Epidemiology)

9. Patient and public involvement

Patients or members of the public were not involved in the design, conduct, reporting, or dissemination plans of this research

III. RESULTS

A. DESCRIPTIVE ANALYSIS

1. General characteristics of the study population

A total of 100 patients were included in the study. The median age was 60 years [54.5–68], with a range from 12 to 92 years. The sex ratio was 2.23, with 69 males and 31 females.

Comorbidities were present in 64 patients (64%), including diabetes (26%), hypertension (22%), ischaemic heart disease (9%), dyslipidaemia (6%), and pulmonary tuberculosis (6%).

The surgeries leading to ICU admission were primarily visceral (48%), followed by vascular (38%)

and thoracic (14%) procedures. Visceral surgery was mainly represented by pancreaticoduodenectomy and hepatic resection. Vascular surgery was predominantly aortic reconstruction for aneurysmal or occlusive pathology. Thoracic surgery mainly included pulmonary resections.

2. Preoperative biological parameters

Table 1: Preoperative biological parameters (n=100)

Parameter	Mean ± standard deviation	Range
Haemoglobin (g/dl)	8.36 ± 2.30	4.7 – 13.9
Prothrombin time (%)	68.6 ± 20.3	20 – 100
Platelet count (×10³/mm³)	246 ± 125	15 – 807
Serum creatinine (mg/l)	11.5 ± 10.5	2.6 – 53
Total bilirubin (mg/l)	48.7 ± 57.4	1 – 213

The results of the preoperative laboratory investigations are summarised in **Table 1**.

3. Transfusion status

Among the 100 patients, 64 received a blood transfusion (64%). Transfusion was administered postoperatively in 52 cases (81.25%) and intraoperatively in 12 cases (18.75%).

The primary indication was poorly tolerated anaemia (77%), followed by haemorrhagic shock (23%). All transfused patients received red blood cell concentrates (RBCs); 15 patients also received fresh frozen plasma (FFP), and one received platelet concentrates. The mean number of RBC units transfused was 2.98 ± 2.10. The mean volume of FFP administered was 4.07 ± 1.94 units per patient.

4. Clinical outcomes

Overall morbidity was 20%, mainly due to respiratory complications (8%), sepsis (6%), acute kidney injury (4%), and peritonitis (2%). The overall mortality during the ICU stay was 9%, attributed to septic shock (55.6%) or haemorrhagic shock (44.4%).

The median length of ICU stay was 5 days [3–7], and the median duration of mechanical ventilation was 1 day [1–3].

B. Analytical Analysis

1. Univariate analysis

Transfused patients had a significantly lower preoperative haemoglobin level (8.36 ± 2.30 vs 12.88 ± 1.78 g/dL; $p < 0.001$). Their mean ICU stay was also significantly longer (7.20 ± 6.95 vs 4.44 ± 2.06 days; $p = 0.004$). There was a trend towards a higher rate of postoperative complications in transfused patients (35.9% vs 5.5%, $p = 0.06$). Mortality was also higher in the transfused group but did not reach statistical significance (10.9% vs 5.56%, $p = 0.367$). (Tables 2 and table 3)

Table 2: Predictive factors for transfusion (univariate analysis)

Variable	Transfused (n = 64)	Non-transfused (n = 36)	p-value
Age (years)	57.5 ± 16.2	60.3 ± 10.5	0.340
Male sex (%)	65.6%	75.0%	0.331
Comorbidities (%)	68.8%	55.6%	0.270
Haemoglobin (g/dL)	8.36 ± 2.30	12.88 ± 1.78	<0.001
Platelets (×10³/mm³)	246 ± 125	291 ± 157	0.159
Prothrombin time (%)	68.6 ± 20.3	72.9 ± 13.6	0.224
Creatinine (mg/L)	11.5 ± 10.5	9.1 ± 5.4	0.125
Bilirubin (mg/L)	48.7 ± 57.5	35.7 ± 35.9	0.310

Table 3: Prognostic outcomes by transfusion status (univariate analysis)

Variable	Transfused (n = 64)	Non-transfused (n = 36)	p-value
Postoperative complications (%)	35.9%	5.5%	0.060
ICU length of stay (days)	7.2 ± 6.9	4.4 ± 2.1	0.004
Duration of intubation (days)	2.74 ± 2.97	2.00 ± 2.45	0.531
Deaths (%)	10.9%	5.56%	0.367
ICU: intensive care unit			

2. Multivariate analysis

Variables with a potential association with transfusion ($p \leq 0.20$) in univariate analysis were included in a multivariate binary logistic regression model. This model incorporated the following variables: age, sex, haemoglobin level, platelet count, serum creatinine, prothrombin time, and bilirubin level.

Among these, only preoperative haemoglobin level emerged as an independent predictor of transfusion. A lower haemoglobin level was significantly associated with an increased likelihood of transfusion (OR = 0.52; 95% CI: 0.36–0.75; p < 0.001).

Other variables, including sex, age, and the remaining biological parameters (platelets, PT, creatinine, bilirubin), were not significantly associated with transfusion in the adjusted model (**Table 4**).

Table 4: Multivariate logistic regression results

Variable	Adjusted OR	95% CI	p-value
Haemoglobin (g/dL)	0.52	0.36 – 0.75	<0.001
Platelets (10^3/mm^3)	0.99	0.98 – 1.00	0.08
Creatinine (mg/L)	1.01	0.98 – 1.04	0.37
Prothrombin time (%)	0.99	0.97 – 1.01	0.41
Age (years)	0.98	0.95 – 1.01	0.17
Male sex	0.65	0.25 – 1.67	0.37

IV. DISCUSSION

Our retrospective study, conducted in a surgical intensive care unit, highlights the high frequency of blood transfusion (64% of patients), primarily due to poorly tolerated anaemia or haemorrhagic shock. In univariate analysis, several biological parameters were associated with transfusion status, most notably haemoglobin level. Multivariate analysis confirmed that preoperative haemoglobin concentration was the only independent predictor of transfusion in our cohort (OR = 0.52; 95% CI: 0.36–0.75; p < 0.001).

These findings are consistent with the existing literature. Anaemia is common in ICU settings, with multifactorial aetiology involving blood loss, impaired erythropoiesis, and inflammation-induced iron metabolism disorders [1]. It remains one of the main drivers of transfusion, both perioperatively and in critical care. Additional risk factors for transfusion have been reported, including advanced age, comorbidities, sepsis, and the complexity of surgical procedures.

In a prospective study including 117 ICU patients admitted for trauma or post-surgical care, Bein et al. reported a transfusion rate of 65% [2]. Independent predictors included a haematocrit ≤ 20% and an APACHE II score ≥ 20, emphasising the combined effect of anaemia severity and overall clinical acuity.

Roubinian *et al.,* developed a predictive model for transfusion within 24 hours of hospital admission in a cohort of 275,874 patients [3]. They found haemoglobin on admission to be the strongest predictor, surpassing comorbidities and severity markers.

More recently, artificial intelligence (AI) approaches have been explored to predict transfusion needs. Sheikhalishahi *et al.,* retrospectively analysed 9,118 postoperative ICU admissions to construct a predictive algorithm using 32 clinical and laboratory variables [4]. The XGBoost model outperformed logistic regression, with haemoglobin, haematocrit, red blood cell count, and systolic blood pressure being the most influential variables. This underscores the relevance of algorithmic tools in optimising transfusion decisions.

Several studies have examined transfusion predictors in specific perioperative contexts. Bansal *et al.,* identified low preoperative haemoglobin and associated venous resection as predictors of early transfusion (<24h) in a cohort of 628 patients undergoing pancreaticoduodenectomy (OR = 0.65 and OR = 2.78, respectively) [5].

In orthopaedics, a large study on 367,894 total hip replacements reported a perioperative transfusion rate of 3.5%, with sickle cell disease (OR = 4.81), cirrhosis (OR = 3.02), chronic dialysis (OR = 2.22), and male sex (OR = 1.99) as independent predictors [6].

Similarly, Huang *et al.,* analysed data from 1,250,533 total knee arthroplasties, identifying advanced age, female sex, and preoperative anaemia as risk factors. Nutritional anaemia (OR = 3.62) and blood-loss anaemia (OR = 3.78) were strongly associated with transfusion [7].

In our cohort, haemoglobin concentration was significantly lower among transfused patients in both univariate (8.36 vs 12.88 g/dL; p < 0.001) and multivariate analyses. This result aligns with previous findings. Nevertheless, it must be interpreted in light of haemorrhagic shock, which accounted for 23.4% of transfusion indications—justifying immediate intervention. Outside of such acute cases, transfusion decisions were left to the clinical judgment of the medical team within a generally restrictive policy.

Unlike other studies, we did not find advanced age to be a predictor of transfusion, possibly due to our younger cohort (median age: 60 years). While comorbidities were more prevalent among transfused patients (68.8% vs 55.6%), the difference was not statistically significant (p = 0.27).

We noted a non-significant trend toward more frequent transfusion after visceral surgery, possibly reflecting the complexity of the procedures (e.g.,

pancreaticoduodenectomy, liver resection). Conversely, vascular surgery was not associated with higher transfusion rates, perhaps due to the elective nature of most aortic reconstructions (notably Leriche syndrome).

None of the other biological parameters (platelet count, prothrombin time, creatinine, calcium, CRP) were independently associated with transfusion in our cohort.

Numerous studies have highlighted the adverse effects of transfusion in surgical and ICU contexts. In a prospective study of 167 critically ill patients, Da Silva Junior *et al.,* found transfusion to be an independent predictor of both mortality and prolonged ICU stay [8].

In oesogastric surgery, a cohort of 253 patients revealed a 38% transfusion rate, with significant association between transfusion and anastomotic leak (OR = 4.60) [9]. Similarly, Al-Harbi *et al.,* in a study of 459 coronary bypass cases, reported a transfusion rate of 60.1%, with a 2.6-fold increase in postoperative infections and longer ICU stays (11.5 vs 8.7 days) [10].

Dosch *et al.,* analysing 6,869 pancreaticoduodenectomies, found transfusion associated with significantly increased postoperative infections (34.7% vs 26.5%; $p < 0.001$), and as an independent predictor of pneumonia, sepsis, and septic shock [11].

Beyond infectious complications, transfusion is linked to thromboembolic events. Gritis *et al.,* reported higher thromboembolic risk in transfused patients after hip fracture surgery (OR = 1.26; $p = 0.003$) [12], confirmed by a meta-analysis of 1,880,990 surgical patients (OR = 1.61; $p < 0.001$) [13].

A recent meta-analysis by Morris *et al.,* of 37 studies in major abdominal surgery found that transfusion significantly increased overall morbidity (OR = 2.18) and infectious morbidity (OR = 1.90) [14].

In our study, transfusion was significantly associated with longer ICU stay (7.20 vs 4.44 days; $p = 0.004$). While postoperative morbidity (20%) was mostly respiratory and infectious, the risk was higher in transfused patients (35.9% vs 5.5%), although this did not reach statistical significance ($p = 0.06$), likely due to limited sample size. A similar non-significant difference was observed in ventilation duration.

The detrimental impact of transfusion on morbidity and mortality is well documented. In 1997, Hebert *et al.,* showed increased ICU mortality among transfused patients (41.6% vs 28%; $p < 0.0001$) [15]. Da Silva Junior *et al.,* later confirmed transfusion as an independent mortality predictor (OR = 2.67; $p = 0.011$) [8].

A meta-analysis by Marik et al. (n = 272,596) also found transfusion to be independently associated with ICU mortality (OR = 1.7), infectious complications (OR = 1.8), and ARDS (OR = 2.5) [16].

In surgery, Hallet *et al.,* found significantly higher 30-day mortality (5.6% vs 1.0%) and morbidity (25.3% vs 11.3%) among transfused patients after hepatic resection (n = 11,712) [17]. Similarly, Morris *et al.,* reported increased early (OR = 2.72) and late mortality (OR = 1.35) associated with transfusion in abdominal surgery [14].

In a massive cohort of over 1.25 million knee arthroplasties, Huang *et al.,* found higher mortality among transfused patients (0.21% vs 0.04%; $p < 0.001$) [7].

In our own cohort, mortality was nearly doubled in transfused patients (10.9% vs 5.56%), though this difference was not statistically significant. No clinical or biological variable was independently associated with mortality in multivariate analysis, likely due to sample size limitations and lack of prognostic severity scores (e.g., APACHE II or SOFA).

V. Study Limitations

Our study presents several methodological limitations that must be acknowledged to appropriately contextualise and interpret the findings.

First, the retrospective and single-centre nature of the study introduces potential selection bias and heterogeneity in clinical management. In particular, transfusion decisions were partly based on the subjective judgement of individual medical teams. No standardised transfusion strategy (liberal vs restrictive) was explicitly applied or documented in the patient records, limiting the ability to infer causality.

Second, the relatively small sample size (n = 100) reduces the statistical power, especially for detecting significant associations in multivariate analysis. Certain observed trends—particularly with respect to morbidity and mortality—might have reached statistical significance in a larger cohort.

Third, several potential confounders could not be accounted for in the analysis, including commonly used severity scores such as APACHE II, SAPS II, or SOFA.

Fourth, some biological and clinical variables that might influence outcomes—such as markers of systemic inflammation, nutritional status, or detailed coagulation profiles—were not consistently available in the medical records, thereby limiting the depth of the analysis.

Finally, the study design does not allow for a clear distinction between the direct effects of transfusion and the clinical consequences of the underlying context in which it was administered (e.g., haemorrhagic shock or complex surgery), thus precluding any definitive causal inference.

Despite these limitations, the study provides valuable insights into the high prevalence of transfusion in surgical intensive care and its association with less favourable clinical outcomes.

VI. CONCLUSION

Our study highlights the central role of preoperative haemoglobin as the main predictive factor for the use of blood transfusion in surgical intensive care. While transfusion may be indispensable in certain acute situations—particularly in the context of haemorrhagic shock—our findings, consistent with previous reports, confirm its association with prolonged ICU stay and a tendency toward increased postoperative morbidity.

Although no independent prognostic factor was identified in multivariate analysis, the observed trends underscore the importance of a cautious and individualised approach to transfusion indications. The implementation of restrictive transfusion strategies, in accordance with current international guidelines, appears essential to minimise the potential adverse effects of transfusion, particularly in high-risk patients.

Lastly, the development of robust predictive models incorporating clinical, biological, and procedural variables—potentially supported by artificial intelligence—represents a promising avenue to improve risk stratification and optimise transfusion practices in surgical critical care. Larger prospective studies will be necessary to validate and refine these strategies.

Data availability statement: The datasets generated and analysed during the current study are available from the corresponding author on reasonable request.

Funding: This research received no specific grant from any funding agency in the public, commercial or not-for-profit sector.

Competing interests: The authors declare no competing interests.

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