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Research Paper

Predictors of blood product utilization (RBC, FFP, and Platelet) in severe burn patients: A single-center retrospective study

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ABSTRACT

This single-center retrospective study aimed to identify predictors of any blood product transfusion—defined as the administration of one or more units of packed red blood cells (RBCs), fresh frozen plasma (FFP), or platelets—among adult patients with severe burns. In this cross-sectional study, 112 patients with burns that affected 20-50% of their total body surface area (TBSA) were analyzed. Demographic information, burn characteristics, and clinical outcomes were taken from medical records. Multivariate logistic regression was used to identify independent predictors. Transfusion indications during the study period followed institutional practice: RBC transfusion was generally considered for hemoglobin ≤7–8 g/dL or active bleeding; FFP was used for clinically significant coagulopathy or INR >1.5; and platelets were administered for counts <50×10⁹/L in surgical candidates. Blood product transfusion was administered to 46.4% of patients. The transfused group had significantly larger burns, higher rates of third-degree burns, more frequent inhalation injuries, and worse clinical outcomes, including higher rates of intensive care unit (ICU) admission (65.4% vs. 13.3%) and mortality (28.8% vs. 3.3%). Multivariate analysis revealed that third-degree burns (odds ratio (OR) = 5.98), the number of surgical procedures (OR = 1.80 per procedure), and the length of ICU stay (OR = 1.55 per day) are significant independent predictors of transfusion. Burn depth, surgical burden, and intensive care unit stay are key determinants of transfusion needs. These findings provide locally relevant evidence for transfusion management in severe burn patients, reflecting real-world practice patterns in our regional burn center. These findings support the development of risk-based protocols to optimize blood utilization and improve outcomes in patients with severe burns.

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1. Introduction

Severe thermal injury is a very serious type of trauma that sets off a chain reaction of complicated physiological responses [1,2]. This makes it one of the hardest things to deal with in critical care. Patients with severe burns face a multifaceted hematologic crisis. Burn patients develop complex hematologic disturbances involving both anemia and coagulopathy. In the acute phase, massive plasma leakage and tissue injury result in hypovolemia, inflammation-induced coagulopathy, and varying degrees of anemia. The causes include direct red cell destruction, surgical blood loss, nutritional deficiency, and impaired marrow response. At the same time, transfusion therapy in these patients often involves multiple blood components—red blood cells (RBCs) for oxygen delivery, Fresh Frozen Plasma (FFP) for coagulation support, and platelets for hemostasis during surgery or critical illness [3,4].

Because of this complex hematologic derangement, blood product transfusion, including RBCs, FFP, and platelets, remains an important and often necessary part of supportive care for these patients [5]. However, administering blood products is not a benign intervention. More and more evidence is linking allogeneic transfusions to several bad results. These include a higher chance of getting infections, transfusion-related acute lung injury (TRALI), immunosuppression, and problems with multiple organs [4,6]. Large-scale studies highlight this well-known risk-benefit dilemma, some of which have found associations between blood product transfusions and increased morbidity or mortality in critically ill and burn patients [7,8]. However, the multicenter TRIBE study by Palmieri et al. (2006) did not demonstrate increased mortality among burn patients receiving higher transfusion volumes [7]. Mortality was similar between groups transfused to lower versus higher hemoglobin thresholds, suggesting that transfusion amount alone was not an independent determinant of outcome.

To develop effective blood conservation and optimized product utilization strategies, it is imperative first to understand the epidemiology of blood product utilization and identify the specific factors that predict the need for any transfusion (RBCs, FFP, or platelets) in this unique patient population. While previous studies have identified predictors such as the total body surface area (TBSA) affected, burn depth, and the number of surgical procedures, findings can vary significantly between centers due to differences in patient populations, surgical techniques, and institutional protocols [5,9,10]. Comprehensive data from specific regional burn centers are therefore essential for tailoring and optimizing local clinical guidelines.

There is limited data on the specific patterns and predictors of comprehensive blood product transfusion within our regional healthcare system. Given the limited sample size, transfusion was analyzed as a composite outcome including RBCs, FFP, and platelets. Therefore, the primary objective of this study was to characterize the epidemiology of any blood product transfusion—defined as administration of one or more units of packed RBCs, FFP, or platelets—and to identify demographic and clinical predictors of transfusion requirements among adult patients with severe burns admitted to the regional referral burn center in Guilan, Iran. This approach provides a more comprehensive understanding of transfusion patterns beyond red cell transfusion alone and locally relevant data to optimize transfusion policies.

2. Materials and Methods

2.1 *Study Design*

This single-center, retrospective observational study was conducted on patients admitted to a university-affiliated referral burn center in northern Iran.

2.2 *Patient Population*

The study population comprised all patients with severe burn injuries admitted to the referral burn center between March 2023 and March 2024. Using a convenience sampling approach, 112 patients who met the eligibility criteria were included in the analysis. Inclusion criteria were (1) age ≥ 18 years and (2) burn injury involving 20%–50% of the TBSA. This TBSA range (20-50%) was intentionally selected to create a more homogenous study population. Patients with <20% TBSA burns seldom require transfusion, while those with >50% TBSA almost universally do; including these extremes could mask predictors for the largest, most variable group of patients. This design choice was made to improve internal validity by reducing the effects of extreme burn sizes while concentrating on the subgroup with the most variable transfusion needs. Although this approach limits generalizability to very small or extensive burns, it allows more precise identification of independent predictors within the clinically most relevant population.

Exclusion criteria were (1) transfer from another medical facility, (2) incomplete or missing medical records, and (3) a documented history of pre-existing anemia. The sample size was calculated a priori for the primary outcome of identifying predictors using logistic regression. Based on a previous study, assuming an odds ratio of approximately 4.1, a 30% event rate (transfusion), an alpha of 0.05, and a power of 90%, the required sample size was calculated to be 102 patients. This was inflated to 112 to account for a potential 10% dropout or incomplete records [9].

2.3 *Data Collection and Variables*

Data were extracted from patients' medical records and the hospital's blood bank request forms using a standardized checklist. Collected variables included demographic data (age, sex, and body mass index); burn characteristics (etiology such as flame, scald, or

electrical, %TBSA burned, burn depth [second or third degree], and presence of inhalation injury—diagnosed by facial burns, soot in sputum, singed nasal hairs, hoarseness, or stridor, and confirmed by bronchoscopy when available); clinical and outcome data (comorbidities, infection—defined as a positive wound, blood, or sputum culture requiring targeted antibiotic therapy—number of surgical procedures, duration of intensive care unit (ICU) stay, total hospital stay, and survival outcome); and transfusion data (transfusion status, total number of units, and types of blood products administered, including RBCs, FFP, and platelets). The primary outcome variable for the multivariate logistic regression analysis was "any blood product transfusion." The information was defined as a binary (yes/no) variable, where "yes" indicated that the patient received one or more units of packed RBCs, FFP, or platelets during hospitalization. To clarify institutional practice during the study period, RBC transfusion was generally indicated for hemoglobin ≤7–8 g/dL or active bleeding; FFP was used for clinically significant coagulopathy or INR >1.5; and platelets were administered for platelet counts <50×10⁹/L in surgical candidates. These indications followed the local institutional standard and are summarized here for transparency. All transfusion-related data were collected from hospital records and verified by two independent reviewers.

2.4 *Statistical Analysis*

Statistical analyses were performed using IBM SPSS Statistics, version 26.0 (IBM Corp., Armonk, NY, USA). The Shapiro–Wilk test was used to assess the normality of continuous variables. Descriptive data are presented as mean ± standard deviation (SD) or median with interquartile range (IQR) for continuous variables and as frequencies and percentages for categorical variables.

Between-group comparisons were conducted using the independent t-test or Mann–Whitney U test for continuous variables and the chi-square or Fisher's exact test for categorical variables. Variables with p-values <0.10 in univariate analyses were included in a multivariate logistic regression model (backward elimination) to identify independent predictors of transfusion. This threshold was chosen to prevent premature exclusion of potential confounders, consistent with standard exploratory analytical practice. Odds ratios (ORs) with 95% confidence intervals (CIs) were reported, and a two-tailed p-value <0.05 was considered statistically significant.

3. Results

3.1 *Patient Characteristics*

A total of 112 patients met the inclusion criteria. The mean age was 42.3 ± 16.5 years, and 74.1% (n = 83) were male. Flame or fire burns were the most common cause of injury (69.6%), followed by scald (25.9%) and electrical burns (4.5%). The mean %TBSA burned was 31.1 ± 10.2%. Most patients sustained second-degree burns (77.7%), whereas 22.3% had third-degree (full-thickness) burns. The hospital records did not consistently document the exact %TBSA of full-thickness burns; this missing information is acknowledged as a data limitation. The hands (84.8%) and posterior trunk (66.1%) were the most frequently affected anatomical sites (Table 1, Figure 1).

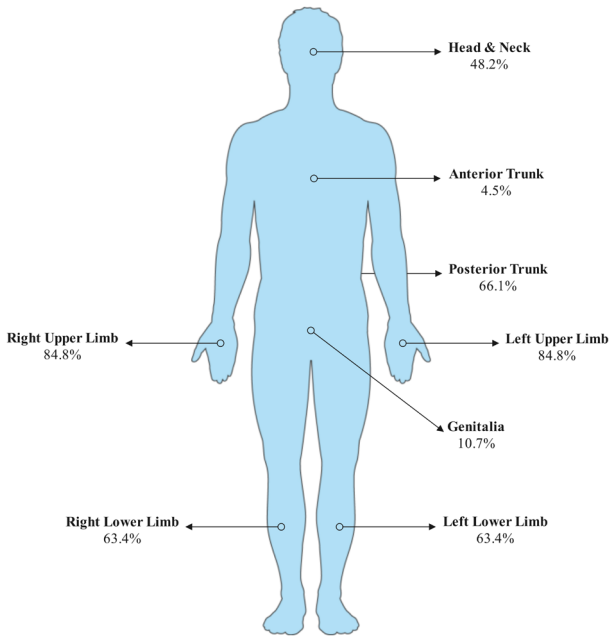

Figure 1. Anatomical distribution of burn sites in the study population.

Table 1. Demographic, clinical, and outcome characteristics of patients stratified by product transfusion status.

Characteristic	Total cohort (N = 112)	No product transfusion (n = 60)	Product transfusion (n = 52)	P-value
Demographics				
Age, years, mean ± SD	42.32 ± 16.54	38.35 ± 14.52	46.90 ± 17.65	0.007†
Male Sex, n (%)	83 (74.1)	44 (73.3)	39 (75.0)	0.841*
BMI, kg/m², mean ± SD	24.58 ± 3.31	24.72 ± 3.49	24.42 ± 3.11	0.642†
Any comorbidity, n (%)	55 (49.1)	21 (35.0)	34 (65.4)	0.001*
Diabetes mellitus, n (%)	40 (35.7)	14 (23.3)	26 (50.0)	0.003*
Burn characteristics				
Cause: Flame/Fire	78 (69.6)	33 (55.0)	45 (86.5)	
Scald burns	29 (25.9)	23 (79.31)	6 (20.69)	<0.001
Electrical	5 (04.5)	4 (80.0)	1 (20.00)	
Burn depth: Third-degree, n (%)	25 (22.3)	3 (5.0)	22 (42.3)	<0.001*
TBSA, %, mean ± SD	31.13 ± 10.16	27.20 ± 7.89	35.60 ± 10.72	<0.001†
Inhalation injury, n (%)	25 (22.3)	6 (10.0)	19 (36.5)	0.001
Clinical outcomes				
Infection, n (%)	51 (45.5)	14 (23.3)	37 (71.2)	<0.001*
ICU admission, n (%)	42 (37.5)	8 (13.3)	34 (65.4)	<0.001
ICU stay, days, median [IQR]	4.0 [2.0-7.0]	2.0 [1.5-2.5]	5.0 [2.0-8.0]	0.011
Hospital stay, days, median [IQR]	8.0 [3.0-11.0]	4.0 [3.0-8.0]	11.0 [7.5-12.5]	<0.001
Number of surgeries, median [IQR]	4.0 [2.0-7.0]	2.0 [1.0-4.0]	6.0 [4.0-7.5]	<0.001
Mortality, n (%)	17 (15.2)	2 (3.3)	15 (28.8)	<0.001*

Abbreviations: SD, standard deviation; BMI, body mass index; TBSA, total body surface area; ICU, intensive care unit; IQR, interquartile range. P-values were derived from *Chi-square test or Fisher's exact test, †Independent t-test, or Mann-Whitney U test for variables reported as median.

3.2 *Transfusion Epidemiology and Bivariate Analysis*

Blood product transfusion was required in 46.4% of patients (n = 52; 95% CI: 37.4–55.7%). Among transfused patients, RBCs were the most frequently administered component (96.2%), followed by FFP (32.7%) and platelets (7.7%). Whole blood and cryoprecipitate were not used in this cohort. The median number of transfused units was 2.0 (IQR: 1.5–6.0). Compared with non-transfused patients, those who received transfusions were significantly older (46.9 ± 17.7 vs. 38.4 ± 14.5 years; p = 0.007) and had higher rates of comorbidities (61.8% vs. 38.2%; p = 0.001), diabetes mellitus (50.0% vs. 23.3%; p = 0.003), and third-degree burns (42.3% vs. 5.0%; p < 0.001). They also had a larger burn size (%TBSA: 35.6 ± 10.7 vs. 27.2 ± 7.9; p < 0.001) and a higher incidence of inhalation injury (36.5% vs. 10.0%; p = 0.001).

Clinical outcomes were poorer among transfused patients, including higher ICU admission rates (65.4% vs. 13.3%), longer ICU stays (median 5.0 vs. 2.0 days; p = 0.011), prolonged hospitalization (median 11.0 vs. 4.0 days; p < 0.001), and higher mortality (28.8% vs. 3.3%; p < 0.001). However, this association likely reflects greater injury severity and treatment intensity rather than a direct causal relationship with transfusion. Transfused patients also underwent more surgical procedures (median 6.0 vs. 2.0; p < 0.001). Table 2 summarizes detailed transfusion characteristics, and Figure 2 illustrates the distribution of transfused versus non-transfused patients.

3.3 *Factors Associated with Transfusion Volume*

Table 3 presents factors associated with transfusion volume. Diabetic patients required significantly higher transfusion volumes than non-diabetics (mean ± SD: 3.58 ± 5.11 vs. 2.85 ± 4.72 units; p < 0.001). Similarly, patients with hypertension (3.02 ± 4.93 units; p = 0.098), third-degree burns (4.96 ± 5.98 units; p < 0.001), inhalation injury (3.84 ± 4.30 units; p < 0.001), infection (3.94 ± 5.12 units; p < 0.001), and ICU admission (4.71 ± 5.32 units; p < 0.001) required more transfused units.

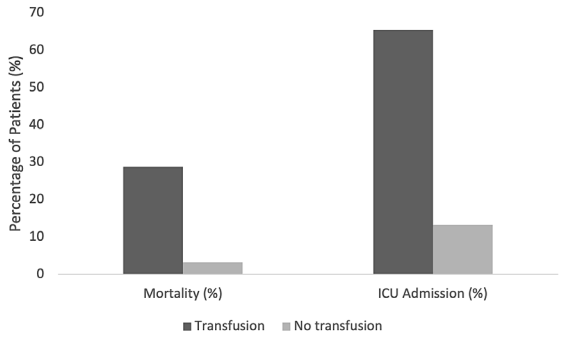

Figure 2. Comparison of in-hospital mortality and ICU admission according to blood product transfusion status

Spearman's correlation revealed strong positive associations between transfusion volume and number of surgeries (ρ = 0.690; p < 0.001), hospital stay (ρ = 0.626; p < 0.001), ICU stay (ρ = 0.545; p < 0.001), and TBSA (ρ = 0.476; p < 0.001). Age correlated weakly but significantly with transfusion volume (ρ = 0.252; p = 0.007).

3.4 *Independent Factors Influencing Blood Product Transfusion*

Multivariate logistic regression identified three independent predictors of transfusion in severe burn patients (Table 4). The presence of third-degree burns was associated with nearly sixfold higher odds of requiring transfusion (OR = 5.98; 95% CI: 1.08–33.04; p = 0.040).

Table 2. Blood product transfusion details (n=112).

Variable	Category/Statistic	Value
Transfusion status	No	60 (53.6%)
	Yes	52 (46.4%)
Units transfused (n=52)	Median (IQR)	2.0 (1.5, 6.0)
Blood products received	RBC	50 (96.2%)
	FFP	17 (32.7%)
	Platelets	4 (7.7%)

Abbreviations: IQR, interquartile range.

Table 3. Factors associated with transfusion volume in severe burn patients.

Characteristic	Group comparisons		Correlation analysis	
	Transfusion volume (Units)	P-value	Correlation (ρ)	P-value
Demographics				
Age, years	3.21 ± 4.85*	0.012	0.252	0.007
Male sex	3.21 ± 4.85*	0.012	-	-
Diabetes mellitus	3.58 ± 5.11	<0.001	-	-
Hypertension	3.02 ± 4.93	0.098	-	-
Burn characteristics				
Third-degree burn	4.96 ± 5.98	<0.001	-	-
TBSA	-	-	0.476	<0.001
Inhalation injury	3.84 ± 4.30	<0.001	-	-
Clinical outcomes				
Infection	3.94 ± 5.12	<0.001	-	-
ICU admission	4.71 ± 5.32	<0.001	-	-
ICU stay, days	-	-	0.545	<0.001
Hospital stay	-	-	0.626	<0.001
Number of surgeries	-	-	0.690	<0.001

Abbreviations: TBSA, total body surface area; ICU, intensive care unit. P-values for Group Comparisons were derived from the Independent t-test or Mann-Whitney U test. Correlation analysis was performed using Spearman's rank correlation (ρ). *Value represents the mean ± SD of transfusion volume for the entire transfused cohort.

Table 4. Multivariate logistic regression analysis of factors associated with blood product transfusion.

Predictor	Odds ratio (OR)	95% CI	P-value
Burn depth (Third-degree vs. Second-degree)	5.98	1.08–33.04	0.040
ICU stay (Per day increase)	1.55	1.01–2.38	0.045
Number of surgeries (Per additional surgery)	1.80	1.37–2.37	<0.001

Abbreviations: OR, odds ratio; CI, confidence interval; ICU, intensive care unit.

Hospital records documented only the presence or absence of third-degree burns and inconsistently reported the exact %TBSA of full-thickness injury; therefore, burn depth was analyzed as a binary variable (present vs. absent). Each additional day of ICU stay increased the likelihood of transfusion by 55% (OR = 1.55; 95% CI: 1.01–2.38; p = 0.045), and each additional surgical procedure increased the odds by 80% (OR = 1.80; 95% CI: 1.37–2.37; p < 0.001). These associations remained statistically significant after adjusting for age, comorbidities, TBSA burned, and inhalation injury, underscoring the importance of burn depth, surgical burden, and ICU trajectory in predicting transfusion requirements. While these predictors have been identified in previous multicenter analyses, our single-center findings provide context-specific confirmation from a regional burn care system, reinforcing the external validity of these results.

4. Discussion

This single-center study identified key predictors of blood product transfusion in patients with severe burns. Nearly half of the cohort (46.4%) required at least one transfusion, suggesting an ongoing need for blood support in this population. The determinants of transfusion were multifactorial, reflecting both injury severity and treatment intensity. Extensive and deep burns cause significant vascular destruction, plasma exudation, and surgical blood loss, necessitating replacement with RBCs, FFP, and platelets to restore oxygen-carrying capacity, volume, and hemostasis [5,9].

While transfusion is often life-saving, it carries well-documented risks including TRALI, allergic and febrile reactions, immunosuppression, and infection [4,6,10].

In our cohort, RBCs were the most commonly used product (96.2%), followed by FFP (32.7%) and platelets (7.7%). The overall transfusion rate (46.4%) is consistent with international reports ranging from 35% to 55% [5,7,11]. Comparatively, Palmieri et al. (2006) reported a 74.7% RBC transfusion rate in patients with >20% TBSA burns, while Lu et al. (2013) found RBC use in 71.9% and plasma in 44.9% of patients. Tavousi et al. (2018) reported a lower overall rate (34.2%) in Iran, attributed to conservative surgical techniques and intraoperative hemostatic methods [4,7,11]. These inter-study variations reflect institutional differences in surgical timing, transfusion triggers, and blood product availability.

Multivariate analysis revealed three independent predictors of transfusion: third-degree burns, ICU stay, and number of surgeries. Full-thickness burns increased

the odds of transfusion nearly sixfold (OR = 5.98, p = 0.040), consistent with Tichil et al. (2021) and Wu et al. (2016) [5,9]. This finding likely reflects deeper tissue destruction, greater surgical excision, and resuscitation needs. Each additional ICU day and surgical procedure increased the likelihood of transfusion by 55% and 80%, respectively—findings that mirror prior studies linking transfusion to critical illness severity and operative blood loss [9,10,12]. It is important to emphasize that ICU length of stay should not be interpreted as a causal predictor of transfusion. Instead, a prolonged ICU stay serves as a surrogate marker of injury severity, physiological instability, and treatment complexity. Patients with more severe burns and complications are more likely to require extended ICU care, undergo multiple surgical interventions, and consequently receive blood product transfusions. This significant impact of surgical burden is understandable given the unique challenges of anesthetic management in burn care, which includes complex airway control, fluid resuscitation, and perioperative monitoring [13]. Although inhalation injury and diabetes were associated with transfusion on univariate analysis, they did not remain significant after adjustment, consistent with Tichil et al. (2021) [9]. Age and sex were also non-predictive, contrasting with reports by Wu et al. (2016) and Tichil et al. (2021) suggesting possible sex-related variability [5,9]. Transfused patients had higher infection and mortality rates (71.2% and 28.8%), but this association likely reflects greater injury severity rather than a direct transfusion effect, as shown in prior multicenter analyses [4,7,14,15]. Beigi et al. (2025) reported that 4.79% of transfusions resulted in adverse reactions, primarily allergic responses and TRALI, underscoring the necessity for restrictive and prudent transfusion practices [16].

These findings highlight the need for proactive transfusion planning, including restrictive hemoglobin thresholds, improved intraoperative hemostasis, and evidence-based use of plasma and platelets in high-risk burn patients.

This study has several limitations. First, the outcome was defined as any blood product transfusion, precluding separate analysis of individual components such as RBCs, FFP, or platelets. Second, the extent of third-degree burns was recorded only as a binary variable rather than as %TBSA. Third, institutional transfusion triggers, deep vein thrombosis (DVT) prophylaxis, and anticoagulant use were not uniformly documented. Finally, being a retrospective single-center study, its generalizability is limited. Nonetheless, the results provide region-specific insights into transfusion practices that can inform prospective, multicenter research and the development of standardized local protocols.

In this single-center study of patients with severe burns, nearly half required at least one blood product transfusion, underscoring the ongoing demand for blood support in burn care. The need for transfusion was primarily influenced by burn depth, ICU stay, and surgical burden—factors that independently predicted transfusion requirements after adjustment for injury extent and comorbidities. These findings highlight the importance of early identification of high-risk patients and implementation of restrictive, protocol-driven transfusion strategies. Establishing clear transfusion thresholds, optimizing surgical hemostasis, and improving perioperative blood management may reduce unnecessary transfusions, minimize complications, and improve outcomes for patients with severe burns.

Authors' contributions

MO: Investigation, Writing – Review & Editing. NN: Investigation, Writing – Review & Editing. MMo: Conceptualization, Methodology, Supervision, Project Administration, Funding Acquisition, Writing – Review & Editing. MT: Conceptualization, Methodology, Investigation, Data Curation, Writing – Original Draft, Visualization. PBT: Investigation, Writing – Review & Editing. MS: Methodology, Formal Analysis, Validation, Writing – Original Draft, Visualization. MMa: Investigation, Data Curation. PA: Investigation, Data Curation. All authors read and approved the final version of manuscript.

Conflict of interest

No potential conflict of interest was reported by the authors.

Ethical declarations

The study protocol was reviewed and approved by the Ethics Committee of Guilan University of Medical Sciences (Ethics Code: IR.GUMS.REC.1403.220). The committee waived the requirement for individual patient consent because the study used existing, anonymized data. The Helsinki Declaration's ethical standards were followed for all procedures.

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