

# Effect of blood transfusion on outcome after major burn injury: A multicenter study\*

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**Objective:** To delineate blood transfusion practices and outcomes in patients with major burn injury.

**Context:** Patients with major burn injury frequently require multiple blood transfusions; however, the effect of blood transfusion after major burn injury has had limited study.

**Design:** Multicenter retrospective cohort analysis.

**Setting:** Regional burn centers throughout the United States and Canada.

**Patient Population:** Patients admitted to a participating burn center from January 1 through December 31, 2002, with acute burn injuries of  $\geq 20\%$  total body surface area.

**Outcomes Measured:** Outcome measurements included mortality, number of infections, length of stay, units of blood transfused in and out of the operating room, number of operations, and anticoagulant use.

**Results:** A total of 21 burn centers contributed data on 666

patients; 79% of patients survived and received a mean of 14 units of packed red blood cells during their hospitalization. Mortality was related to patient age, total body surface area burn, inhalation injury, number of units of blood transfused outside the operating room, and total number of transfusions. The number of infections per patient increased with each unit of blood transfused (odds ratio, 1.13;  $p < .001$ ). Patients on anticoagulation during hospitalization received more blood than patients not on anticoagulation ( $16.3 \pm 1.5$  vs.  $12.3 \pm 1.5$ ,  $p < .001$ ).

**Conclusions:** The number of transfusions received was associated with mortality and infectious episodes in patients with major burns even after factoring for indices of burn severity. The utilization of blood products in the treatment of major burn injury should be reserved for patients with a demonstrated physiologic need. (Crit Care Med 2006; 34:1602–1607)

**KEY WORDS:** blood transfusion; burn injury; infection; mortality

The traditional blood transfusion threshold of 10-g/dL hemoglobin level resulted in the use of  $>11$  million units of blood each year in the United States alone (1–6). This practice has been challenged by the TRICC study (Transfusion Requirements in Critical Care), which compared the outcomes of a restrictive policy (transfusion for hemoglobin level of

$<7$  g/dL) with the traditional standard (7). The restrictive transfusion strategy was as effective as the liberal strategy in the critically ill and had lower in-hospital mortality, cardiac complication rate, and organ dysfunction. The effect of the TRICC study on transfusion practices in the United States has been variable. The CRIT study, a prospective, multicenter, observational study of intensive care unit

(ICU) patients, analyzed the transfusion practices of 284 ICUs in 213 U.S. hospitals (8). Transfusion occurred at a hemoglobin level of  $8.6 \pm 1.7$  g/dL, and the amount of blood transfused was associated with mortality and ICU length of stay. This observational study supported the TRICC study findings and demonstrated that the restrictive policy has not been incorporated into practice in the United States.

**\*See also p. 1822.**

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The applicability of the TRICC and CRIT studies to burn patients is limited. Burn patients were not analyzed in either study, and in the TRICC study, patients were excluded for a hemoglobin drop of 3 g/dL or a 3-unit transfusion within 24 hrs of admission, which commonly occurs after burn injury due to blood loss, hemodilution, or hemolysis. We subsequently surveyed burn unit directors on their blood transfusion practices for patients with  $\geq 20\%$  total body surface area (TBSA) burn (9). The mean hemoglobin transfusion threshold of 8.1 g/dL was influenced by burn size and patient age. However, this study examined physician-reported transfusion thresholds, not actual transfusion practice.

The purpose of the current study was to evaluate burn center transfusion practices in patients with burn injury of  $\geq 20\%$  TBSA and to assess the effects of blood transfusion on patient survival. We hypothesized that reported transfusion thresholds would differ from actual transfusion practices and that the number of units of blood transfused during the hospital stay would have an adverse effect on patient survival.

## METHODS

Burn centers participating in the American Burn Association Multicenter Trials Group, dedicated to the identification, development, and conduct of multicenter studies analyzing burn-related treatments and outcomes, were recruited for participation in the study. Each center provided input into both the study design and data collection.

**Patient Eligibility Criteria.** Patients were eligible for inclusion if they had an acute burn injury of  $\geq 20\%$  TBSA and were admitted to a participating member of the Burn Multicenter Trials Group during the period from January 1, 2002, to December 31, 2002. Patients admitted  $>72$  hrs after burn injury were excluded from the study. Each institution obtained approval from its human subjects review board.

**Data Recorded at Admission.** The following admission variables were recorded: demographics (sex, age, weight), TBSA burn (percentage of partial thickness, full thickness, and total burn size), and presence of inhalation injury. Other preinjury factors that might influence transfusion practices including pre-existing cardiac disease and the use of anticoagulants (Coumadin or aspirin) before burn injury were also documented. Data were collected on a standardized data collection form and sent to the first author (T. L. Palmieri).

**Burn Treatment Data.** Variables associated with patient treatment that might alter blood

transfusion requirements, specifically the need for escharotomies or fasciotomies and the use of anticoagulation during hospitalization, were recorded. Treatment modalities specific to the burn injury itself, including the total number of operations, and the interval from admission to the first burn-related operation (defined as the first excision and grafting procedure) were gathered.

**Blood Transfusion Data.** To determine differences in blood transfusion thresholds over time, the number of days from admission to the first blood transfusion and the number of days between admission and the last blood transfusion were recorded for each patient. The hemoglobin level immediately before the first and last blood transfusions were also noted. The total number of units of blood transfused in the operating room (defined as blood received while the patient was physically in the operating room) and the total number of units of blood transfused during the hospitalization were recorded. The difference between the total number of units transfused during the hospitalization and the number of units transfused in the operating room was used to determine the number of units of packed red blood cells transfused "outside" the operating room (i.e., in the burn ICU or ward).

**Outcome Measurements.** The primary outcome measure was mortality from all causes during hospitalization. Secondary outcome measures included the number of infectious episodes (urinary tract infection, pneumonia, blood stream infection, wound infection, and central venous catheter infection as defined by the Centers for Disease Control (10)) and hospital length of stay. Infectious complications were recorded based on culture results documented in the patient record throughout the hospital stay by independent study coordinators who were not familiar with the hypothesis of the study. Bloodstream infections were recorded from the chart review and consisted of growth of a recognized pathogen from blood culture, not related to another site of an infection, and for which a course of antibiotics was given.

**Statistical Analysis.** A  $p$  value of  $<.05$  was set as the criterion for statistical significance. Overall, binary data were compared with chi-square tests; Student's  $t$ -tests were used for continuous or count data. Specifically, survivors were compared with nonsurvivors using Student's  $t$ -test for patient characteristics and treatment variables. Transfusion thresholds for a given TBSA, hemoglobin level at first transfusion, and hemoglobin level at last transfusion were compared for selected comorbidities (cardiac disease, acute respiratory distress syndrome [ARDS], sepsis, children, burn of  $\geq 50\%$  TBSA) using analysis of variance with Tukey's correction for multigroup comparisons. Transfused and nontransfused patients were compared using Student's  $t$ -test. Spearman's rank-correlation coefficient was used to determine the association between the number of blood transfusions and infection.

Age in years was a continuous variable for the analyses, except when recoded into the age groups of  $<5$ , 5–18, 19–39, 40–60, and  $>60$  yrs for comparisons of hemoglobin levels at first and last transfusion.

A series of statistical comparisons were made between survivors and nonsurvivors for the patient characteristics and treatment- and transfusion-related variables. Multivariate adjusted logistic regression analysis for survival was used to determine independent predictors of survival and for calculating the odds ratio between the number of units transfused and infectious episodes. Two separate multivariate models for survival were developed: the first analyzed the total number of transfusions as an independent predictor of survival. A second model was used to analyze the effects of the number of units of blood transfused in the operating room and outside the operating room on survival. For these analyses, age and TBSA were forced into the model because they were considered important biological variables to be statistically controlled. The data are expressed as the mean  $\pm$  SEM, with  $p < .05$  as the determinant of statistical significance.

## RESULTS

**Demographics.** Data were collected on a total of 666 patients from 21 different burn centers. Survival for the entire patient cohort was 79%. A total of 46 patients (3%) died within 24 hrs of admission and were not included in multivariate data analysis. These patients were older and had primarily sustained massive, nonsurvivable burns (mean age,  $46.3 \pm 3.9$  yrs; mean TBSA burn, 72.5%; 83% had severe inhalation injury). The mean age for the remaining 620 patients with burns of  $\geq 20\%$  TBSA burn was  $32.1 \pm 0.9$  yrs, with the highest percentage of patients being in the age group of 19–39 yrs (Table 1). Males sustained burn injury far more frequently than females (76% vs. 24%). The mean burn size was  $36.4\% \pm 0.8\%$  TBSA. The number of patients decreased as burn size increased; the greatest number of patients sustained burns between 20% and 39% TBSA. Inhalation injury was present in 35% of patients. At the time of admission, 8.1% of patients had a history of cardiac disease, and 2.2% of patients were receiving anticoagulation before their injury. Ninety of the 620 patients died (14.5%) (Table 1).

**Transfusion-Related Results.** Of the 620 patients analyzed, 463 (74.7%) received blood during their hospital stay (total of 8488 units of blood transfused). The percentage of patients receiving transfusion did not differ between survivors (75%) and nonsurvivors (74%) (Table 1).

Table 1. Patient characteristics at admission

Parameter	Survivors (n = 530)	Nonsurvivors (n = 90)	All (n = 620)
<b>Demographics</b>			
Age, yrs	29.3 ± 3 <sup>a</sup>	48.5 ± 2.6 <sup>a</sup>	32.1 ± 0.9
Sex, male/female	3:1	3:1	3:1
<b>Severity of illness</b>			
TBSA total	34.4 ± 0.8 <sup>a</sup>	48.0 ± 2.2	36.4 ± 0.8
TBSA full thickness	18.3 ± 0.8 <sup>a</sup>	34.9 ± 2.6	20.8 ± 0.8
Inhalation injury	160 (30) <sup>a</sup>	56 (62)	216 (35)
<b>Medical history</b>			
Cardiac disease	30 (5.7) <sup>a</sup>	22 (24)	52 (8)
Anticoagulation	11 (2.1)	3 (3.3)	14 (2)
<b>Interventions during first 24 hrs</b>			
Escharotomy	139 (26) <sup>a</sup>	44 (49)	183 (30)
Fasciotomy	37 (7) <sup>a</sup>	14 (15)	51 (8)
<b>Interventions during hospitalization</b>			
Anticoagulation	182 (34)	35 (39)	217 (35)
Time to 1st operation (days)	6.1 ± 0.3 <sup>a</sup>	3.8 ± 0.4	5.8 ± 0.3
Number of operations	3.7 ± 0.2 <sup>a</sup>	2.7 ± 0.4	3.6 ± 0.1
Received Transfusion	396 (75)	67 (74)	463 (75)

TBSA, total body surface area.

<sup>a</sup>*p* < .001 survivors vs. nonsurvivor. Variables expressed as mean ± SEM or actual number with percentages in parentheses.

Table 2. Transfusion thresholds for patients with significant comorbidities

Variable (No. of Patients)	TBSA	Hb First	Hb Last	Total Units PRBC
Cardiac disease (41)	34.7 ± 1.9	9.3 ± 0.3	8.6 ± 0.2 <sup>a</sup>	19.5 ± 4.2
Inhalation injury (181)	43.8 ± 1.3	9.4 ± 0.1	9.1 ± 0.1 <sup>a</sup>	23.0 ± 2.7
ARDS (126)	45.9 ± 1.7	9.6 ± 0.2	8.9 ± 0.1 <sup>a</sup>	29.0 ± 4.2
Sepsis (193)	45.4 ± 1.4	9.3 ± 0.2	8.9 ± 0.1 <sup>a</sup>	27.8 ± 3.0
TBSA of ≥50% (112)	66.1 ± 1.3	9.2 ± 0.2	8.9 ± 0.2	34.1 ± 4.9
Age of <18 yrs (190)	36.6 ± 1.2	8.9 ± 0.1	9.1 ± 0.1	13.2 ± 2.8
All patients	34.4 ± 0.8 <sup>b</sup>	9.3 ± 0.1	9.1 ± 0.1 <sup>a</sup>	13.7 ± 0.1 <sup>b</sup>

TBSA, total body surface area; Hb, hemoglobin; PRBC, packed red blood cell; ARDS, acute respiratory distress syndrome.

<sup>a</sup>*p* < .05 by Student's *t*-test vs. Hb at first transfusion; <sup>b</sup>*p* < .05 for TBSA burn and total number of PRBC transfusions in all patients vs. cardiac, inhalation, ARDS, sepsis, and TBSA of ≥50% groups.

Patients received their first blood transfusion a mean of 5.3 ± 0.3 days after admission, and the last transfusion was administered 28.8 ± 1.4 days after admission. Hemoglobin levels immediately before transfusion differed significantly (*p* < .05) between the first (9.3 ± 0.1 g/dL) and last (9.1 ± 0.1 g/dL) transfusion. The mean total number of blood transfusions received per patient throughout the hospital stay was 13.7 ± 1.1 units. Of those, 4.3 ± 0.3 units were transfused in the operating room. The mean hemoglobin level for patients who received their first transfusion in the operating room (presumably given for acute blood loss during surgery) was 10.2 ± 0.2 g/dL. Patients who received their first unit of blood outside of the operating room had a significantly lower mean hemoglobin level (8.9 ± 0.1 g/dL, *p* < .05) at the time of transfusion. However, both groups received their first

unit of blood a mean of 5.3 ± 0.3 days after admission.

The effects of the extent of the burn injury on hemoglobin transfusion threshold demonstrated a similar pattern. The hemoglobin level at the time of transfusion was not significantly different among burns of different sizes (i.e., the transfusion threshold was not altered by the extent of burn injury). The hemoglobin level at the first transfusion was higher than the hemoglobin level at the last transfusion for all burn sizes.

Hemoglobin transfusion practices differed for "high-risk" patients, including children and patients with cardiac dysfunction, inhalation injury, ARDS, TBSA burn of ≥50%, and sepsis (Table 2). Patients with inhalation injury, cardiac dysfunction, ARDS, and blood stream infection had larger burn injuries and received more blood products than patients with-

out these comorbidities. Patients with burns of ≥50% TBSA (massive burns) received the greatest number of transfusions (>30 units of blood per patient, twice that of all patients and approximately one third more than patients with other comorbidities). Children were the sole exception among the high-risk groups; they had burns of similar magnitude and received the same number of transfusions as their adult counterparts, despite having a lower initial hemoglobin level at the first transfusion.

A total of 157 patients (25.3%) with hospital length of stay of >24 hrs did not receive any blood transfusions. Patients who did not receive blood transfusion had smaller burns (29.5% ± 1.0% vs. 38.8% ± 0.8% TBSA burn, *p* < .0001), fewer infections (pneumonia, urinary tract infection, blood stream infection, and wound), fewer operations (0.54 ± 0.1 vs. 4.6 ± 0.2, *p* < .0001), lower rate of inhalation injury (19.7% vs. 40.0%, *p* < .05), lower rate of ARDS (5.1% vs. 25.3%, *p* < .05), and shorter hospital length of stay (13.5 ± 0.9 vs. 48.8 ± 1.9 days, *p* < .001) than patients receiving blood transfusion (Table 3). Thus, groups not receiving blood transfusion seemed to have fewer complications than groups receiving transfusion. However, this is likely due to an overall lower severity of illness (smaller burn, lower rate of inhalation injury). Survival did not differ between the groups. Of the 23 deaths in the nontransfused group, 13 occurred within 72 hrs of admission in older patients with massive nonsurvivable burns (mean age, 60 ± 5.4 yrs; TBSA, 50.3% ± 6.2%). The mortality in the nontransfused group without this patient cohort would be 6%.

**Other Treatment Variables.** Thirty-five percent of the patients (n = 217) received anticoagulation during their hospital stay. Of these, 5% of patients (10 of 217 patients; primarily those patients who were on anticoagulation before burn injury) received continuous intravenous heparin therapy. The remaining 98% of patients (212 of 217) received anticoagulation primarily with low molecular weight heparin or subcutaneous heparin for deep venous thrombosis prophylaxis. The dosage, route of administration, and interval of administration varied markedly between different centers, precluding analysis of any anticoagulation modality. Patients receiving anticoagulation received more transfusions than patients not receiving anticoagulation (16.3 ± 1.5 vs. 12.3 ± 1.5, *p* < .001). The number of units of

Table 3. Comparison of transfused and nontransfused patients

Variable	Transfused (n = 463)	Nontransfused (n = 157)
<b>Demographics</b>		
Age, yrs ± SEM	31.9 ± 1.1	33.2 ± 1.7
Female sex (%)	130 (27)	20 (12) <sup>a</sup>
<b>Severity of illness</b>		
TBSA burn, % ± SEM	38.8 ± 0.8	29.5 ± 1.0 <sup>a</sup>
Inhalation injury (%)	185 (40)	31 (20) <sup>a</sup>
Cardiac disease (%)	41 (9)	11 (7)
<b>Treatment</b>		
Escharotomy (%)	169 (36)	18 (11) <sup>a</sup>
No. of operations ± SEM	4.6 ± 0.2	0.54 ± 0.1 <sup>a</sup>
<b>Infections</b>		
Ventilator-associated pneumonia (%)	195 (42)	10 (6) <sup>a</sup>
Urinary tract infection (%)	130 (27)	10 (6) <sup>a</sup>
Blood stream infection (%)	186 (40)	6 (4) <sup>a</sup>
Wound infection (%)	186 (40)	24 (15) <sup>a</sup>
<b>Outcome</b>		
Length of stay, days ± SEM	48.8 ± 1.9	13.5 ± 0.9 <sup>a</sup>
Survival (%)	396 (86)	134 (85)

TBSA, total body surface area.  
<sup>a</sup>*p* < .05 by Student's *t*-test.

Table 4. Adjusted logistic regression model for survival

	Odds Ratio	<i>P</i>	95% Confidence Interval
Age	0.953	<.001	0.934–0.972
Female sex	0.938	.890	0.375–2.342
TBSA total	0.946	<.001	0.920–0.973
Inhalation injury (1 = yes)	0.324	.006	0.144–0.728
Number of infections	1.283	.258	0.833–1.977
Number of operations	1.339	.003	1.107–1.619
Admission to first operation	1.115	.106	0.977–1.272
Admit to first transfusion	1.105	.113	0.977–1.250
Admit to last transfusion	1.043	.002	1.015–1.071
Total blood transfusions	0.982	.012	0.967–0.996
Escharotomies	0.675	.343	0.299–1.522
Cardiac disease	0.165	.002	0.052–0.520
ARDS	1.720	.312	0.601–4.916
Blood stream infection	0.124	<.001	0.041–0.374

TBSA, total body surface area; ARDS, acute respiratory distress syndrome.

blood transfused during surgery was also significantly higher for patients receiving anticoagulation (6.3 ± 0.7 vs. 3.9 ± 0.3 units, *p* < .001). The total number of blood transfusions correlated with anticoagulation during the hospital stay (rho coefficient, 0.163; *p* < .001).

Escharotomies were performed in 30% of patients (n = 183), and 8% of patients (n = 51) had fasciotomies. Anticoagulation (either unfractionated low-dose heparin, low molecular weight heparin, or aspirin) was administered to 35% of patients (n = 217) during their hospital stay. Nineteen percent of the patients did not have an operation. The mean number of operations for those patients who underwent surgery was 3.6 ± 0.1, with the first operation occurring an average of 5.8 ± 0.3 days after admission. Survivors required fewer escharotomies and fasciotomies

than nonsurvivors, reflecting the lesser severity of their injury. Of note, survivors had a longer interval between admission and the first operation (6.1 days) than nonsurvivors (3.8 days) (Table 1).

**Outcome.** The total number of units of blood transfused correlated with the number of infectious episodes documented during the hospital stay (Spearman's rank correlation, 0.647; *p* < .001). However, the site of infection did not differ between survivors and nonsurvivors, and there was no difference in the prevalence of pneumonia. By logistic regression, the odds ratio of developing an infection per unit of blood transfused was 1.13 (*p* < .001), an increase of 13% per unit of blood transfused.

The mortality rate for the 620 patients surviving for >24 hrs was 14.5%, and the mean length of stay was 37 ± 1.5 days.

Survivors differed significantly from nonsurvivors in age, burn size (both full thickness and partial thickness), and the presence of inhalation injury at the time of admission (Table 1). Analysis of institution-specific outcomes based on number of patients enrolled revealed no significant differences in survival between institutions. Sixty-four patients (31.2%) of patients with escharotomies died. Nonsurvivors received more blood than survivors (17.9 ± 3.0 vs. 13 ± 1.2 units, *p* < .05) during their hospital stay. No difference between survivors and nonsurvivors existed in the number of units of blood transfused in the operating room (4.4 ± 0.3 units in survivors vs. 3.7 ± 0.8 units in nonsurvivors). Nonsurvivors received significantly more blood transfusions outside the operating room (14.0 ± 2.4) compared with survivors (8.6 ± 0.1, *p* < .05). Survivors also received their first blood transfusion later in their hospital stay than did the nonsurvivors.

Multiple logistic regression analysis was performed to determine the independent variables for survival after burn injury, as depicted in Table 4. There was a negative relationship between survival (i.e., increased mortality) and age, TBSA burn, total number of blood transfusions, presence of cardiac disease, and blood stream infection. Survival was positively associated (i.e., patients were more likely to survive) with the number of operations and the interval to the last transfusion.

## DISCUSSION

Patients with major burns differ from other critically ill patients due to their sustained hyperdynamic cardiovascular and metabolic response to injury; thus, the traditional physiologic variables used to determine transfusion need are not applicable (11). In this study, 75% of patients with burns of ≥20% TBSA received a blood transfusion. Survival decreased with increasing age, increasing percentage TBSA burn, inhalation injury, preexisting cardiac disease, number of blood stream infections, and the total number of blood transfusions received during hospitalization. Blood transfusion also increased the risk of infection by approximately 13% per unit transfused.

The frequency of blood transfusion in this study is comparable with a previous report for ICU patients with a hospital length of stay of >13 days (8). However, burn patients received their first blood transfusion in the perioperative period,

and this initial transfusion occurred later in the hospital course (5 days) than in previous ICU reports (3 days) (8, 12, 13). Blood transfused in the operating room, which was not addressed in previous ICU studies, did not affect survival. However, blood transfused outside the operating room influenced survival, suggesting that emphasis should be placed on indications and timing of transfusion in the burn ICU in future prospective studies.

Our findings, similar to other ICU studies, suggest that the number of blood transfusions received during hospitalization may be a marker for disease severity and survival (2, 7, 8). Recent prospective studies of trauma patients reported that blood transfusion was an independent predictor for mortality, ICU admission, systemic inflammatory response syndrome, ARDS, ventilator associated pneumonia, and hospital length of stay independent of injury severity (14–16). Similarly, a European study of both medical and surgical ICU patients suggested an association between transfusion and organ dysfunction in critically ill patients (17).

The administration of blood products has been linked to increased infection and immunosuppression in several animal and ICU studies (18–21). Blood transfusion was associated with infectious complications in the present study, with each unit of blood transfused increasing the risk of infection by 13%. Immunosuppression after burn injury is ubiquitous; further compromise of the immune system by blood transfusion may increase the patient's susceptibility to infection and may affect mortality (22, 23).

The use of blood transfusions in the treatment of major burn injuries reported here also differed from that previously reported by burn surgeons and the ICU literature (8, 9). Factors reported as altering the hemoglobin transfusion trigger (such as ARDS, sepsis, cardiac disease, inhalation injury, age of >60 yrs, and extent of burn) did not alter transfusion thresholds in this study. These findings highlight the fact that perceived and actual medical practices are not equivalent.

Anticoagulant use, which has not been addressed in previous blood transfusion studies, may increase blood loss and the need for blood transfusion after burn injury. In this study, the 35% of patients who received anticoagulation received more blood transfusions (16 vs. 12 units of packed red blood cells), particularly in the operating room (6 vs. 4 units of packed red blood cells). The risk/benefit

ratio of anticoagulation must be assessed before instituting anticoagulation in patients with large burns requiring multiple operations.

Previously documented survival determinants after major burn injury include patient age, burn size, and the presence of inhalation injury (24). The demographic variables in this study are consistent with national burn statistics: the majority were men 19–30 yrs of age with a 20–30% TBSA burn and a mean length of stay of 1 day per percent burn (25, 26). The data from this study are a representative sampling of major burn injury.

Although this study confirms previous findings and adds further information to the risk/benefit ratio of blood transfusion after a major burn injury, it has several limitations. The study is potentially limited by the sample size, which may have resulted in undetected associations. Due to the many variables in both disease presentation and treatment, residual confounding may have occurred, despite appropriate statistical analysis. Although an association exists between blood transfusion and survival, other factors, such as medical comorbidities, may affect survival. The severity of burn injury varied among the patients studied; we used established measures of injury severity (age, TBSA burn, and inhalation injury) in our statistical model to adjust for these differences. This study provides data on the total number of transfusions but does not provide insight into the time course of blood transfusion or the reasons for administering the transfusions. Thus, although this study suggests that blood transfusions are associated with a decrease in survival after major burn injury, it does not provide direct evidence that blood transfusions were the sole cause of survival differences between groups.

## CONCLUSIONS

Although blood transfusion is ubiquitous in the treatment of major burn injury ( $\geq 20\%$  TBSA burn), appropriate indications for transfusion in burns remain elusive. This study suggests that mortality and infectious complications may be related to the number of blood transfusions received. The amount of blood received outside the operating room, a situation in which burn intensivists have control of therapy, has the greatest association with survival. A prospective, randomized, multicenter study is needed to determine the appropriate indications for

blood transfusion in burn patients. In the interim, the use of blood transfusions in the treatment of patients with major burn injury should be reserved for patients with a demonstrated physiologic need.

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## APPENDIX

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