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Impact of anaemia on outcome in burn patients

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Abstract

Background: Currently, most critical care physicians maintain a patient's haemoglobin levels at 7 to 8 g dL^{-1}. However, little data have been available on haemoglobin-related outcomes in burn patients. The purpose of this study was to evaluate inpatients with greater than 20% total body surface area burns and the effects of haemoglobin below 8 g dL^{-1} on clinical outcomes.

Methods: This study included 70 patients with burns amounting to greater than 20% of total body surface area. Data were retrospectively evaluated and included age, gender, adult respiratory distress syndrome presence, length of intensive care unit stay, length of mechanical ventilation, days requiring vasopressors, renal insufficiency, positive cultures/infections, cardiovascular complications, number of operations, inhalation injury, and mortality. Logistic regression analyses that were adjusted for age, sex, and percent total body surface area were used to assess the relationships between haemoglobin and multiple clinical outcomes. Odds ratios (OR) were estimated with 99% confidence intervals (99% CI).

Results: Haemoglobin below 8 g dL^{-1} was associated with a need for vasopressors (OR = 2.17; 99% CI = 1.03–8.22). Furthermore, haemoglobin below 8 g dL^{-1} was associated with higher positive wound (OR = 2.86; 99% CI = 1.00–34.40), urine (OR = 4.63; 99% CI = 1.15–67.00), and lung cultures (OR = 2.24; 99% CI = 1.06–5.47). These associations largely remained after controlling for blood transfusions.

Conclusions: Contrary to most other patient groups, burn patients with burns amounting to greater than 20% of total body surface area and low haemoglobin levels were more likely to develop positive cultures in urine, wounds, and the lung and require vasopressor treatment.

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Key words: burn patient, anaemia, haemoglobin levels

The purpose of this study was to evaluate the effects of haemoglobin (Hgb) values less than 8 g dL^{-1} on various outcome parameters in burn patients. The most definitive study in critically ill patients with lowered Hgb values demonstrated no difference in outcome when Hgb values of 8.5 ± 0.7 g dL^{-1} were compared to a similar cohort with Hgb values of 10.7 ± 0.7 g dL^{-1} [1]. However, in patients who were less acutely ill, mortality was significantly lower in the restrictive group, though no burn patients were included. A more recent European study evaluated septic shock patients with Hgb values as low as 7.0 g dL^{-1} before transfusion to those transfused when levels were less than 9 g dL^{-1}[2]. Again, there were no outcome differences. One study [3] examined patients with burns amounting to greater than 20% of total body surface area (TBSA) and found no difference in outcome when patients were transfused at a threshold of Hgb 7.1 ± 1.2 or 9.2 ± 2.1 g dL^{-1}. We hypothesized that burn patients who experienced below threshold Hgb levels (< 8 g dL^{-1}) would have poorer clinical outcomes and a greater likelihood of infection compared to burn patients who did not experience below-threshold Hgb levels during their hospital stay.

METHODS

This was a retrospective study conducted at a single academic medical centre. It included all patients admitted with burns amounting to 20% or greater of total body surface area (TBSA) from July 1, 2011 through June 30, 2014. It was approved by, and followed the guidelines of the centre's Institutional Review Board. Written informed consent was not required for this retrospective study.

Patients were treated by a burn team, which consisted of an attending physician, one resident, and one intern. Hgb level transfusion triggers were determined by the patients' clinical status. Consistency was assured by the small team size, one housestaff and only two attending physicians. All patients whose Hgb levels were below 7.0 g dL^{-1} were transfused. Adequacy of intravascular volume was based on clinical parameters including blood pressure, urine output, mixed venous oxygen tension, and lactic acid levels. In addition, central venous pressure and stroke volume variation were often utilized as an added guide. Transfusion occurred both in the Burn Intensive Care Unit (ICU) and the operating room. Any day, or part of a day, when the Hgb level was less than 8 g dL^{-1} was considered a low Hgb day. This did not include any Hgb values during the actual time of surgery. All blood transfused had been previously leukoreduced, and the amount of packed red blood cells (pRBC) transfused throughout the ICU stay was recorded. Other measures and clinical outcomes collected included: age, sex, %TBSA, adult respiratory distress syndrome (ARDS: [positive end-expiratory pressure > 10 cm H_2O to keep PaO_2 > 90 mm Hg {FiO_2 0.4}]), days ventilated, days of ICU stay, days on vasopressors (to keep mean arterial pressure above 60 mm Hg), renal insufficiency (either a blood urea nitrogen > 30 mg dL^{-1} or creatinine > 1.8 mg dL^{-1}), positive cultures for blood, urine, wound, and/or lung (analyzed separately and combined), cardiovascular complications (myocardial infarction, brain stroke, atrial fibrillation), number of operations, inhalation injury, and mortality.

All positive cultures reported were considered significant and were treated with appropriate antibiotics. All central lines were changed after 7 days to a new site. Universal sterile precautions were always employed.

STATISTICAL ANALYSIS

Statistical analysis was performed using SAS version 9.3 (SAS Institute, Cary, USA). Descriptive statistics were calculated as means and standard deviations for continuous variables; medians and interquartile ranges for continuous, non-normally distributed variables; and frequencies for categorical variables. Patient characteristics (gender, age, burn size, number of operations, inhalation injury) were compared between: 1) patients who had at least one day with Hgb < 8 g dL^{-1} and patients who had no days with Hgb < 8 g dL^{-1} and 2) patients who received any blood transfusion (units of pRBC) and those who had no pRBC transfusion, using Student's *t* test (age and burn size) and a chi-square test (gender).

To assess the association between anaemia (indexed by both days with Hgb < 8 g dL^{-1} or units of pRBC) and multiple clinical outcomes, multiple logistic regression analysis was used that controlled for sex, age, burn size, inhalation injury, and any positive cultures (except in analyses in which positive cultures were the outcome). Odds ratios (OR) were estimated with 99% confidence intervals (CI), with CIs including "1.0" indicating no association; 99% confidence intervals we used to account for potential issues due to multiple testing.. For Hgb, comparisons were made between patients who had at least one day with Hgb < 8 g dL^{-1} and patients who had no days with Hgb < 8 g dL^{-1} and between patients who had at least three days with Hgb < 8 g dL^{-1} and patients who less than three days with Hgb < 8 g dL^{-1} (serving as a sensitivity analysis) For pRBC, comparisons were made between patients who received any blood transfusion (units of pRBC) and those who had no pRBC transfusion. Logistic regression analyses were also used to assess the association of burn size and age with the clinical outcomes. Due to the small sample, Firth's correction was employed for logistic regression analyses to reduce bias. $P < 0.05$ was considered statistically significant.

POWER ANALYSES

The primary hypothesis of this study was that people who had at least one day with Hgb < 8 g dL^{-1} would have worse clinical outcomes; thus the null would be that clinical outcomes do not differ between patients with or without instances of Hgb < 8 g dL^{-1}. Our sample of n = 70 would be able to detect an odds ratio = 2.14 at a power = 80% and an alpha = 0.05 in a multiple logistic regression.

RESULTS

Seventy patients met the inclusion criteria for this study; Table 1 summarizes their characteristics. Burn size was 42 ± 19% TBSA and mean age was 45.5 ± 16.6 years. Seventy-one percent required mechanical ventilator support with a median length of ventilation support of 9.5 days. Median length of stay was 23 days, and the mortality rate was 38.6%. A majority (65.7%) of these patients underwent multiple operations while 37.1% experienced inhalation injury. Not surprisingly, there were more pulmonary infections than any involving blood, urine, or wounds. This most likely reflected the high percentage of patients requiring extended mechanical ventilation.

The number of median days when Hgb was less than 8.0 g dL^{-1} was 12.0 (Table 2). Seventy-seven percent of patients had at least one day when Hgb was <8.0 g dL^{-1}. The proportion of total hospital days of Hgb < 8.0 g dL^{-1} was 46%.

There was no statistical difference in burn size, age, or gender between these patients and those whose Hgb value always remained above 8.0 g dL^{-1} (48.9% ± 22.3% compared to 41.6% ± 18.0%) (Table 3). As previously stated, the thresh-

Table 1. Patient characteristics (n = 70)

Variable	Statistic
Age; mean years (SD)	45.5 (16.6)
Sex	
Male (%)	72.3%
Female (%)	28.7%
Burn size; mean % area (SD)	42.0 (19.0)
Ventilation required (%)	71.4%
Ventilation days, median (IQR)[a]	9.5 (38.0)
Length of stay; median days (IQR)	23.5 (56.0)
Vasopressor administered (%)	57.1%
ARDS (%)	48.6%
Renal insufficiency	38.6%
Dialysis (%)	17.1%
Stroke (%)	2.9%
Atrial fibrillation (%)	18.8%
Myocardial infarction (%)	8.6%
Died (%)	38.6%
Number of operations, median (IQR)	3.0 (5.0)
Multiple operations (%)	65.7%
Inhalation injury (%)	37.1%
Number of positive blood cultures	
0	65.7%
1	18.6%
2	7.1%
3+	8.6%
Number of positive urine cultures	
0	72.9%
1	15.7%
2	4.3%
3+	7.1%
Number of positive wound cultures	
0	74.3%
1	12.9%
2	5.7%
3+	7.1%
Number of positive pulmonary cultures	
0	45.7%
1	15.7%
2	12.9%
3+	25.7%
Overall positive cultures (% any)	67.1%

old for transfusion was a clinical decision by the burn team. Forty-nine patients were transfused (70%). There was no statistical difference in burn size, age, or gender in those transfused and those who never received blood (Table 4). However, nearly every patient who had at least one day with Hgb < 8.0 g dL^{-1} or received a transfusion had multiple operations (P <0 .001).

Table 2. Anemia and blood transfusion characteristics of patients

Variable	Measurement
Median days (IQR)[a] with Hgb < 8 g dL^{-1}	12.0 (37.3)
Haemoglobin < 8 g dL^{-1} on any day (%)	77.0%
Haemoglobin < g dL^{-1} on at least 3 days (%)	68.6%
Proportion of total days in hospital with Hgb < 8 g dL^{-1} (median, IQR)	46.0% (53.7)
Median units (IQR) of pRBC	6.5 (23.3)
pRBC transfusion (% requiring pRBC on any day)	70.0%
pRBC units per day (median units/day, IQR)	0.26 (0.42)

[a]Number of infections coded as 0, 1, 2, and 3 or more

Logistic regression analysis compared burn size to clinical outcomes (Table 5). Statistical differences were found for burn size and the need for mechanical ventilation (P = 0.002), the use of vasopressors (P = 0.002), positive blood culture (P = 0.002), ARDS (P = 0.001), and mortality (P = 0.0001), with increased burn size related to poorer outcomes. Table 6 illustrates outcomes related to age. Those requiring mechanical ventilation were older, 48 ± 16.3 years versus 34.5 ± 13.5 years (P = 0.005). Older age was also associated with renal insufficiency (53.2 ± 15.2 years compared to 40.8 ± 15.8 years; P = 0.002). Mortality was also higher as age increased; 55.5 ± 15.9 years in those who died compared to 39.4 ± 14 years (P = 0.004) in survivors. Finally, older patients were more likely to develop a cardiovascular complication; 57.9 ± 13.2 years compared to were 41.4 ± 15.6 years (P = 0.001) in those without complications.

Regarding clinical outcomes, patients with any day with Hgb < 8 g dL^{-1} and patients who required a pRBC transfusion were more likely to need vasopressors (Table 7). Additionally, patients with any day with Hgb < 8 g dL^{-1} were more likely to have a greater amount of positive cultures in urine, wound, and lung (Table 8; Fig. 1). Similar associations were observed for patients who required a pRBC transfusion (Table 8). These were significant associations even after controlling for the effects of age, sex, burn size, and inhalation injury. Due to the high confounding with both Hgb and pRBC with number of operations, number of operations could not be included in these models. Interestingly, after controlling for pRBC, any day with Hgb < 8 g dL^{-1} was still significantly associated with urine infection (P = 0.030) and wound infection (P = 0.020. These results were similar in our sensitivity analysis that changed the Hgb < 8 g dL^{-1} cutoff to at least three days (Supplemental Tables 1 and 2).

Table 3. Baseline characteristics associated with haemoglobin and blood transfusion status

Characteristic	Haemoglobin < 8 g dL^{-1} n = 54	Haemoglobin > 8 g dL^{-1} n = 16	*P*-value
Mean age (SD)	44.5 (15.8)	48.9 (19.3)	0.354
Sex (%)			0.529
Male	70.4%	81.2%	
Female	29.6%	18.8%	
Mean burn size % (SD)	48.9 (22.3)	41.6 (18.0)	0.182
Multiple operations (%)	95.7%	4.3%	< 0.001
Inhalation injury (%)	88.5%	11.5%	0.07

Table 4. Characteristics of transfused patients

Characteristic	Transfusion n = 49	No transfusion n = 21	*P*-value
Mean age (SD)	45.5 (14.4)	45.5 (21.3)	0.988
Sex (%)			0.169
Male	75.5	66.7	
Female	25.5	33.3	
Mean burn size % (SD)	44.1 (18.6)	41.6 (20.6)	0.612
Multiple operations (%)	93.5%	6.5%	<0.001
Inhalation injury (%)	80.8%	19.2%	0.12

DISCUSSION

Today, most clinicians subscribe to the theory that red blood cell transfusion avoidance when possible improves morbidity and mortality. Transfusion thresholds in burn patients have been reported as Hgb values, incidence of inhalation injury, as well as burn size and known cardiac disease [4]. Marik and Corwin [5] synthesized this point in a meta-analysis of 45 articles that appeared to essentially involve "stable" ICU patients [5]. However, these results have not been consistent in all patient groups. In a study of critically ill patients [1], while 30-day mortality between restrictive and liberal transfusion groups was not significantly different, patients who were less acutely ill had less mortality in the restrictive group when compared to the liberal group. This study, however, may have been confounded because the liberal group had higher rates of patients with cardiac events, pulmonary oedema, and myocardial infarction [1]. In a study of cardiac surgery patients,[6] a restrictive transfusion strategy resulted in a slightly higher death rate after 90 days, but not after 28 days. Pre-existing cardiac function was not included as baseline data in our study. A European observation study [7] that used a Cox proportional hazard analysis actually showed improved outcome in transfused patients. As mentioned earlier, the European Sepsis Study [2] also demonstrated no outcome difference between restrictive and liberal transfusion strategies. Although the statistical methodologies may vary, at least three studies now question the routine use of restrictive transfusion strategies in critically ill patients. The now widespread use of leukodepleted blood may mitigate some of the deleterious effects attributed to transfusion.

A study by Kwan *et al.* [3] did show a higher mortality in the designated liberal transfusion treatment group (Hgb 10.2 ± 2.2 g dL^{-1}). However, this group was treated over a 2-year period in the 1990s. The evolution of overall treatment strategies and, as the authors point out, closer care and monitoring of the restricted transfusion group, may have accounted for the different outcome. Other factors such as the age of the blood may have impacted outcome, but were not accounted for either in *Kwan et al.* [3], or in our study.

In our study, daily Hgb values were evaluated by the clinical care team. In general, they attempted to maintain Hgb values above 7 g dL^{-1}. This resulted in 77% of patients with at least one day when Hgb was less than 8 g dL^{-1} (54 of the 70 patients). Patients whose Hgb values always remained > 8.0 g dL^{-1} could not be distinguished by age, sex, or burn size from those whose Hgb values at times were < 8.0 g dL^{-1}.

It is doubtful that phlebotomy had any significant role in Hgb levels. Two recent studies in critically ill patients indicated daily phlebotomy volumes of 35 to 41 mL [8, 9]. Other evidence suggests a loss of 100 to 250 mL of blood for each 1% body surface area of burn wound excision. This is the case despite topical epinephrine or tourniquet use [10, 11].

Table 5. Logistic regression analyses for the association of burn size with clinical outcomes and infection

Outcome	Mean burn size (%, SD)	Odds ratio (99% CI)[a]	*P*-value
Ventilation		1.15 (1.05–1.35)	0.002
Yes	46.6 (18.9)		
No	26.7 (6.2)		
Vasopressor		1.06 (1.02–1.13)	0.002
Yes	49.9 (20.0)		
No	33.8 (12.4)		
Blood cultures		1.05 (1.01–1.10)	0.002
Yes	53.3 (20.9)		
No	37.5 (15.2)		
Urine cultures		0.99 (0.95–1.03)	0.64
Yes	41.2 (17.2)		
No	43.6 (19.5)		
Wound cultures		1.02 (0.99–1.06)	0.10
Yes	49.1 (17.7)		
No	40.6 (18.9)		
Pneumonia cultures		1.00 (0.97–1.04)	0.73
Yes	43.6 (16.9)		
No	42.1 (21.2)		
ARDS[a]		1.06 (1.02–1.12)	0.001
Yes	51.2 (20.6)		
No	34.8 (12.6)		
Renal insufficiency[b]		1.03 (1.00–1.07)	0.02
Yes	49.4 (20.2)		
No	38.8 (16.9)		
Mortality		1.08 (1.03–1.15)	0.0001
Yes	55.8 (20.4)		
No	34.8 (12.3)		
Cardio- or Cerebrovascular[c]		0.99 (0.95–1.03)	0.69
Yes	41.1 (13.9)		
No	43.1 (20.3)		

[a]Number of infections coded as 0, 1, 2, and 3 or more

Forty-nine patients (70%) were transfused. Blood administration did not appear to be influenced by burn size as the percentage of burn was identical in both groups; neither age nor sex appeared to be factors. The decision to transfuse was primarily based on the patient's clinical status, which included the need for, and amount of vasopressors, as well as consideration of their current fluid regimen. In addition, factors such as blood pressure, urine output, central venous pressure, and stroke volume variations were also use to determine the adequacy of intravascular volume. Transfusion also had the added advantage over crystalloids in that all of the volume transfused was likely to stay in the intravascular space.

The need for mechanical ventilation and the development of ARDS did statistically correlate to burn size. Likewise, vasopressor use, the incidence of positive blood cultures, and mortality were all statistically related to larger burn size. None of these findings seem unusual [12, 13]. Most burn physicians dealing with our population would likely predict the same outcome.

In addition, when age was plotted against the same outcome measures, the need for mechanical ventilation, the incidence of renal insufficiency, cardiovascular complications, and mortality were all statistically significant. Elderly patients, pre-burn, are often medically compromised, and a burn injury of the magnitude in this study is often enough to upset their precarious health balance and lead to these comorbid events; even smaller burns can do so.

Of interest is the fact that this study found a relationship between Hgb less than 8.0 g dL^{-1} and the need for vasopres-

Table 6. Logistic regression analysis for the association of age with clinical outcomes and infections

Outcome	Mean age (years, SD)	Odds ratio (99% CI)	*P*-value
Ventilation		1.06 (1.00–1.14)	0.005
Yes	48.0 (16.3)		
No	34.5 (13.5)		
Vasopressor		1.04 (0.99–1.08)	0.03
Yes	49.5 (13.8)		
No	40.9 (18.6)		
Blood cultures		1.02 (0.98–1.06)	0.21
Yes	49.0 (13.9)		
No	43.7 (17.7)		
Urine cultures		1.02 (0.98–1.07)	0.25
Yes	49.6 (15.1)		
No	44.1 (17.1)		
Wound cultures		1.00 (0.95–1.04)	0.82
Yes	44.7 (14.8)		
No	45.7 (17.3)		
Pneumonia cultures		1.01 (0.98–1.05)	0.39
Yes	47.0 (14.9)		
No	43.6 (18.6)		
ARDS[a]		1.01 (0.97–1.05)	0.52
Yes	46.8 (13.8)		
No	44.3 (18.9)		
Renal insufficiency[b]		1.05 (1.01–1.15)	0.002
Yes	53.2 (15.2)		
No	40.8 (15.8)		
Mortality		1.07 (1.02–1.14)	0.0004
Yes	55.5 (15.9)		
No	39.4 (14.0)		
Cardio- or cerebrovascular[c]		1.07 (1.02–1.15)	0.001
Yes	57.9 (13.2)		
No	41.4 (15.6)		

[a]Number of infections coded as 0, 1, 2, and 3 or more

sors, which is inconsistent with most clinical studies and present-day findings in most centres. However, indications for pressor use can be somewhat subjective. This observed result may reflect institutional bias or may also be a function of the relatively small size of the study.

Minimizing transfusion by tolerating lower Hgb values has often been shown to reduce infection rates. Blood is a well-known immune modulator. When the incidence of positive cultures was evaluated, blood, urine, wound, and pulmonary cultures demonstrated a statistically positive relationship to the patient having any day level of Hgb < 8.0 g dL^{-1}, as well as requiring pRBC transfusion. Furthermore, the relationship between Hgb and infections rates largely remained after controlling for pRBC transfusion. It is unclear what this means. In addition, the known and continued high stress states in burn patients may have an impact on immune function. The relatively small size of this study precludes any suggestion of changing current practice. However, when our results are evaluated in conjunction with studies by Murphy *et al.* [6] and Vincent *et al.* [7], a large controlled study is warranted and necessary to clarify this issue.

In general, blood has been known to have immunosuppressive properties [14]. However, after white cells have been filtered or units washed prior to transfusion, this effect may not be as apparent. All blood administered in this

Table 7. Logistic regression analyses for the association of any day haemoglobin < 8 mg dL^{-1} and any need for pRBC transfusion with clinical outcomes

Outcome	Hgb < 8 any day (% Yes)	Odds ratio (99% CI)	*P*-value	pRBC any (% Yes)	Odds ratio (99% CI)	*P*-value
Ventilation		1.54 (0.63–4.08)	036		1.557 (0.66–3.89)	0.37
Yes	80.7			77.2		
No	61.5			38.5		
Vasopressor		2.17(1.03–8.22)	0.03		2.02(1.00–4.65)	0.04
Yes	85.0			82.5		
No	65.5			51.7		
ARDS		1.25 (0.65–2.53)	0.51		1.23 (0.68–2.31)	0.50
Yes	76.5			76.5		
No	77.8			63.9		
Renal insufficiency[a]		1.67 (0.83–3.70)	0.12		1.19 (0.66–2.25)	0.55
Yes	81.5			74.1		
No	74.4			67.4		
Mortality		0.64 (0.23–1.77)	0.43		0.60 (0.23–1.45)	0.26
Yes	66.7			63.0		
No	83.7			74.4		
Cardio- or Cerebrovascular[b]		1.62 (0.75–4.03)	0.18		1.18 (0.61–2.49)	0.61
Yes	83.3			72.2		
No	74.5			68.6		

[a]Combined incidence of blood urea nitrogen and creatinine > 30 and dialysis; bCombined incidence of atrial fibrillation, myocardial infarction, and stroke

Table 8. Logistic regression analyses for the association of any day haemoglobin < 8 mg dL^{-1} and any need for pRBC transfusion with number of infectionsb

	Any day with Hgb < 8 g dL^{-1}		Any need for pRBC	
	Odds ratio (99% CI)	*P*-value	Odds ratio (99% CI)	*P*-value
Blood cultures	1.27 (0.60–3.32)	0.48	1.36 (0.67–3.32)	0.36
Urine cultures	2.86 (1.00–34.40)	0.04	4.06 (1.19–49.40)	0.006
Wound cultures	4.63 (1.15–67.00)	0.008	4.06 (1.22–54.60)	0.005
Pulmonary cultures	2.24 (1.06–5.47)	0.005	3.67 (1.65–12.18)	< 0.001

study had been previously leukodepleted. Moreover, most reports of anaemia and sepsis are related to the chronic, not the acute, anaemia of burns [15].

The age of transfused blood has also been implicated in worse outcomes after transfusion [16, 17]. Most blood in this country is stored for up to 42 days. After about 20 days, red cell deformability, necessary to transverse capillary flow, is lost. Likewise, 2,3-diphosphoglycerate is mostly depleted. Theoretically, this sludging and impaired flow can contribute to poor organ perfusion, organ malperfusion, and possible worsened outcome.

Our study did not account for the age of transfused units. The breakdown of white cells and the release of various cytokines has also been implicated as part of the process. Two recent studies were unable to demonstrate a diminished or worsened outcome related to the use of "old" (> 20 or 75 days) blood [18, 19]. The Steiner study used leukoreduced red cells, whereas the Lacroix study made no mention of washing on leukoreduction.

This study has limitations imposed by the relatively small patient population and by its retrospective nature. While the number of individuals who ordered blood was limited, the only specific transfusion was a Hgb value below 7.0 g dL^{-1}. All other transfusions were based on the clinical assessment of the patient. Furthermore, we could not disentangle the effects of Hgb levels and the number of operations because these variables were nearly all confounding (i.e. nearly every patient with at least one day with Hgb less than 8 g dL^{-1} had multiple operations).

In summary, Hgb levels below 8 g dL^{-1} in patients with greater than 20% second and third degree burns influenced the incidence of positive cultures, as well as the requirements for needing a vasopressor, even after accounting for inhalation injury, age, burn size, and sex. However, the relationship of acute anaemia to positive cultures cannot be easily explained. A large randomized controlled study in burn patients of restricted versus liberalized transfusion

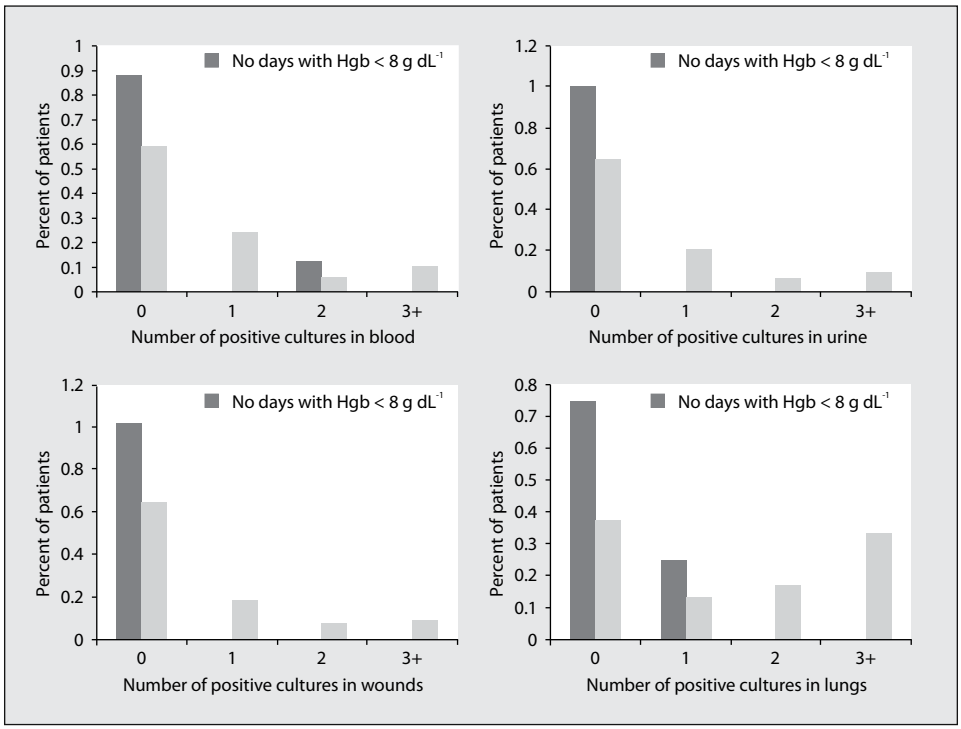

Figure 1. Association between number of positive bacterial cultures (blood, urine, wound, and pneumonia) and proportion of hospital stay with haemoglobin < 8 g dL^{-1}

would help to answer questions on the specific aetiology of these relationships. Overall, though, our results suggest that, in burn patients, there may be clinical consequences related to decreased Hgb levels that are not mitigated by transfusion alone and that this phenomena should be addressed early so that appropriate therapies can be evaluated and implemented. A large randomized controlled study in burn patients of restricted versus liberalized transfusion would help to answer questions on the specific aetiology of these relationships.

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Supplemental Table 1. Logistic regression analyses for the association of at least 3 days with haemoglobin < 8 g dL^{-1} with clinical outcomes

Outcome	Hgb < 8 g dL^{-1} at least 3 days (% Yes)	Odds ratio (99% CI)	*P*-value
Ventilation		2.02 (65–6.23)	0.14
Yes	80.7		
No	61.5		
Vasopressor		2.42 (1.20–5.71)	0.008
Yes	85.0		
No	65.5		
ARDS		1.36 (0.75–2.58)	0.30
Yes	76.5		
No	77.8		
Renal insufficiency[a]		1.76 (0.96–3.55)	0.05
Yes	81.5		
No	74.4		
Mortality		0.46 (0.18–1.04)	0.05
Yes	66.7		
No	83.7		
Cardio- or Cerebrovascular[b]		1.22 (0.64–2.47)	0.52
Yes	83.3		
No	74.5		

[a]Combined incidence of blood urea nitrogen and creatinine > 30 and dialysis; [b]Combined incidence of atrial fibrillation, myocardial infarction, and stroke

Supplemental Table 2. Logistic regression analyses for the association of at least 3 days haemoglobin < 8 g dL^{-1} with number of infections[a]

	Odds ratio (99% CI)	*P*-value
Blood cultures	1.75 (0.82–4.52)	0.11
Urine cultures	5.41 (1.46–72.11)	0.002
Wound cultures	6.10 (1.60–84.52)	< 0.001
Pulmonary cultures	10.50 (3.22–85.63)	< 0.001

[a]Number of infections coded as 0, 1, 2, and 3 or more