Determinants of red blood cell transfusion in pediatric trauma patients admitted to the intensive care unit

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BACKGROUND: There are no well-designed prospective studies evaluating transfusion practices in pediatric trauma. We sought to describe red blood cell (RBC) transfusion practices in trauma patients who were admitted to a pediatric intensive care unit (PICU).

STUDY DESIGN AND METHODS: This study is a post-hoc analysis of a prospective, 6-month observational study in 30 PICUs. We studied a total of 580 patients aged less than 18 years who had been admitted to a PICU for more than 48 hours, including 95 who were trauma patients.

RESULTS: Trauma patients more frequently received transfusion before PICU admission ($p < 0.001$), were older ($p < 0.0001$), and more frequently were mechanically ventilated ($p = 0.05$). In the PICU, trauma patients received more transfusions (55% vs. 37%; $p < 0.001$), although admission hemoglobin levels were similar in both groups ($p = 0.86$). The mean ($\pm$ standard deviation) pretransfusion hemoglobin level in the PICU was 9.0 ± 2.4 g/dL for trauma patients compared with 8.3 ± 2.4 g/dL for nontrauma patients ($p = 0.09$). Among the trauma patients, transfusion was associated with younger age, higher Pediatric Logistic Organ Regression scores, mechanical ventilation, bleeding, and transfusion before PICU admission. Multivariate regression demonstrated that receiving an RBC transfusion before admission was strongly associated with receiving a blood transfusion in the PICU ($p = 0.008$).

CONCLUSION: Trauma patients are at high risk for receiving an RBC transfusion both before and during their PICU stay, despite a similar transfusion threshold compared with nontrauma patients. Transfusion before PICU admission is a strong determinant, suggesting ongoing bleeding that will require re-transfusion. Further studies are needed to evaluate whether a restrictive transfusion strategy can safely be considered in these patients.

Injury is the leading cause of mortality in children older than 1 year of age, and traumatic brain injury and hemorrhagic shock are the primary causes of death among them.[1-3] Red blood cell (RBC) transfusion is an important component in the acute management of the unstable or bleeding trauma patient. Furthermore, anemia is very common among patients in a pediatric intensive care unit (PICU).[4] Despite the risks associated with severe anemia, increasing data suggest that significant risks are associated with transfusion.[5,6] Both adult and pediatric critical care practices have shifted to restrictive transfusion strategies given the potential adverse outcomes associated with transfusions.[5,6]

Transfusion guidelines for adults with trauma recommend RBC transfusion for those with hemorrhagic shock or hemodynamic instability with acute hemorrhage but,

ABBREVIATIONS: PELOD = Pediatric Logistic Organ Dysfunction; PICU = pediatric intensive care unit.

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otherwise, suggest transfusion for hemoglobin (Hb) <7 g/dL in resuscitated trauma patients.[7] Given the risks associated with ongoing hemorrhage, trauma patients may not be subject to a restrictive transfusion strategy. Adult literature has shown that blood transfusion in trauma patients is common (range, 10-23%) and is an independent predictor of mortality and length of stay in the intensive care unit.[8,9] A survey on the stated clinical practice and determinants of RBC transfusions among critical care practitioners revealed that high Pediatric Risk of Mortality (PRISM) scores, active bleeding, and surgery were statistically significant predictors of receiving a blood transfusion while in the PICU,[10] and a more recent survey reported a mean (± standard deviation [SD]) transfusion threshold Hb level of 8.1 ± 1.2 g/dL for trauma cases.[11] However, literature on the observed transfusion practice in severe pediatric trauma is lacking, because currently there are no well-designed, prospective studies describing baseline transfusion values in pediatric trauma.

The objectives of the current study were to describe the RBC transfusion practices in pediatric trauma patients admitted to the PICU and to characterize the determinants of RBC transfusion in this population. We hypothesized that trauma patients receive transfusion at higher Hb levels than nontrauma patients.

PATIENTS AND METHODS

This study was a post-hoc analysis of a data set from a large, multicenter, prospective cohort.[4]

Study population and sites

The original cohort study was prospectively conducted in 30 American and Canadian PICUs (all of which are members of the Pediatric Acute Lung Injury and Sepsis Investigators [PALISI] Network), for 6 months from September 2004 to March 2005. All consecutive patients younger than 18 years of age who were admitted to the PICU for over 48 hours were eligible. Exclusions from the original study included premature neonates, prior involvement in the study, a family history of refusing blood transfusions, involvement in another transfusion study, pregnancy, impending brain death, and admission to the PICU for more than 72 hours in the last 7 days. Further exclusions for the purpose of the current study included all patients who were admitted for cardiac surgery and patients with cyanotic heart disease, because it is known that both of these patient groups are associated with higher transfusions thresholds.[12,13] The Institutional Ethics Committee approved the current study (no. 3997) with a waiver of consent, because no new information was collected from patients.

Data collection and management

Because patient inclusion occurred 48 hours after PICU admission, all data in the first 48 hours of admission were collected retrospectively (except blood loss data, which were captured prospectively from admission in all patients). The database was used to identify trauma patients based on their reason for PICU admission. Data collected on admission included: demographics, severity of illness (estimated using the PRISM III score), severity of organ dysfunction (estimated using the Pediatric Logistic Organ Dysfunction [PELOD] score), transfusions before admission, and baseline Hb. All data after the first 48 hours of admission, including blood loss information, blood transfusion information, clinical parameters, reasons for transfusion, laboratory values (Hb), and complications, were collected prospectively. To prevent protopathic bias, which is defined here as when the initiation of the exposure (transfusion) occurs in response to an outcome under study, only events that happened after the first RBC transfusion in the PICU were considered as possible transfusion-related complications.

Statistical analysis

Results of descriptive statistics were expressed as a fraction of the total population, as the mean ± SD, or as the median with interquartile range (IQR), as appropriate. Categorical variables were analyzed using chi-square statistics. Continuous variables were compared using an analysis of variance for normally distributed variables and the Wilcoxon test for discrete variables that were not normally distributed. A p value of 0.05 was chosen as statistically significant. Multivariate analysis was performed on factors that were identified as significant ($p < 0.05$) in univariate analysis with no interaction and that were not redundant, up to a maximum of five variables. Results are reported as odds ratios (ORs) and confidence intervals (CIs). All statistical analyses were done by biostatistician (TD) using SAS statistical software (SAS, Inc.).

RESULTS

Of the 977 patients who were included in the original study, 580 had no exclusion criteria and were included in the current analysis, of which there were 95 were patients with trauma and 485 without trauma (Fig. 1).

Trauma versus nontrauma patients

Demographics for patients with and without trauma are described in Table 1. Compared with nontrauma patients, trauma patients were statistically more likely to be older ($p < 0.001$) and mechanically ventilated ($p = 0.05$). Baseline PELOD and PRISM scores were similar in both groups as well as the need for inotropic support. Trauma patients were more likely than nontrauma patients to have

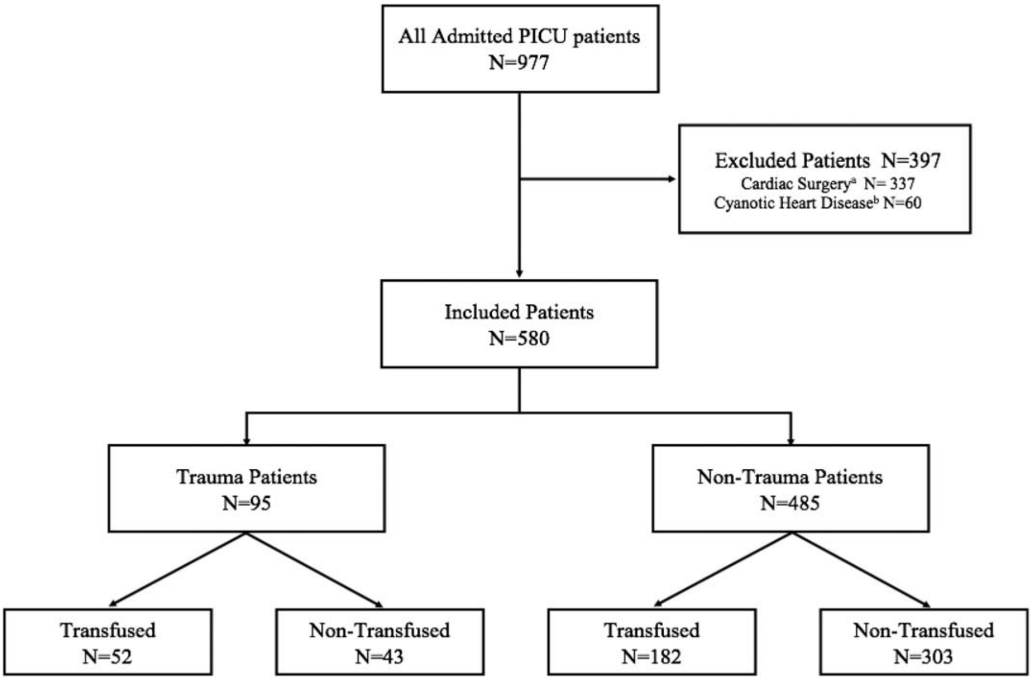

Fig. 1. Flowchart of patients included in the study. (A) Patients who were admitted to a critical care unit for elective or emergency cardiac surgery not related to trauma. (B) All patients with cyanotic heart disease who were not admitted for cardiac surgery (one cyanotic trauma patient who was admitted for emergency cardiac surgery was excluded).

TABLE 1. Baseline characteristics at PICU admission of all included patients, and in trauma and nontrauma patients

	No. of patients (%)			
Characteristic	All patients, n = 580	Trauma, n = 95	Nontrauma, n = 485	p value
Males	341 (59)	63 (66)	278 (57)	0.11
Age: Mean ± SD, years	6.7 ± 6	10.15 ± 5	6 ± 6	< 0.0001
Weight: Mean ± SD, kg	28 ± 26	47 ± 27	25 ± 24	< 0.0001
PRISM III score: Median [IQR]*	2.0 [0-6]	2.0 [0-7]	2.0 [0-6]	0.41
PELOD score: Median [IQR]*	10 [0-20]	11 [0-20]	10 [0-12]	0.12
Admission type				
Medical	443 (76)	0 (0)	443 (91)	—
Surgical	42 (7)	0 (0)	42 (9)	—
Trauma	95 (16)	95 (100)	0 (0)	—
Mechanical ventilation	282 (49)	55 (58)	227 (47)†	0.05
Concomitant shock				
Septic shock	59 (10)	0 (0)	59 (12)	< 0.0001
Hemorrhagic shock	9 (2)	7 (7)	2 (0.1)	< 0.0001
Cardiogenic shock	14 (2)	1 (1)	13 (3)	0.48
Other	10 (2)	0 (0)	10 (2)	0.38
None	488 (84)	87 (92)	401 (83)	0.03
Vasoactive agents	21 (4)	3 (3)	18 (4)	0.79
Transfusion before admission‡	57 (10)	20 (21)	37 (8)§	< 0.0001
PICU admission hemoglobin	N = 368	N = 72	N = 296	
Mean ± SD, g/dL	11.2 ± 2.4	11.3 ± 2.2	11.1 ± 2.2	0.86
Transfusion during PICU stay	234 (40)	52 (55)	182 (38)	0.0017
Pretransfusion hemoglobin	N = 222	N = 47	N = 175	
Mean ± SD, g/dL	8.4 ± 2.4	9.0 ± 2.4	8.3 ± 2.4	0.090

*Severity of illness was measured using the Pediatric Risk of Mortality (PRISM III) score and the Pediatric Logistic Organ Dysfunction (PELOD) score.
†n = 484.
‡Within 7 days before PICU admission.
§n = 476.

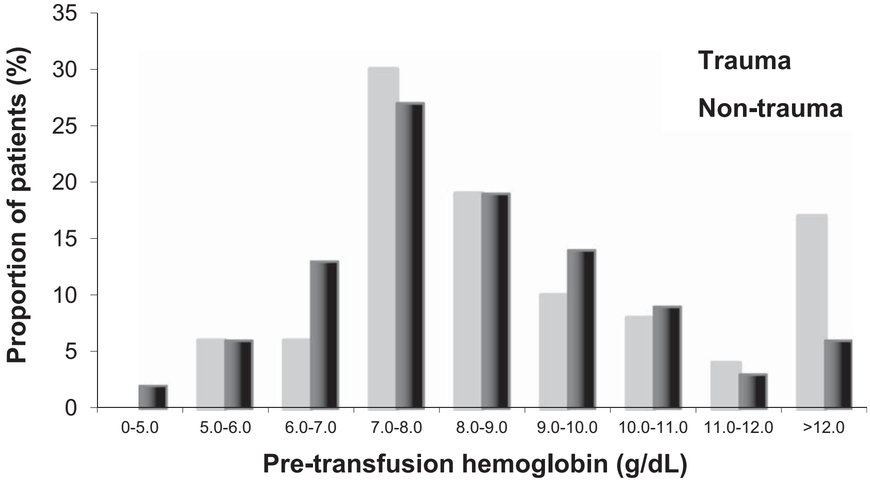

Fig. 2. PICU hemoglobin levels before transfusion (in proportions) for trauma patients (N = 47 of 52) and nontrauma patients (N = 175 of 182; p = 0.09).

TABLE 2. Characteristics of trauma patients who did and did not receive transfusions

Characteristic	No. of patients (%) Trauma, n = 95	With transfusion, n = 52	Without transfusion, n = 43	p value
Males	63 (66)	32 (62)	31 (72)	0.38
Age: Mean ± SD, years	10.2 ± 5.7	9.0 ± 5.0	11.5 ± 5.6	0.02
Weight: Mean ± SD, kg	47.4 ± 28	43.2 ± 27	52.5 ± 28	0.13
Day 1 PRISM III score: Median [IQR]*	2.0 [0-7]	4.5 [0-7]	2.0 [0-5]	0.17
Day 1 PELOD score: Median [IQR]*	11 [0-20]	11 [10-21]	10 [0-20]	0.03
Mechanical ventilation†	55 (53)	35 (67)	20 (46)	0.04
Concomitant shock	8 (8.5)	8 (15)	0 (0)	0.03
Active bleeding‡	22 (23)	16 (31)	6 (14)	0.053
Transfusion before admission§	20 (21)	19 (36)	1 (2)	< 0.0001
Hb at PICU admission	N = 72	N = 46	N =26	
Mean ± SD, g/dL	11.3 ± 2.2	11.0 ± 2.5	11.8 ± 1.6	0.09
Pretransfusion Hb or lowest Hb without transfusion: Mean ± SD, g/dL	N/A	9.0 ± 2.4	9.8 ± 2.2	0.10
Pretransfusion hematocrit or lowest without transfusion: Mean ± SD, %	N/A	31.9 ± 7.0	34.0 ± 4.5	0.16

*Severity of illness was measured using the Pediatric Risk of Mortality (PRISM III) score and the Pediatric Logistic Organ Dysfunction (PELOD) score.
†Mechanical ventilation occurred before transfusion in patients who received transfusion or during intensive care unit admission in those without transfusion.
‡Active bleeding included gastrointestinal bleeding, chest tubes and drains, and other sources.
§These were transfusions received within 7 days before admission.

hemorrhagic shock ($p < 0.001$), and they received more blood transfusions before PICU admission (57% trauma group vs. 38% nontrauma group; $p < 0.0001$). In addition, trauma patients were more likely to receive a transfusion during their PICU course (55% vs. 38%; $p = 0.002$), despite similar baseline admission Hb levels in each group (11.3 vs. 11.1 g/dL, respectively; $p = 0.86$) (Table 1). The mean ± SD pretransfusion Hg level in the PICU was 9.0 ± 2.4 g/dL in the trauma group and 8.3 ± 2.4 g/dL in the nontrauma group ($p = 0.09$), with a proportionally similar distribution of pretransfusion Hb levels (Fig. 2).

Transfusion practices in trauma cases

Among the 95 trauma patients, those who received transfusions were more likely to be young ($p = 0.02$), to have higher PELOD scores ($p = 0.03$), to be mechanically ventilated ($p = 0.04$), and to have active bleeding ($p = 0.053$) on admission (Table 2). Patients who received transfusions also were more likely to have received a transfusion before admission to PICU ($p < 0.0001$). In the PICU, the mean ± SD pretransfusion Hb level was 9.0 ± 2.4 g/dL in the transfused trauma group compared with a nadir Hb of 9.8 ± 2.2 g/dL in the nontransfused trauma group

TABLE 3. Odds ratios for association of various factors and RBC transfusion in trauma patients*

Predictors of RBC transfusion	OR (95% CI)	Chi-square p value
Age, years		
0-5	Reference	
5-12	0.55 (0.13-2.11)	0.39
12-18	0.32 (0.10-1.01)	0.052
PELOD 1 score		
0-10	Reference	
≥11	0.95 (0.34-2.67)	0.92
Pretransfusion Hb or lowest Hb, g/dL	0.76 (0.58-1.00)	0.053
Presence of active bleeding		
No	Reference	
Yes	3.13 (0.81-12.19)	0.10
Transfusion before PICU		
No	Reference	
Yes	20.36 (2.45-168.7)	0.005

*Odds ratios (ORs) were calculated using multivariable logistic regression analysis. An OR > 1 represents a greater likelihood for transfusion. All variables included in regression model are presented.
PELOD 1 = Day 1 Pediatric Logistic Organ Dysfunction score.

TABLE 4. Characteristics of blood transfusions among trauma patients, N = 52

Characteristic	No. of patients (%)
Characteristics of patients who received transfusion, N = 53	
No. who received transfusion (% of all trauma patients)	52 (54)
Incidence rate of transfusion: Transfusion events/1 trauma patient	1.5
Volume of blood during first PICU transfusion: Median [IQR], mL/kg*	10 [5-15]
Time from entry to first transfusion, days	
1	30 (58)
2	8 (15)
3	6 (11)
4	4 (8)
>5	4 (8)
No. of RBC transfusions received in the PICU	
1	21 (40)
2	13 (25)
3	1 (2)
4	9 (17)
>5	8 (15)
Characteristics of transfusions received, N = 141	
Length of storage of packed RBCs: Median [IQR], days†	14 [9-21]
Irradiated blood	8 (25)
Transfusion received	
Autologous	0 (0)
Related donor	2 (6)
Unrelated donor	29 (94)
Leucocyte depleted	28 (87)

*Values were available for N = 47 patients.
†Transfusion values were available for N = 84 patients.

($p = 0.053$) (Table 2). There were eight cases of shock, seven of which were hemorrhagic, and all eight patients received transfusions. Head injury was not associated with receiving a blood transfusion in trauma patients. Multivariate logistic regression analysis revealed that receiving a transfusion before PICU admission was strongly associated with an increased likelihood of receiving a transfusion in the PICU (OR, 20.3; 95% CI, 2.24-168.7; $p = 0.005$) (Table 3).

The majority of trauma patients who received transfusions ($n = 30$; 58%) received their first transfusion in the first 24 hours after PICU admission (Table 4). The median number of units transfused was 1, but 8 patients (15%) required more than five RBC transfusions. The incidence rate of transfusion events was 1.5 per trauma case. The median storage length of transfused RBCs was 14 days (IQR, 9-21 days). The primary reasons for transfusion in trauma patients were low Hb (44%), emergency surgery (9%), and acute blood loss (6%). In nontrauma patients, the primary reason for transfusion was also low Hb (39%), followed by a large variety of other reasons, including extracorporeal membrane oxygenation and aiming to increase oxygen delivery.

Outcomes and complications

Table 5 reports the adverse events observed during the entire PICU stay in trauma patients who did and did not receive transfusions. P values are not presented in the table, because the values are descriptive, and the two groups are poorly comparable. There were no deaths amongst all 95 trauma patients included in the study.

DISCUSSION

In our study, trauma patients were more likely to be older and mechanically ventilated compared with nontrauma patients, but they had similar severity scores and need for inotropic support. Furthermore, trauma patients who were admitted to the PICU had a higher likelihood of having received an RBC transfusion before PICU admission, despite similar baseline Hb levels compared with nontrauma patients. After PICU admission, trauma patients were more likely than nontrauma patients to receive a blood transfusion (55% vs. 37%, respectively; $p < 0.001$), even though their Hb level was similar at the time they entered the PICU ($p = 0.86$) and before they received a transfusion in the PICU ($p = 0.09$). Among trauma patients, the receipt of transfusion was associated with younger age, higher PELOD scores, mechanical ventilation, active bleeding, and transfusion before PICU entry. These findings suggest that trauma patients already may

TABLE 5. Incidence rate of outcomes after first transfusion in trauma patients who received transfusion and during PICU stay in trauma patients who did not receive transfusion (N = 95)

Outcome	No. of patients (%) Transfusion, N = 56: Before first transfusion	After first transfusion*	No transfusion, N = 43 Entire PICU stay
Complications			
Respiratory dysfunction	6 (11)	9 (16)	6 (14)
Reintubation	2 (4)	7 (13)	3 (7)
Fluid overload: CVP >8 mmHg	8 (15)	8 (15)	3 (7)
Cardiovascular dysfunction	5 (10)	8 (15)	2 (5)
Systemic inflammatory response	10 (19)	13 (25)	7 (16)
Hematologic dysfunction	0 (0)	3 (6)	1 (2)
Acute nonhemolytic fever	11 (21)	13 (25)	7 (16)
Nosocomial infection†	14 (27)	5 (10)	13 (30)
Neurologic dysfunction	9 (17)	11 (21)	5 (12)
Length of stay: Mean ± SD, days	10.8 ± 7.2		5.1 ± 3.8
Mortality	0 (0)		0 (0)

*These complications occurred during transfusion or within the first 48 hours after transfusion.
†These included catheter-related infections, nosocomial pneumonia, sinusitis, and urinary tract infections as well as “other” nosocomial infections.
CVP = central venous pressure.

be subject to a restrictive transfusion strategy or are more likely to bleed rapidly, requiring subsequent transfusion before admission and on arrival to the PICU.

Among pediatric trauma patients who are admitted to the PICU, the likelihood of RBC transfusion increases as the severity of injury increases,[12,14] with the incidence rate of transfusion in pediatric trauma patients ranging from 5% to 30%[15-17]; in the current study, we observed an incidence rate of 54.7%. This higher incidence of transfusion may be because of data collected before the Toward a Restrictive Transfusion Practice in the PICU (TRIPICU) study of restrictive transfusion practices in critically ill children[6] or overall sicker patients, given the inclusion only of patients who were admitted for over 48 hours to PICU.

Predictors of transfusions in adult trauma patients include low hematocrit, indices of shock (lactate and base deficit), low Glasgow coma score, and penetrating trauma.[9,18,19] A retrospective study in all pediatric trauma patients by Allen and colleagues indicated that hematocrit, the Glasgow coma score, base deficit, and the Injury Severity Score were associated with receiving a blood transfusion, with hematocrit remaining an independent predictor on multivariate analysis.[16] Our predictors of RBC transfusion in patients with severe trauma who are admitted to the PICU include young age, the PELOD score, and receipt transfusion before admission, with the latter being strongly associated in multivariate analysis. This suggests that, in patients with severe trauma, the receipt of transfusion before likely means transfusion after PICU admission. Therefore, bleeding, whether visible or occult, must be suspected and managed rapidly, as suggested by Advanced Trauma Life Support management.[20]

Despite the predictors described above, both the surgical and resuscitative management of patients with trauma is moving toward more conservative management with increasing evidence of harmful effects from trauma interventions. In terms of surgical care, the current standard of care in stable patients with solid organ injury is nonoperative management, a practice initiated by the pediatric population.[21-25] A randomized controlled trial evaluating liberal versus restrictive fluid strategies in trauma suggested that initial liberal fluid management might be harmful.[26] The harmful effects of blood transfusion have also been established in adult patients with trauma[8,27,28] and more recently in a pediatric population.[17] Hassan and colleagues previously reported an increased risk of adverse events, including mechanical ventilation and mortality, in pediatric trauma patients who received a blood transfusion.[17] Nosanov and coworkers studied a large retrospective cohort of 6675 trauma patients and demonstrated that, in a group of 105 pediatric trauma patients who received massive transfusions, mortality was related to neurologic injury and coagulopathy, with no conferred benefit from an increased plasma/RBC ratio.[15] Chidester and colleagues conducted a small prospective study of patients who received transfusion versus massive transfusion and observed that, although mortality was similar in both groups, coagulopathy was more common with massive transfusion.[29] Multiple adult studies also have suggested harmful effects of transfusion in patients with traumatic brain injury despite evidence suggesting that anemia is detrimental in such patients.[30,31] It is unclear, however, that transfusion practices have changed significantly in pediatrics, in trauma, and in the intensive care unit. In a recent study, Klaus and coworkers concluded that pediatric transfusion triggers remain above 7 g/dL, and vary widely (>2.5 g/dL) within and between pediatric subspecialties.[32] No literature currently exists that specifically addresses transfusion thresholds in trauma patients, let alone changes in transfusion practice. The studies by Nosanov and colleagues and Chidester and coworkers involving pediatric trauma patients who received massive transfusion[15,29] have underlined the need for prospective studies to evaluate lower transfusion thresholds in larger cohorts of trauma patients. It is important to include the large proportion of patients with trauma who receive only one or two RBC transfusions in prospective studies regarding transfusion thresholds, because massive transfusion is not the norm in trauma patients and does not appear to confer a survival benefit. Therefore, our current study should serve as a baseline for transfusion practices in pediatric trauma and aid in preparing a future large, prospective study to evaluate transfusion thresholds and restrictive transfusion strategies in pediatric trauma.

In terms of adverse events, we observe that re-intubation, fluid overload, cardiac dysfunction, and nonhemolytic fever are relatively frequent after patients received blood transfusions in the PICU. Despite wide distribution, length of stay was longer in the group that received transfusions. These results must be interpreted with caution, because our sample size is small, and the study was not adjusted for severity of illness in the patients who received transfusions. It is noteworthy that we were able to discriminate the adverse events that occurred after transfusion from those already present before transfusion to avoid protopathic bias, in which the exposure occurs in response to an outcome in the study. This is rarely taken into account in similar observational studies and can be very problematic in case-control studies, because it becomes unclear which event occurred first: outcome or exposure. However, with a prospective study design, it is impossible to determine whether adverse outcomes were associated with the exposure or the patients' baseline characteristics. In any case, a randomized trial of different transfusion strategies in trauma cases would be necessary to draw conclusions regarding the adverse events associated with RBC transfusion in this group.

A limitation of the current study is the lack of information with respect to the mechanism of injury, type of trauma (blunt or penetrating), bleeding sites, organ involvement, and types of emergency surgery required. Pelvic fractures, penetrating injury, open long-bone fractures, splenic lacerations, and scalp lacerations can lead to massive blood loss. These factors may also be independent determinants of receiving a transfusion in the PICU, because supportive, nonsurgical care, including blood transfusion, is the standard of practice for hepatic, splenic, and renal injury in hemodynamically stable children.[23-25] Indeed, conservative management has been suggested to reduce blood use in this population[33]; however, before restrictive transfusion strategies are implemented, prospective studies in patients with trauma detailing types of injury and ongoing hemodynamic stability are needed.

In addition, the data used for this study date back to 2005 and may not reflect current transfusion practices, because it predates publication of the TRIPICU study, which supports restrictive transfusion strategies in critically ill children.[6] As stated above, it is unclear whether transfusion practices have changed significantly in the last few years. Surgical and acute-care pediatric subspecialties (orthopedics, general surgery, general pediatrics, PICU) continue to use transfusion at a higher Hb trigger than recommended by a restrictive strategy,[32] and this study has allowed us to establish a baseline transfusion trigger and determinants in severe pediatric trauma.

Another possible limitation is that the study only included patients who were admitted to the PICU for over 48 hours, which represents about 20% of the PICU population. Therefore, there may be a selection bias for more patients with severe and unstable trauma. The small sample size prohibited the calculation of interactions in multiple regression analyses.

In summary, our study is an important step in the understanding of transfusion practices in pediatric trauma patients. As we move toward a culture of harm reduction in transfusion practice through restrictive transfusion protocols, it remains important to ensure that certain groups, such as trauma patients, are not at increased risk. Trauma patients admitted to the PICU are at high risk for receiving an RBC transfusion both before and during their PICU stay. The risks associated with RBC transfusions must be balanced with the risks of hemorrhagic shock and anemia in patients with trauma. A reliable knowledge of RBC transfusion practices in pediatric trauma cases is critical in the preparation of future interventional trials, because transfusion thresholds in this group have not been established, and increasing literature indicates harmful outcomes related to RBC transfusions. Randomized controlled trials will be required to determine the optimal RBC transfusion practice, or Hb transfusion threshold, in pediatric patients with severe trauma.

CONFLICT OF INTEREST

The authors have disclosed no conflicts of interest.

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