Survey on transfusion practices of pediatric intensivists*

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Objective: To describe the red blood cell transfusion practices of pediatric intensivists.

Design: Cross-sectional self-administered survey. Setting: Pediatric intensive care units. Patients: Academic pediatric intensivists. Interventions: None.

Measurements and Main Results: Scenario-based survey among English- or French-speaking intensivists from Canada, France, Belgium, or Switzerland, working in tertiary-care pediatric intensive care units. Respondents were asked to report their decisions regarding transfusion practice with respect to four scenarios: cases of bronchiolitis, septic shock, trauma, and the postoperative care of a patient with Fallot's tetrad. The response rate was 71% (163 of 230). The overall baseline hemoglobin transfusion threshold that would have prompted intensivists to transfuse a patient ranged from 7 to 13 g/dL (70–130 g/L) within almost all scenarios. There was a significant difference between scenarios of the average baseline hemoglobin transfusion thresholds (p < .0001). A low Pao₂, a high blood lactate concentration, a high Pediatric Risk of Mortality score, active gastric bleeding, emergency surgery, and age (2 wks) were important determinants of red blood cell transfusion, whereas none of the respondents' personal characteristics were. The average volume of packed red blood cells transfused in the four scenarios did not differ significantly.

Conclusions: This survey documented a significant variation in transfusion practice patterns among pediatric critical care practitioners with respect to the threshold hemoglobin concentration for red blood cell transfusion. The volume of packed red blood cells given was not adjusted to the hemoglobin concentration. (Pediatr Crit Care Med 2002; 3:335–340)

KEY WORDS: blood; child; critical care; erythrocyte; hematocrit; hemoglobin; intensive care; pediatrics; physician practice pattern; practice; risk factors; surveys; transfusion.

significant proportion of critically ill children receive red blood cell (RBC) transfusions during their pediatric intensive care unit (PICU) stay (15% in the PICU of Sainte-Justine Hospital) (1). There are few data on the indications for packed RBC

*Also see p. 381.

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transfusions in critically ill children, and therefore one may ask on what evidence pediatric intensivists base their transfusion decisions. The cost/efficacy of RBC transfusion is not clear: The risk of infection from an RBC transfusion is well recognized, but some data suggest also that transfusion may be a risk factor for nosocomial infection and multiple organ dysfunction syndrome (2). Moreover, a number of articles report that RBC transfusions are not optimally used (2). A survey reported a significant variation in transfusion practices among Canadian intensivists who take care of critically ill adults (3). The practice pattern that is advocated by pediatric intensivists with respect to RBC transfusion has not been studied. Thus, we undertook a survey among pediatric intensivists to find out their stated practice patterns in regard to RBC transfusion and to determine whether a consensus existed regarding the indications for RBC transfusion therapy.

METHODS

Study Design. We undertook a crosssectional, self-administered survey designed to detect determinants of RBC transfusion in critically ill children. The questions were developed to find out if the characteristics of the respondents, patients, and/or PICUs changed the threshold hemoglobin (Hb) concentration at which pediatric intensivists transfused RBCs. The questionnaire was scenario-based, and the possible clinical determinants were changed one at a time in each of the four clinical scenarios. The survey aimed to elicit information about the physicians' behavior in clinical practice (4).

Study Population. The questionnaire was mailed to English- and French-speaking intensivists practicing in academic PICUs in Canada and French-speaking European countries (mostly France, Belgium, and Switzerland). The mailing list of Canadian pediatric intensivists was based on the list of members of the Canadian Critical Care Society and the Canadian Pediatric Society; we also phoned pediatric critical care program directors to ensure that our listing was complete. The mailing list of French-speaking pediatric intensivists was constructed from the membership of the Groupe francophone de Réanimation et d'Urgence pédiatrique and the Société de Réanimation de Langue française. We decided a priori to exclude retired members, physicians who have ceased to work in a PICU. intensivists working outside the jurisdictions under study, neonatologists, intensivists working with adults, and physicians who had outdated addresses.

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Development of Questionnaire. Clinical determinants potentially affecting transfusion practices were identified through consultations with experts in pediatric critical care, hematology, and transfusion practice and through a systematic literature search (5). Items were chosen through the use of a Delphi panel submitted to three experts (PH, HH, JL).

The questionnaire included nine possible clinical determinants of RBC transfusion, other than Hb concentration: age and gender of the patient; low Pao₂; lactic acidosis; severity of the case ascertained by an increased Pediatric Risk of Mortality (PRISM) score (6); active bleeding; nonbleeding thrombocytopenia; nonbleeding disseminated intravascular coagulation; and need for surgery. The influence of these determinants on the baseline threshold Hb concentration stated for each scenario was estimated by systematically altering one factor at a time.

Within each scenario, respondents were asked to indicate the lowest Hb concentration resulting in a decision to transfuse RBCs; seven responses were possible: <7, <8, <9, <10, <11, <12, or <13 g/dL.

The self-administered questionnaire included four scenarios that are described in Table 1. We intentionally held certain factors constant within each scenario. All scenarios gave information on the patient's age, PRISM score, respiratory and hemodynamic status, lactate concentration, bleeding status, platelet count, and coagulation profile. These data were similar in the different scenarios, except if warranted by the underlying condition (e.g., blood pressure was low in the case of septic shock while it was normal for the other conditions).

We also requested information concerning physician characteristics (Table 2) and characteristics of the PICUs (number of beds, type of patients, number of admissions per year, average PRISM score). *Format and Pretesting of Questionnaire.* The survey instrument was professionally formatted (7, 8). French and English versions were simultaneously developed by using the back-translation technique (9).

The final questionnaire was validated with the following strategy. We first ensured the clarity of the questionnaire, its relevance, its completeness, and its accuracy by conducting semistructured interviews with two pediatric intensivists, one adult intensivist, one pediatric hematologist, and two fellows in pediatric intensive care. Few modifications were suggested, and corrections were made.

As a second step, three PICU attending physicians, six PICU fellows, and four pediatric surgeons rated the final version of the questionnaire's clarity, utility, face validity, content validity, construct validity, and redundancy (8). Respondents were asked to rate the questionnaire with respect to each quality by using a 7-point Likert scale ranging from 1 (complete disagreement) to 7 (complete agreement). A response of 5, 6, or 7 was considered satisfactory. The proportion with satisfactory response was >77% and the mean score on the Likert scale was >4.9 for all quality criteria.

The completed questionnaires were administered twice, 2 wks apart, to eight physicians, with perfect concordance in 60% of questions and good concordance (same threshold Hb concentration ± 1 g/dL) in all the remaining questions; overall, the weighted kappa coefficient was 0.67 (10).

Administration of the Questionnaire. The survey was carried out according to the principles of Dillman et al. (11). The mailing agenda followed the recommendation of Woodward et al. (12). The first mailing was sent in September 1997, and a reminder card or letter was sent 2 wks later, followed by a mailing of a second survey 1 month after the first. Finally, a second reminder (phone call or letter) was sent 6 wks after the first mailing.

Statistical Analysis. Three categories of variables were considered as possible determinants of RBC transfusion in critically ill children: a) disease of the patient (scenarios); b) clinical characteristics of the patient; and c) characteristics of respondents and PICUs.

Average threshold Hb concentrations were calculated for each scenario. Mean and SD of threshold Hb concentrations were also calculated for each possible determinant of RBC transfusion within each scenario. Differences from baseline threshold Hb concentration were calculated for each determinant within each scenario and were compared to estimate if the change was statistically significant from one determinant to another. The effect of scenarios (1-4) on baseline Hb was assessed by one-way repeated-measures analysis of variance (ANOVA). The effect of possible determinants on the difference between baseline scenario Hb and determinant-defined Hb was estimated with two-way repeated-measures ANOVA. Significant interactions between scenarios and determinants were found: Thus, a separate one-way repeated-measures ANOVA (factor = scenario) was carried out for each determinant to estimate the effect of scenarios and, likewise, a separate one-way repeatedmeasures ANOVA (factor = determinants) was carried out for each scenario to estimate the effect of determinants. The latter analysis compared the mean change associated with each determinant for each scenario separately. Pairwise comparisons between determinants were carried out, and a Bonferroni adjustment was used. Finally, the effect of each respondent characteristic on baseline Hb was analyzed separately with a two-way repeatedmeasures ANOVA with the scenarios as one factor and the respondent characteristic as the other. Analyses were done by a statistician

Table 1. Description of the four scenarios

Scenario 2—A 2-month-old boy is mechanically ventilated for acute respiratory distress syndrome and septic shock from toxic shock syndrome. Ventilator variables include a respiratory rate of 20 breaths/min, a peak inspiratory pressure of 30 cm H₂O, a PEEP of 6 cm H₂O, and an Fio₂ of 60%. Laboratory results are similar to those in scenario 1. The blood pressure is 45/25 torr; the heart rate is 140/min. A dopamine infusion (20 μ g·kg⁻¹·min⁻¹) and a dobutamine infusion (10 μ g·kg⁻¹·min⁻¹) are being administered. Presently, the baby is not actively bleeding. He is receiving midazolam, fentanyl, pancuronium, and antibiotics.

Scenario 3—A 2-month-old boy is mechanically ventilated after severe multiple trauma. Ventilator variables include a respiratory rate of 20 breaths/ min, a peak inspiratory pressure of 30 cm H_2O , a PEEP of 6 cm H_2O , and an FIO_2 of 60%. Laboratory results are similar to those in scenario 1. His spleen is ruptured but is not actively bleeding. A pneumothorax is drained by a chest tube. The acute respiratory distress syndrome he is experiencing is stabilized. The blood pressure is 80/50 torr; the heart rate is 110/min. Both legs are fractured. The baby is not bleeding. He is receiving midazolam, fentanyl, pancuronium, and antibiotics.

Scenario 4—A 2-month-old boy arrives in the intensive care unit following a correction surgery for Fallot's tetrad. Ventilator variables include a respiratory rate of 30 breaths/min, a peak inspiratory pressure of 20 cm H₂O, and a PEEP of 3 cm H₂O. Other ventilator variables and laboratory results are similar to those in scenario 1. A dopamine infusion (5 μ g·kg⁻¹·min⁻¹) and a dobutamine infusion (10 μ g·kg⁻¹·min⁻¹) are given. The heart rate is 140/min, and the blood pressure is 75/50 mmHg. Presently, the boy is not bleeding. He is receiving midazolam, fentanyl, pancuronium, and antibiotics.

Scenario 1—A 2-month-old boy is mechanically ventilated for bronchiolitis. Ventilator variables include a respiratory rate of 40 breaths/min, a peak inspiratory pressure of 30 cm H₂O, a positive end-expiratory pressure (PEEP) of 2 cm H₂O, and an Fio₂ of 60%. Laboratory results are as follows: pH, 7.41; Pao₂, 86 torr (11.5 kPa); Pco₂, 45 torr (6.8 kPa); bicarbonate, 22 mmol/L; base excess, 1.1 mmol/L; blood lactate, 1.2 mmol/L; platelet count, 210 × 10⁹/L (210,000/mm³); D-dimers, 0.5 µg/L; prothrombin time (PT), 15 secs; activated thromboplastin time (aPTT), 30 secs. Cardiovascular, neurological, and metabolic statuses are normal. Presently, the boy is not bleeding.

(M-CG) with the SAS program (release 6.11, SAS Institute, Cary, NC).

RESULTS

Demographic and Baseline Data Analyses. The survey was carried out between September and December 1997. The response rate was 71% (163 of 230). The proportion of Canadian respondents (40 of 50; 80%) was significantly higher than the proportion of non-Canadian respondents (123 of 180; 68%). Of the 163 respondents, 60 were excluded from the analysis of the survey, mostly because they were neonatologists (15%) or because they were retired or had stopped working in a PICU (47%).

In 103 questionnaires, 93.7% of questions were completed. Most of the 424 missing responses were attributed to an unknown average PRISM score of the PICU (88 of 424, 21% of missing data) or by the fact that some physicians were reluctant to make a decision about the postoperative care of a cyanotic cardiopathy such as Fallot's tetrad (scenario 4; 114 of 424, 27%).

Fourteen physicians did not respond to the scenario on a case of trauma. Only respondents who answered the four scenarios were retained for the statistical analyses of possible determinants of RBC transfusion; Table 2 details the characteristics of the 89 retained respondents.

The average number of beds in the PICUs was 14 ± 6 ; 31% of the units reported that >50% of their admissions were cases of neonatology (this happened almost exclusively in European PICUs). The average number of admissions per year was 723 ± 264 per PICU. The average PRISM score was 9.6 ± 3.3 in the 15 PICUs where this information was available.

Hemoglobin Concentration at Baseline and Following a Change in a Determinant. Figure 1 shows the frequency of choices for the baseline threshold Hb concentration of the four scenarios. The Hb concentration that would have prompted respondents to transfuse the patient was 7.9 ± 0.8 g/dL on average for the case of bronchiolitis, 9.7 ± 1.3 g/dL for the case of septic shock, 9.0 ± 1.3 g/dL for the case of trauma, and 9.3 ± 1.3 g/dL for the case of Fallot's tetrad; the degree of variation between threshold for different scenarios was significant (F =53.9, df = 3; p < .0001).

Tables 2 and 3 report the results of the analyses carried out to detect variables

that may prompt the pediatric intensivists to change their threshold Hb concentration from the baseline within each scenario. Table 3 shows the average threshold of the possible clinical determinants within each scenario. The increase of threshold Hb concentration was almost similar for all four scenarios. On the other hand, respondents considered some determinants more important in deciding to increase the transfusion threshold. When contrasted with other determinants, the following determinants caused the most important change in Hb concentration in all scenarios: lower Pao₂ (1.4 g/dL), active bleeding from the stomach (1.3 g/dL), high lactate concentration (1.1 g/dL), age (2 wks rather than 2

Table 2. Characteristics of 89 respondents who answered the four scenarios

Characteristic	Response	Respondents	p Value ^a	
Age of the respondents (vrs)	Yrs of age	42 ± 7	.74	
Gender	Male	67 (76)	.87	
Primary language	English	30 (34)	.97	
, , , ,	French	58 (65)		
Primary specialty other than	Pediatrics	77 (88)	.71	
intensive care	Anesthesiology	8 (9)		
	Respirology	2(2)		
	Pediatric surgery (including cardiac surgery)	1 (1)		
Academic rank	Professor	16 (18)	.67	
	Associate professor	19(21)		
	Assistant professor	21(24)		
	Clinical assistant, lecturer, or fellow	33 (38)		
Year of graduation (MD degree)	Prior to 1970	10 (11)	.30	
	1970-1979	22 (25)		
	1980–1989	44 (50)		
	≥1990	12(14)		
Number of years in critical care	0-4	13 (15)	.60	
practice	5-9	30 (36)		
	10-14	15 (18)		
	≥15	26 (31)		
Country	Belgium	8 (9)	.49	
	Canada	34 (39)		
	France	37 (42)		
	Switzerland	4 (5)		
	Other	5 (6)		

Values in parentheses are percentages.

^{*a*}Two-way repeated-measures analysis of variance: one characteristic (x_1) and the four scenarios (x_2) vs. baseline threshold hemoglobin level (y). The *p* values describe the characteristic's effect.



Figure 1. Respondents were asked: "What hemoglobin concentration (g/dL) would prompt you to transfuse this patient?" The distribution of the hemoglobin (Hb) concentration below which respondents would prescribe a packed red blood cells transfusion was statistically different between scenarios (p < .0001). The range of threshold Hb concentration chosen varied by 4 g/dL for the case of bronchiolitis, 5 g/dL for the case of trauma, and 6 g/dL for the cases of septic shock and cyanotic cardiopathy. The proportion of responses where the threshold Hb concentration chosen was lower or higher than 1 g/dL with respect to the median of each scenario was 5% (bronchiolitis), 32% (septic shock), 34% (trauma), and 35% (cyanotic cardiopathy).

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Table 3. Analysis of determinant	: (n	= 89	respondents	who	answered	the four	scenarios
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Determinant	Difference With				
	Bronchiolitis	Septic Shock	Trauma	Fallot	All Scenarios
2-wk-old rather than 2-month-old	$+1.4\pm1.0$	$+0.7\pm0.9$	$+1.1\pm0.9$	$+0.9 \pm 1.0$	$+1.1 \pm 1.4$
2-yr-old rather than 2-month-old	-0.1 ± 0.6	-0.1 ± 0.8	-0.1 ± 0.7	-0.2 ± 0.7	0 ± 1.4
A girl rather than a boy	0 ± 0.2	$+0.04 \pm 0.3$	0 ± 0.3	-0.06 ± 0.4	$+0.1 \pm 1.4$
Pao_2 (26 rather than 86 torr)	$+2.3 \pm 1.2$	$+0.9\pm0.9$	$+1.4 \pm 1.2$	$+1.3 \pm 1.1$	$+1.4 \pm 1.4$
Lactate (6.2 rather than 1.2 mmol/L)	$+1.8 \pm 1.3$	$+0.6 \pm 0.8$	$+1.1 \pm 1.1$	$+1.0 \pm 1.1$	$+1.1 \pm 1.4$
PRISM score (17 rather than 4)	$+1.6 \pm 1.2$	$+0.6 \pm 0.9$	$+0.8\pm1.0$	$+0.7 \pm 1.1$	$+0.9 \pm 1.4$
Active gastric bleeding	$+1.8\pm1.1$	$+0.9\pm1.0$	$+1.2 \pm 1.0$	$+1.0\pm1.0$	$+1.3 \pm 1.4$
No bleeding, but low platelet $count^b$	$+0.8\pm1.0$	$+0.1 \pm 0.7$	$+0.4\pm0.8$	$+0.2\pm0.8$	$+0.4 \pm 1.2$
No bleeding, but presence of DIC^c	$+0.9 \pm 1.1$	$+0.2 \pm 0.7$	$+0.6\pm0.9$	$+0.3\pm0.9$	$+0.4 \pm 1.4$
Urgent surgery required	$+1.4 \pm 1.2$	$+0.7\pm1.0$	$+0.9\pm1.0$	$+0.7 \pm 1.1$	$+1.0 \pm 1.3$
The child is your son	$+0.04\pm0.3$	$+0.03\pm0.2$	$+0.05\pm0.4$	0 ± 0.5	$+0.1\pm1.4$

Hb, hemoglobin; Δ g/dL, difference with baseline threshold Hb level; PRISM, pediatric risk of mortality score; DIC, disseminated intravascular coagulation. The question was, What would be the lowest acceptable Hb value (g/dL) that will prompt you to transfuse the patient described in the scenario if the following characteristic was modified while other factors remain unchanged?

^{*a*}Mean \pm sp. ^{*b*} Platelet count, 20.0 \times 10⁹/L (20,000/mm³); D-dimers, 0.5 µg/mL; prothrombin time (PT), 20 secs; activated thromboplastin time (aPTT), 30 secs. ^{*c*} Platelet count, 20.0 \times 10⁹/L (20,000/mm³); D-dimers, 4.0 µg/mL; PT, 40 secs; aPTT, 120 secs.

months; 1.1 g/dL), urgent surgery required (1.0 g/dL), and higher PRISM score (0.9 g/dL).

No respondent characteristic significantly affected the change from baseline Hb within a scenario (Table 2). However, although country was generally not a significant determinant (p < .48), there was a significant interaction between country of respondents and scenario 3, which was a case of trauma (the threshold was higher in France than in other countries: 9.4 ± 1.4 g/dL rather than 8.6 ± 1.0 g/dL; p < .02).

The characteristics of some PICUs were significant. The baseline Hb threshold tended to be higher across all scenarios in large PICUs where the number of beds was >12 (p < .02). The baseline Hb threshold tended also to be higher across all scenarios in PICU where the proportion of neonatal cases was >50% (p < .002). No other PICU characteristic was statistically significant.

Volume of Packed RBCs Per Transfusion. Figure 2 reports the frequency of choices for the seven volumes of packed RBCs that could be given per transfusion once the baseline threshold Hb concentration was reached in the different scenarios. The average volume of packed RBCs given was almost identical for the four scenarios (range, 11.2 ± 5.1 to 12.3 ± 5.3 mL/kg) although there was a significant difference in the baseline threshold Hb concentrations between the four scenarios.

DISCUSSION

The survey demonstrated a significant variation in stated RBC transfusion prac-



Figure 2. Respondents were asked: "Once the baseline threshold hemoglobin concentration has been reached, how much packed red cells (mL/kg) would you transfuse (please assume that the hemoglobin concentration of the packed red blood cells available in your institution is 18 g/dL, or 180 g/L)?" Seven responses were possible: Respondents could choose to prescribe 0–5, 5–10, 10–15, 15–20, 20–25, 25–30, or >30 mL/kg of packed red blood cells. The volume of packed red blood cell that intensivists were willing to give if the baseline threshold hemoglobin concentration was reached ranged from <5 to >30 mL/kg. The variation of choices was large within scenarios; however, the variation between scenarios of the average volume of packed red blood cells given was quite small, and the distribution of choices of the four scenarios was almost similar.

tices among intensivists working in academic PICUs: Chosen Hb thresholds for RBC transfusion ranged from 7 to 13 g/dL. Respondents believed that many clinical characteristics of their patients might change their transfusion threshold Hb concentration. In addition, there was no clear relationship between the volume of packed RBCs chosen and the patient's Hb concentration before the transfusion.

Practice Variation in Regard to Packed RBCs Per Transfusion. The range of answers in this survey suggests significant variability and perhaps uncertainty in pediatric critical care transfusion practice. In adults, other surveys documented

a large variability in stated transfusion practice patterns (3, 13), and several reviews of transfusion records have noted tremendous variability in observed practice patterns (14-18). This study specifically addressed the question of a threshold for RBC transfusion in critically ill children. We did not find in the pediatric literature any strong recommendations, with the exception of some recommendations for uncorrected cyanotic congenital cardiopathy (19). As others (20, 21), we conclude that an optimal and safe lower limit of the transfusion threshold has not been established in critically ill children; however, current guidelines have suggested that a threshold <10 g/dL might be acceptable (21).

Determinants of Threshold Hemoglobin Concentration for Transfusion: Basic Disease. The scenarios of this survey described four diseases; the baseline threshold Hb concentration was significantly different among the four diseases.

The highest baseline threshold Hb concentration (9.7 \pm 1.3 g/dL) was for the case of septic shock. Clearly, sepsis impairs oxygen delivery and disturbs oxygen consumption. The effectiveness of RBC transfusion to increase oxygen consumption in septic patients remains to be proven when oxygen uptake is not limited by the blood oxygen content or delivering capacity (19). Actually, no data support the view that packed RBC transfusion is the best means to increase oxygen consumption even when oxygen uptake depends on oxygen delivery. Some data even suggest that RBC transfusion may be detrimental in cases of septic shock. There is evidence that the combination of significant systemic microcirculatory dysfunction (22) and the decrease in RBC deformability may dramatically affect tissue oxygen delivery in sepsis and septic shock (23, 24). A study in septic adults reported a decrease in gastrointestinal oxygenation after the administration of packed RBCs (25). McGrady et al. (26) reported an outbreak of necrotizing enterocolitis associated with transfusion of packed RBCs. There is also some evidence that RBC transfusion causes immunosuppression that may predispose critically ill transfusion recipients to nosocomial infections (27) and may increase the rate of multiple organ dysfunction syndrome (2, 28), which ultimately can result in higher mortality rates. In this survey, pediatric intensivists considered that they must maintain the Hb concentration guite high although the cost/efficacy of RBC transfusion in septic children is not well studied.

Most textbooks in pediatric cardiology and pediatric cardiac surgery recommend that a higher Hb concentration (14–18 g/dL) (29, 30) be maintained in children with cyanotic congenital cardiopathy, unless it has been corrected. In this survey, the average baseline threshold Hb concentration chosen with case 4 (repair of Fallot's tetrad) was 9.2 ± 1.3 g/dL. Thus, it seems that the pediatric intensivists answering the questionnaire considered that a lower threshold Hb concentration is acceptable even in a case of cyanotic congenital cardiopathy if it is repaired.

Clinical Determinants of Threshold Hemoglobin Concentration for Transfusion. In this survey, changes of transfusion thresholds from baseline threshold Hb concentration were important for all the following clinical determinants: hypoxemia, active bleeding, lactic acidosis, age (2 wks), preoperative status, and high PRISM score. No clinical trials support the hypothesis that a high Hb concentration in patients who need to undergo a surgery is useful. It is possible that pediatric intensivists as well as pediatric surgeons are too prone to give packed RBC transfusion in children undergoing surgery. A high PRISM score means that the patient is severely ill. A high Score for Neonatal Acute Physiology (31) or a high Acute Physiology and Chronic Health Evaluation II score (3) was also a significant determinant of RBC transfusion, The Score for Neonatal Acute Physiology and the Acute Physiology and Chronic Health Evaluation II are severity of illness indexes validated for critically ill newborns (32) and adults (33).

The wide variation in transfusion practices disclosed in this survey could have been explained by some characteristics of the PICUs. There was a significant relationship between the number of beds in the unit and the baseline threshold Hb concentration; we cannot explain this finding. We also found that the baseline Hb threshold tended to be higher in PICUs where the proportion of neonatal cases was >50%: this may be explained by another finding of this study, namely that respondents to this survey were more willing to give an RBC transfusion to a 2-wk-old baby than to a 2-month-old child. The fact that the normal range of Hb concentration changes with age, especially during the first weeks of life, may explain this trend.

On the other hand, physician characteristics were not important. For example, the threshold Hb chosen by Canadian and European pediatric critical care practitioners was similar. Hébert et al. (3) documented that physicians with an academic affiliation transfused more RBCs than community hospitals; we cannot comment on this because all respondents of our survey worked in academic PICUs.

Volume of Packed RBCs Per Transfusion. In this survey, we found that the average volume of packed RBCs given was similar for all scenarios although there was a significant difference between the four scenarios in the baseline Hb concentrations chosen as a threshold to trans-



fuse. It is a common practice in PICUs to prescribe a volume of 10 mL/kg when a transfusion is given, without adjusting the volume for the Hb concentration before the transfusion. Such practice can increase the number of units and the risks to which a patient is exposed. Two measures can resolve this problem: a) the volume can be calculated according to the increase of Hb concentration that the physician wants to obtain; and b) healthcare workers can keep and use the same packed RBC unit if only a part of the unit is used and if it is expected that repeated transfusions could be required.

Limitation of the Survey. The first concern is that it is impossible to know how many pediatric intensivists were not included in the mailing lists that we used; thus, we cannot know if we surveyed all possible participants, even although we did our best to find them. Moreover, we cannot describe the demographic data of the nonrespondents. Scenario-based studies are limited by recording what health workers say rather than what they do. Also, physicians may have changed their threshold Hb concentration just because they believed the investigators expected it. Last, the lower limit of the Hb concentration (<7 g/dL) that the respondents can choose in the survey as a threshold for transfusion was probably too high.

CONCLUSION

This survey demonstrated a striking variation in practice patterns among pediatric critical care practitioners; such differences have been described both in adult (3, 34) and neonatal ICUs (31, 35). We documented that the threshold Hb concentration chosen by pediatric intensivists for typical cases ranged at least from 7 to 13 g/dL. We also found that the volume of RBCs given is not related to the threshold Hb concentration, which suggests that RBC transfusions are not optimally utilized.

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Hébert et al. (2) reported that less RBC transfusion with packed RBC units was at least as effective in hemodynamically stable critically ill adults than more RBC transfusion; indeed, the latter tended to present more nosocomial infections and more severe multiple organ dysfunction syndrome. When this clinical trial was completed, packed RBC units were not leuko-depleted. There is evidence that prestorage leuko-depletion of packed RBC units decreases the risk of nosocomial infections (36). In Canada and many European countries, all packed RBC units are now leuko-depleted prestorage. We are presently carrying out a large multiple-center, randomized, controlled, noninferiority clinical trial to determine whether a lower threshold Hb concentration for RBC transfusion with leukodepleted packed RBC units is as safe as or safer than a higher threshold in critically ill children.

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