Original article

Towards optimized red blood cells ordering prior to cardiac surgery: a single center retrospective study

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Abstract

Background: **Cardiac surgery is associated with a high rate of intraoperative transfusion, requiring pre-ordering or ordering of packed red blood cell (PRBC) before surgery. Our institutional strategy is based on a systematic type and screen (T/S) ordering of 3 PRBCs at the blood bank then stored in a dedicated refrigerator in the operating room for each patient scheduled for cardiac surgery. However, these PRBC units are not always transfused and are therefore at risk of destruction if temperature fluctuations are detected during transport and storage processes. In addition, these orders represent a burden for the blood bank. Therefore, it is relevant to move towards a more tailored PRBC order before cardiac surgery and challenge the systematic ordering protocol.**
Methods: **The Transfusion Understanding Scoring Tool (TRUST) and the Transfusion Risk and Clinical Knowledge (TRACK) Score are designed to stratify blood transfusion needs in cardiac surgery. We retrospectively performed both scores for each patient scheduled for cardiac surgery. Then, we compared their performance to predict PRBC transfusion and determined the optimal threshold to optimize the preoperative PRBC order reflecting the needs of our population managed with our local standards.**
Results: **Receiver operating characteristic (ROC) curves for prediction of PRBC transfusion using the two scores were computed for the whole cohort (n=1249). Both scores performed well (areas under ROC curves: 0.81 and 0.82 (95% CI) using the TRACK Score and the TRUST, respectively). A TRUST < 3 identified a subgroup of patients (53.6%) at low risk of transfusion. The availability of 1 T/S PRBC in the OR would cover the needs of the majority (92.5%) of this group.**
Conclusions: **In our institution, the use of the TRUST preoperatively could offer a more tailored T/S PRBC order for the intraoperative period, especially in the low-risk transfusion group.**

Keywords: **Cardiac surgery, red blood cell transfusion, TRACK Score, TRUST.**

Presentation (part of the article) on 23 May 2020 on Graduation Day by L. Thiltgès : « Is the Transfusion Risk and Clinical Knowledge score (TRACK score) better than the Transfusion Risk Understanding Scoring Tool (TRUST) to predict intraoperative red blood cells transfusions in cardiac surgery ?”
Ethical approval for this study (Ethical Committee N°116/2019, NUB : B039201940951) was provided by the Ethical Committee of CHU UCL Namur, Yvoir, Belgium, (Chairperson Prof P. Evrard) on 24 September 2019.

Introduction

Cardiac surgery is characterized by high rates of red blood cells transfusion reported to be between 10 and up to more than 70 % according to the populations studied and the centers[1-3]. Regarding packed red blood cells (PRBC) availability for high risk surgery, two different strategies exist. Either PRBC are pre-ordered: PRBC are readily available at the blood bank (BB) and only when a transfusion trigger is actually met, the PRBC unit is delivered to the operating room (OR). The second strategy which is ours, is to directly order PRBC which are available in the OR. This order may represent a burden for the local BB and a risk of blood component wasting. Indeed, these units may be destroyed in case of excessive temperature fluctuations during transport to the OR or back to the BB. Consequently, it is important to think towards a more optimal PRBC order before cardiac surgery, mainly in the low-risk patient cohort, representing the majority of our cardiac surgery patients, for whom the PRBC are ordered and often not transfused. Transfusion Understanding Scoring Tool (TRUST) and Transfusion Risk and Clinical Knowledge (TRACK) Score were designed to identify cardiac surgery patients most at risk of blood transfusion. However, these scores have never been evaluated as tools to adjust preoperative blood product ordering at the time of the preoperative assessment. The TRUST, ranging from 0 to 8, is an additive algorithm including 8 variables that was internally and externally validate[4]. The TRACK Score is a simple risk model based on five predictors of transfusion rate in cardiac surgery[5]. The data necessary to compute both scores can easily be collected during the preoperative phase and are available at the time of PRBC ordering.

To develop a more tailored preoperative PRBC order, we retrospectively extracted data from medical charts to calculate TRACK and TRUST scores for each patient. We compared the performance of these 2 scores to predict PRBC transfusion, looking for the best predictive score to facilitate preoperative PRBC order and to reduce red blood cell wastage.

Methods

Study population

Local Ethic Committee (CE: 116/2019; NUB: BE039201940951) was obtained before data extraction from medical charts. Written informed consent was not required as this was a retrospective study.

This retrospective study included all patients who underwent on-pump cardiac surgery between January 2015 and September 2019 at the CHU UCL Namur, a tertiary center. Patients were excluded if they received extracorporeal membrane oxygenation (ECMO) or if on-pump surgery was not cardiac surgery (e.g. lung transplant) see Figure 1.

Data

To calculate the TRUST score, eight variables are added, each weighted one unit. The maximal score is then eight. To calculate the TRACK score, each percent of Hct < 40% is scored for 1 point with a maximum of 13 points (corresponding to an Hct

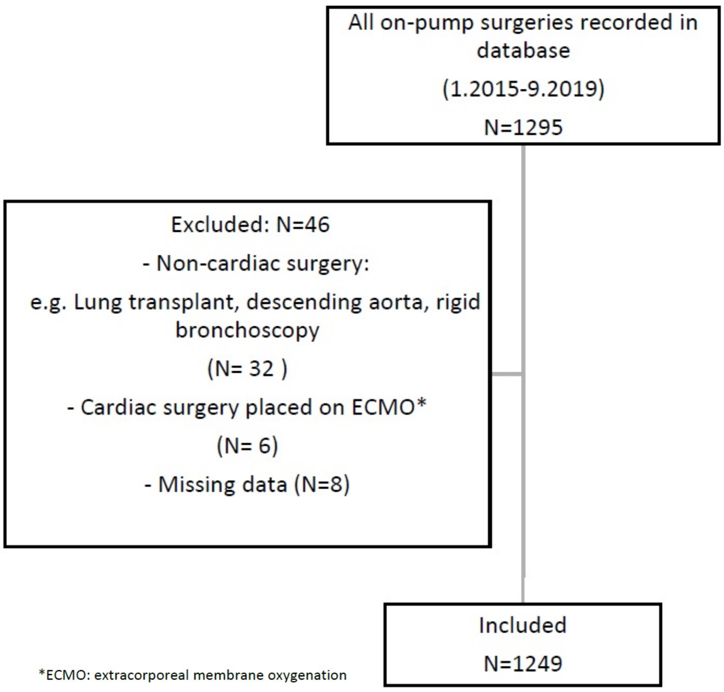

Fig. 1 — Flowchart diagram of study design.

below 28%), a weight < 60 kg for female and < 85 kg for male is scored for 2 points, female gender is scored for 4 points, age > 67 years is scored for 6 points and finally, complex surgery is scored for 7 points. The score is the sum of each variable with a maximal score of 32 (Table I).

The following data were extracted from patients' records: haemoglobin (Hb) (g/dL), haematocrit (%), weight (kg), sex (male/female), age (years), non-elective surgery (yes/no), creatinine > 1.36 mg/dl (yes/no), previous cardiac surgery (yes/no), non-isolated surgery or complex surgery (yes/no). Procedures considered as complex were: coronary revascularization + valve surgery, double or triple valve operation, or aortic valve surgery + ascending aorta operation. Our center does not perform heart transplants and does not implant left ventricular assistance devices. Other extracted data were blood products used intraoperatively: PRBC units, Fresh Frozen Plasma (FFP) units and platelet concentrates (PC).

Clinical and patient blood management

According to our local protocol, principally due to logistic contingency (e.g., no suitable pneumatic tube system, distance from the BB with sometimes delays in obtaining labile blood products), the standard practice is to order 3 units typed and screened (T/S) PRBC directly available in the OR for each patient scheduled in cardiac surgery regardless of the indication: isolated or combined procedures, elective or emergency surgery. If those PRBCs are not transfused, they return to the BB. To ensure optimal blood storage, a temperature tag (Thermo Button Data Logger, ProgesPlus®, France) is attached to the PRBC units. In case of temperature variation during storage in the OR or during transport between the OR and the BB, PRBC units are destroyed.

Patients were managed according to the local standard of care. Briefly, an initial dose of unfractionated heparin (UFH; 300IU/Kg) was given to achieve an activated clotting time (ACT) above 400 s allowing departure on cardiopulmonary bypass (CPB). ACT was performed with Hemochron® Signature Elite Whole Blood Microcoagulation System using Hemochron Jr ACT+ (ACT+) cuvettes (International Technidyne Corporation, Edison, NJ) designed for UFH concentration above 1 UI/ml. ACT was maintained above 400 s during all the CPB by the administration of a supplemental dose of 5000 IU of UFH as needed. At the end of CPB, UFH was antagonized with protamine in a 1:1 ratio of the initial heparin dose.

All the patients included in the study benefited from the same blood conservation strategies including: tranexamic acid 10mg/kg before CPB followed by a continuous infusion of 1mg/kg/h until the OR's departure, retrograde autologous priming, minimizing of colloid priming fluid, use of a cell salvage device and a closed CPB circuit.

The decision to transfuse PRBC was made according to our restrictive transfusion protocol: (i) Hb < 7g/dl or Hct < 20% during CPB; (ii) Hb < 8,5g/dl or Hct < 25% before departure to the Intensive Care Unit or (iii) massive bleeding with hemodynamic instability. The transfusion of FFPs and/or PCs were at the attending anaesthesiologist's discretion based on standard coagulation tests (Activated Partial Thromboplastin Time, Thrombin Time, and Thromboplastin Time, Internationalized Ratio, platelet count) coupled to clinical judgment.

Statistics

Unless otherwise specified, quantitative data are expressed as mean +/- standard deviation (SD) and compared using independent samples Student t tests. Qualitative data are expressed as number

Table I. — Inclusion and exclusion criteria used during patient recruitment.

	TRUST		TRACK Score
Haemoglobin < 13.5 g/dl	1	Haematocrit (%) *	0-13
Weight < 77 kg	1	Weight <60 kg (female) or < 85 kg (male)	2
Female sex	1	Gender (Female)	4
Age > 65 years	1	Age > 67 years	6
Non-elective surgery	1	/	
Creatinine > 1.36 mg/dl	1	/	
Previous cardiac surgery	1	/	
Non-isolated operation	1	Complex surgery**	7
Maximal score	8	Maximal score	32

*Each percent of Hct < 40% is scored for 1 point with a maximum of 13 points (corresponding to an Hct below 28%); ** Complex procedures were: coronary revascularization + valve surgery, double or triple valve operation, or aortic valve surgery + ascending aorta operation.

(percent) and compared using chi-squared tests. Significance was assumed at $p < 0.05$.

Receiver operating characteristic (ROC) curve analysis was performed to assess the performances of TRACK and TRUST scores for predicting PRBC transfusion during on-pump cardiac surgery (primary outcome). Secondary outcome was to assess their performances for prediction of other blood component transfusion during cardiac surgery (i.e. fresh frozen plasma, platelet concentrates and any type of blood product). ROC curves were computed for patient receiving any type of blood products and for each product separately. The areas under ROC curve were calculated and DeLong's test was used for comparison of performances of TRACK and TRUST scores for predicting blood products administration. Youden Index was used to identify the optimal thresholds maximizing sensitivity and specificity for prediction of intra-operative blood components transfusion for both scores[6]. All analyses were performed in R (version 4.0.0).

Results

The data of 1249 patients scheduled for on-pump cardiac surgery were analyzed. Patients' demographic and surgical data are presented in Table II. Among this cohort, 453 (36 %) received PRBC, 282 (23%) received FFP and 167 (13%) received PC intraoperatively; overall, 530 (42%) patients were transfused with any type of blood product intraoperatively.

Mean TRACK and TRUST scores according to the transfusion status are presented in Table III: patients who received PRBC in the OR consistently had higher TRACK and TRUST scores (p<0.001) compared to those who did not; this held true for the other blood products. Regarding PRBC transfusion, the proportion of patients who received PRBC during surgery is correlated with both scores see Figure 2. TRACK Score and TRUST performed well for prediction of PRBC transfusion (AUC of 0.81 or 0.82 using TRACK or TRUST score, respectively Figure 3) and the performance of the scores was not significantly different from each other (Table IV). The best thresholds of TRACK and TRUST scores for transfusion prediction are presented in Table V. Applied to our population, a TRUST score ≥ 3 was predictive of PRBC transfusion with a sensitivity of 71 % and a specificity of 78 % (positive predictive value (PPV) 61%, negative predictive value (NPV) 85%, accuracy 74%), the same optimal threshold being found regardless of the blood component transfused. A TRACK score ≥ 12 provided a sensitivity of 82% and a specificity of 67% for

Table II. — Patients characteristics.

	All patients (n=1249)	PRBC Transfused (n=453)	Not PRBC transfused (n=796)	p-value
Age (y)	70.0 ±10.5	73.6 ±10.2	68.0 ±10.1	<0.001
Weight (kg)	80.4 ±17.2	74.1 ±16.0	84.6 ±16.4	<0.001
Preoperative Hct (%)	40 ±6	36 ±6	41 ±5	<0.001
Sex female	349 (27.9)	215 (47.5)	134 (16.8)	<0.001
Complex surgery/Non-isolated surgery	284 (22.7)	159 (35.1)	125 (15.7)	<0.001
Cardiopulmonary bypass time (min)	104 ±55	119.3 ±64.6	94.8 ±46.0	<0.001
Non-elective surgery	124 (9.9)	55 (12.1)	69 (8.7)	0.06
Creatinine > 1.36 mg/dl	143 (11.4)	78 (17.2)	65 (8.2)	<0.001
Previous cardiac surgery (redo)	45 (3.6)	36 (7.9)	9 (1.1)	<0.001

Note: quantitative data are expressed as mean +/- standard deviation (SD) and compared using independent samples Student t tests. Qualitative data are expressed as number (percent) and compared using chi-squared tests. Significance was assumed at p < 0.05.

Table III. — Mean TRUST and TRACK Score.

	Mean TRUST *			Mean TRACK score °		
	Transfused	Not transfused	p-value	Transfused	Not transfused	p-value
Any type of blood product	3.3 ±1.3	1.8 ±1.2	<0.001	13.6 ±6.5	6.6 ±5.2	<0.001
Packed red blood cells	3.4 ±1.2	1.8 ±1.2	<0.001	14.3 ±6.4	6.9 ±5.3	<0.001
Fresh frozen plasma	3.4 ±1.3	1.8 ±1.2	<0.001	14.2 ±6.6	8.3 ±6.1	<0.001
Platelet concentrates	3.4 ±1.4	2.3 ±1.4	<0.001	13.8 ±6.8	9.0 ±6.5	<0.001

Note: * Data are presented as mean TRUST ± standard deviation (minimum 0-maximum 8); ° Data are presented as mean TRACK Score ± standard deviation (minimum 0-maximum 32).

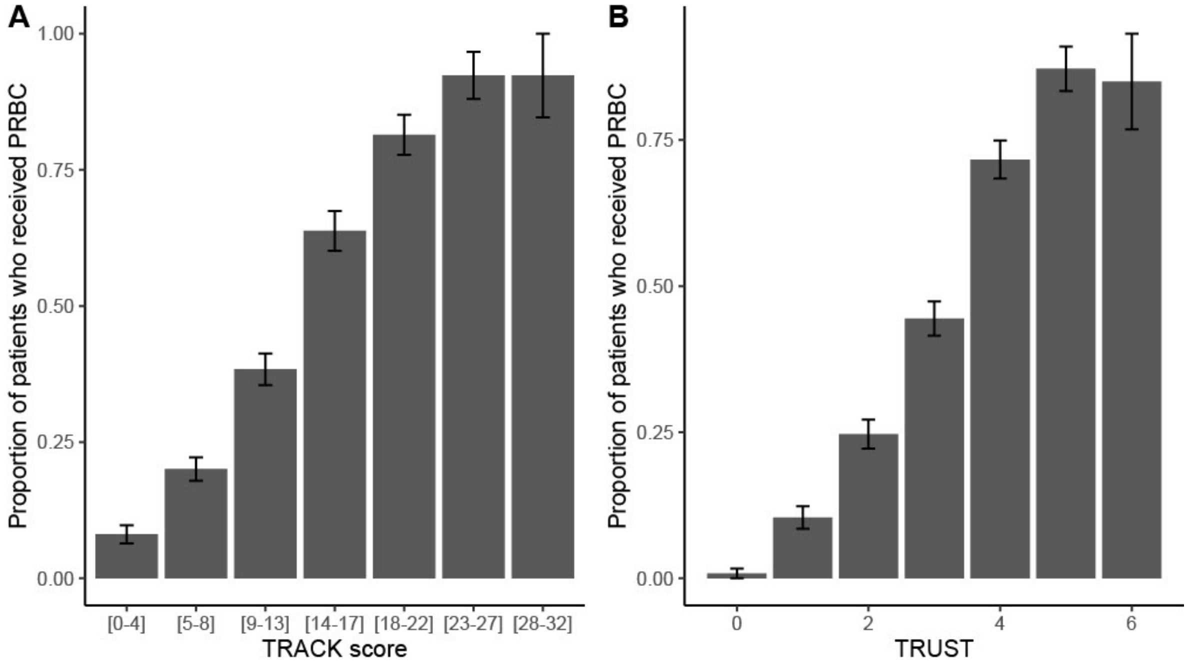

Fig. 2 — Proportion of patients who received PRBC.

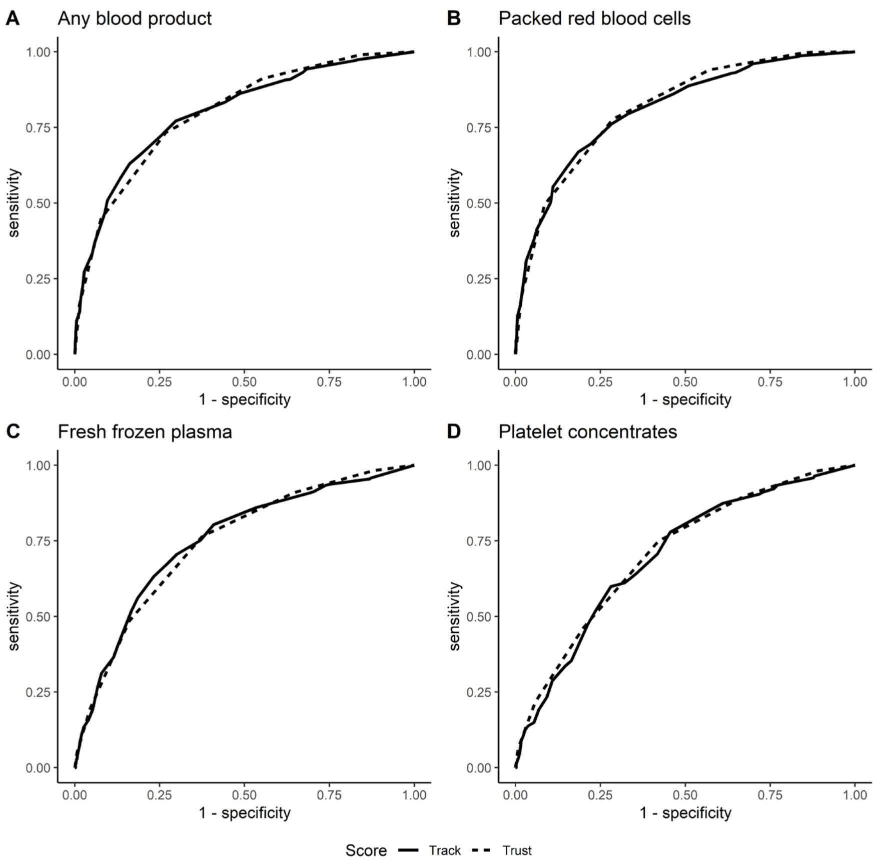

Fig. 3 — ROC transfused blood products.

PRBC transfusion prediction (PPV 67%, NPV 81%, accuracy 76%), a cut-off of 11 being found for fresh frozen plasma, and a cut-off of 9 for platelets and any type of blood component transfusion.

Considering PRBC transfusion, 15% of patients with a TRUST score < 3 required PRBC transfusion in the OR, among which half received more than one PRBC unit, 0.1% of patients with a TRUST score < 3 required more than five PRBC units in the OR. Nineteen percent of patients with a TRACK score < 12 required PRBC transfusion in the OR, of whom 9.3% of patients required more than one PRBC unit and 0.7% of patients required five PRBC units or more in the OR.

Table IV. — Comparison of performances TRACK and TRUST scores.

	AUC Track	AUC Trust	p-value
Any type of blood product	0.80 (0.78-0.83)	0.80 (0.78-0.82)	0.91
Packed red blood cells	0.81 (0.79-0.84)	0.82 (0.79-0.84)	0.58
Fresh frozen plasma	0.75 (0.72-0.78)	0.75 (0.71-0.78)	0.66
Platelet concentrates	0.70 (0.66-0.74)	0.71 (0.67-0.75)	0.57

Note: Areas under ROC curves (AUC) are given with their 95% confidence intervals; p-values correspond to DeLong's test for two correlated ROC curves.

Table IV. — Best thresholds of TRACK and TRUST scores for transfusion prediction.

	TRACK score								TRUST score							
	Cut-off	Se	Sp	PLR	NLR	PPV	NPV	Accuracy	Cut-off	Se	Sp	PLR	NLR	PPV	NPV	Accuracy
Any type of blood product	9	0.70	0.77	3.08	0.39	0.81	0.66	0.73	3	0.73	0.73	2.74	0.36	0.79	0.67	0.73
Packed red blood cells	12	0.82	0.67	2.46	0.28	0.81	0.67	0.76	3	0.71	0.78	3.20	0.37	0.85	0.61	0.74
Fresh frozen plasma	11	0.70	0.71	2.37	0.43	0.89	0.41	0.70	3	0.62	0.77	2.66	0.49	0.90	0.38	0.66
Platelet concentrates	9	0.54	0.78	2.46	0.59	0.94	0.21	0.58	3	0.58	0.75	2.30	0.56	0.94	0.22	0.60

Note: Best thresholds were determined according to Youden indexes. Se, sensibility; Sp, specificity; PLR, positive likelihood ratio; NLR, negative likelihood ratio; PPV, positive predictive value; NPV, negative predictive value.

Discussion

In our study, TRACK and TRUST scores demonstrated good discrimination for predicting PRBC transfusion (AUC 0.81 for TRACK score and 0.82 for TRUST). The fact that the same optimal TRUST score threshold (i.e. 3) was identified regardless of the blood product transfused makes this value easy to remember and to use in daily practice.

A TRUST lower than 3 was also associated with a 15% transfusion rate. This group was defined as a low transfusion rate group because 85% of them were not transfused with PRBCs. Of these 15% transfused patients, only half required more than one PRBC unit. Thus, in patients with a TRUST of less than 3, a reduction of the preoperative PRBC order could be considered. It is also reassuring to observe that only a tiny fraction of these patients (i.e., 0.1%) required massive transfusion, defined as the administration of more than five PRBC units intraoperatively.

Our current practice is to order systematically three PRBCs for each patient scheduled for on-pump cardiac surgery, which is appropriate for patients with a TRUST score ≥ 4, who represent 292/1249 (23%) patients of the cohort. Performing TRUST before cardiac surgery in our population would allow reducing PRBC ordering from three to one unit for 669/1249 (53.6%) patients with a TRUST < 3. Availability of 1 PRBC in the OR covering the need of the majority (92.5%) of the patients with a TRUST < 3, would avoid the transfer of numerous PRBCs units between the OR and the BB with the risk of temperature variation (highlighted by the temperature chip) leading to their destruction. Another aspect is a lower number of PRBCs units stored and immobilized in the OR (ordered PRBCs are blood typed and red cell antibody screened, but they are dedicated to a patient and stored in the OR's refrigerator) which are not available for other patients requiring transfusion in the hospital during this period. Another option for this low-risk transfusion population could be to pre-order T/S PRBCs stored at the BB, except for alloimmunized patients requiring manual cross-matching. This option is not possible at the moment in our institution due to local contingencies: the blood bank is far from the OR and getting the bags to the OR sometimes requires a delay.

Another benefit of this approach is to detect earlier patients at high risk of PRBCs transfusion to, for example, place more emphasis on optimizing preoperative patient blood management strategies such as correction of anaemia, optimization of PRBC mass before non-urgent cardiac surgery, or on the contrary to refer quickly to surgery patient with a low risk of transfusion[7].

The order of 1 RBC unit helps to follow recent data advocating that transfusion of a single unit should be followed by a clinical and a haemoglobin level reassessment before any further transfusion. This practice improves PRBC utilization and exposure to allogeneic transfusion[8]. Patient blood management is actually a cornerstone of blood conservation, especially at a pandemic time as actually caused by the severe acute respiratory syndrome coronavirus 2[9].

Recently, Leff et al.[10] found an AUC of 0.817 (95% CI 0.800-0.835, $p \leq 0.001$) for intraoperative transfusion of PRBCs according to TRACK Score, which is similar to the AUC of 0.81 (95% CI 0.79-0.84) identified in our cohort. This study was performed retrospectively in a high-volume, US-based cardiac surgical population of 2.776 patients over a six-year period and retrieved from the institutional Society of Thoracic Surgeons (STS) database; in this cohort, 21% of patients underwent complex surgery compared to 22.7% in our population. TRACK was also validated in Italy, the United Kingdom, and South Korea, but optimal cut-offs have not been established[5,11,12]. TRUST was also studied but requires eight variables and thus is potentially cumbersome for the daily practice even if multicentre data showed comparable AUC values to the TRACK score to predict blood transfusion in cardiac surgery[11].

This study has several limitations. First, it is a single-centre retrospective study over a five-year period in which the surgeon's staff suffered from several changes. Moreover, even if transfusion triggers were relatively stable during this five-year period, the anaesthesiologist's clinical freedom could have modified this transfusion trigger. Another unrecorded data was disruption or not of any type of antithrombotic drug at the time of the surgery. But on the other hand, those data are the mirror of the daily practice of transfusion among the cardiac surgery population and literature confirms that institution-specific data will presumably reduce unnecessary blood preparation[13]. The absence of transfusion information regarding the postoperative period could be considered as a weakness. However, since our aim was a more tailored PRBC order for the intraoperative period, this data does not concern our study. Further studies should assess the accuracy of this approach prospectively. Finally, we used a previously developed risk score based on monocentric data to estimate the transfusion risk of our patients where a new locally developed transfusion risk score could have performed better. However, the observed performance of the TRACK and TRUST scores in our population was good (e.g., AUC under ROC curves around 0.80), and keeping a previously published and well-accepted score permit keeping a common language and facilitating the application of our results in other centers.

Conclusion

In our institution, both scores are accurate to predict intraoperative packed red blood cells transfusions with good discrimination. For cardiac surgical patients with a TRUST score < 3 and according to local constraints availability of one T/S PRBC unit in the OR in place of three would cover the needs of the majority of the patients, allowing a strong reduction of PRBC ordering before on-pump cardiac surgery in our institution. This finding applies to the low-risk transfusion cohort corresponding to the majority of our patients and is based on common preoperative data. It is therefore possible to optimize red blood cell ordering before cardiac surgery by using specific bleeding risk scores such as TRACK and TRUST.

Acknowledgments: None.

Declarations of interest statement: The authors report no conflict of interest.

Fundings: None.

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doi.org/10.56126/73.4.24