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Research Article

Analysis of the Adult Cardiac Surgery Audit on Blood use in a Tertiary Hospital Prior to the Implementation of a Blood Program -

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ABSTRACT

Objective: To analyse the exposure to allogeneic blood transfusion perioperatively in adult patients undergoing cardiac surgery.

Design: Retrospective cohort study of prospectively collected data.

Setting: Data was collected from consecutive adult patients who underwent cardiac surgery in a single university hospital between January 2013 and July 2013.

Participants: Data of 171 patients was collected from hospital records.

Interventions: None.

Measurements and Main Results: 89.5% of patients received a Blood Component (BC), all the non-transfused patients were men. The average RCC, FFP and PP transfused units per patient was 4.04; 1.02 and 1.12 respectively. Women received more RCC (5.07) than men (3.54). RCC transfused patients had lower height and preoperative haemoglobin; urea levels, Apache II score and EuroSCORE were higher and left ventricular ejection fraction was worse. A TRUST score higher than 2 predicted RCC transfusion. CPB mean time was higher and redo surgery was more common if transfused. RCC transfusion was associated with longer hospital and Critical Care Unit stay. Non-transfused patients had higher nadir (9.48 *vs* 7.42), post-surgery (10.50 *vs* 9.42) and hospital discharge (11.22 g/dL *vs* 10.34) haemoglobin levels. By multivariate regression, predictors of blood transfusion were CPB nadir haemoglobin, preoperative haemoglobin, and transfused plasma units. Patients who survived received fewer RCC units. At hospital discharge 94.5% of patients were anaemic. Anaemic patients were more transfused than non-anaemic patients (5.37 *vs* 3.28).

Conclusions: We found a high perioperative use of BC in cardiac surgery in our hospital, supporting the implementation of interdisciplinary protocols to reduce their use.

Keywords: Transfusion rate; Blood saving program; Anaemia; Cardiac surgery; Audit; Red blood cell transfusion

INTRODUCTION

Transfusion medicine is in transition. The risks associated with the use of allogeneic blood product transfusion include allergic reactions, acute and delayed haemolytic reactions, transfusion related acute lung injury, transfusion associated circulatory overload, febrile reactions, sepsis, immunosuppression, and viral transmission [1,2]. Several studies, on people having various cardiac surgery operations, found strong associations of Red Blood Cells (RBC) transfusion with mortality and postoperative morbidity (including serious wound and systemic infections, renal failure, prolonged ventilation, low cardiac index, myocardial infarction, and stroke)[3-7].

At the beginning of Coronary Artery Bypass Grafting (CABG), transfusion was the rule for almost all patients. This transfusion rate has been decreased but, still, many patients will require transfusion. A low haematocrit in the absence of haemorrhagic shock remains the most common indication in the critically ill. However, the haematocrit level at which the benefits of transfusion outweigh the risks in anaemic cardiac surgery patients is unclear. Consequently, the haematocrit threshold at which patients are transfused varies widely both within and between institutions, and, despite the known risks associated with transfusion, reported mean transfusion rates for cardiac surgery procedures are high and vary between 7 and 97% [5,8]. Cardiac surgery accounts for a significant proportion of all RBC usage in the UK and elsewhere (10-25%) [9-12]. Blood components are expensive, but if we consider RBC transfusion is causing increased morbidity after cardiac surgery, the cost of transfusion-related morbidity (extended intensive care and hospital stay) are likely to be many times greater than the direct costs of the RBC units transfused [3].

Recently the World Health Organization (WHO) has advised to promote initiatives targeting innovative and effective procedures for ensuring logistics and clinical management of blood use. These initiatives are a multimodal concept joined by the term Patient Blood Management (PBM). The WHO requests to provide guidance, training and support to Member States on safe and rational use of blood products and to support the introduction of transfusion alternatives including, where appropriate, autologous transfusion, safe transfusion practices and PBM [13].

Taking into account all these issues, centres should have a policy for the assessment and optimisation of haemoglobin prior to cardiac surgery, hospitals should have a protocol for the management of blood transfusion in cardiac surgery. Not only is the use of these protocols recommended but also the need of conducting regular reviews of blood and blood component usage in cardiac surgery [14].

In that way, prior to the implementation of a blood saving program in cardiac surgery, we decided to evaluate our current situation, to be able in a second phase to assess any achieved improvement. Hospital variation in transfusion practices after CABG has been reported to be considerable, indicating that quality efforts may be able to influence practice and improve outcomes [15].

The audit aims to define the transfusion practice for adult patients undergoing cardiac surgery in a tertiary hospital to provide information on blood loss management and transfusion guidelines.

MATERIAL AND METHODS

This study complied with the Declaration of Helsinki (10th version 2012-2013). The local research ethics committee approved this study and the need for informed consent was waived.

After institutional ethics board approval, a retrospective cohort study of prospectively collected data involving all consecutive adult patients (age >18 years) who underwent cardiac surgery between January 2013 and July 2013 was undertaken at the Hospital Universities i Politecnic La Fe in Valencia, Spain.

Excluded patients were:

- Those who performed preoperative autologous blood donation, because they may be transfused at higher Haemoglobin (Hb) concentrations than the general population

- Heart transplantation and mechanical assist device patients, because most of them receive blood transfusion
- Urgent (clinical condition–mandated surgery within 12 to 72 hours) or emergent (clinical condition– mandated immediate surgery) procedures.

All RBC transfusions prescribed to patients were allogeneic and leukoreduced. Decisions regarding patient care or perioperative transfusions were left to the attending anaesthesiologist and/or surgeon, according to the hospital's transfusion guidelines. On the critical care unit and the ward, transfusions were prescribed by the attending physician based on the assumed cardio and respiratory status of the patient. This guidelines stated that RBC transfusion is usually indicated when the Hb level is less than 7 g/ dL and rarely higher than 9 g/ dL. In case of Hb levels between 7 and 9 g/ dL, cardiopulmonary reserve, age, comorbidity, and blood loss determines the transfusion threshold.

Patients were reviewed for their preoperative demographic, clinical (surrogate coronary artery disease severity and co morbidity) and laboratory variables and then followed till discharge to record their intraoperative data and postoperative outcomes.

Primary outcome was the exposure to allogeneic blood transfusion during the perioperative period.

Patient characteristics were recorded. Use of EPO, transfusions, tranexamic acid, IV iron, acute kidney injury, and postoperative complications including cardiac, vascular complications, neurologic and respiratory complications, and length of hospital stay were recorded.

Anaemia was defined according to the WHO criteria: Hb level of less than 13 g/ dL for men or less than 12 g/ dL for women [16].

Besides peri-operative Red Cell Concentrates (RCC), Platelet Pools (PP) and Fresh Frozen Plasma (FFP) consumption, the following pre-operative variables were collected for each patient: age, gender, weight, height, cardiopulmonary risk factors, previous or concomitant diseases, diagnosis, EuroSCORE, Apache score, ventricular Ejection Fraction (EF), Pulmonary Hypertension (PH), ischemic heart disease, arrhythmia, permanent pacemaker, concomitant antiagregation or anticoagulation therapy and NYHA class. Laboratory parameters such as creatinine level, haemoglobin level, platelet counts and coagulation tests were recorded. We also analysed several intraoperative data such as type of surgery, surgery time, Cardiopulmonary Bypass (CPB) time and aortic cross-clamp time, minimal temperature during extracorporeal circulation, priming volume, haemoglobin levels, lactic acid, pH, potassium, calcium, tranexamic acid use, ACT and ROTEM use. Finally we studied postoperative features such as haemoglobin levels, re-intervention, complications, and length of stay or death.

SPSS for Windows, Release 7.5.1, statistical package (SPSS, Inc., Chicago, IL, USA) was used for statistical analysis. Patients' preoperative, intraoperative and postoperative variables and RCC transfusion data were presented as mean ± SD or number (%) as appropriate. Student's t test or Mann-Whitney U test were used to compare numerical variables and Pearson chi-square test, Yates' correction, or Fisher's exact test were used to compare ordinal variables between transfused and non-transfused patient population. To make multiple comparison methods tests for pairwise comparisons we have used Tukey and Bonferroni, and with unequal group variances Games-Howell and Tamhane's T2. Then, logistic regression analysis was performed to select the best predictors of RCC transfusion. Univariate analysis was done first to detect significant predictors, followed by multivariate regression analysis models. Continuous variables were analysed twice, first as continuous and then as dichotomous variables. Cut points were derived from mean, median, high or low normal, or previously defined values. A P value < 0.05 was considered significant (Table 1 & 2).

RESULTS

Overall, 89.5% (153 patients of 171) of the patients received a blood component transfusion perioperatively. Only 10.5% of the patients were not transfused and all of them were men, 15.5% in the men's group did not receive any blood components ($p < 0.05$) (Table 3).

Of the 171 patients included, RCC transfusion was utilized in 141 patients (82.5%) of which 95 received more than 2 units of RCC (55.6% of the total and 67.3% of the patients who received RCC); of these, 54 patients (31.6%) received more than 4 units (Table 4).

Fifty-four female patients out of 55 included in the study (98.18%)

Table 1: Patient Demographic Data*s.

Variable		N	Mean	Median	S.D.	Minimum	Maximum	Interquartile 1	Interquartile 3
Age (years)		171	66.46	69	13.30	18	87	60	75,25
BMI*		104	28.22	27.36	4.96	20.19	44.80	24.60	27.36
Euro SCORE 1		171	8.49	8	4.01	1	21	5	11
Logistic Euro SCORE		171	17.44	10.09	18.46	1.43	88.29	4.98	24.25
Euro SCORE 2		165	5.12	2.38	8.03	0.5	59.45	1.31	4.95
Apache II		171	14.95	14	5.59	4	35	11	18
Preoperative haemoglobin level (g/dL)	Total	171	13.09	13.1	1.78	7.90	16.50	12.00	14.50
	♂	116	13.47	13.80	1.74	7.90	16.50	12.30	14.77
	♀	55	12.28	12.20	1.58	8.20	15.80	11.10	13.30
Platelet count x 10^9/L		171	206.98	201	69.38	80	476	155	245
INR		169	1.15	1.07	0.38	1	5.24	1.00	1.17
Creatinine (mg/dL)		171	1.00	0.88	0.50	0.48	5.11	0.74	1.10
CPB time (minutes)		161	134.43	133	56.66	0	240	109	170
Ischaemia time (minutes)		110	87.96	84.5	42.37	0	197	69.25	115
Intraoperative circulatory arrest time (minutes)		12	9.92	0	15.35	0	39	0	26.25
Lowest temperature in surgery (C)		153	31.85	32	1.54	24	36	32	32

*BMI: Body Mass Index; INR: International Normalized Ratio; CPB: Cardiopulmonary Bypass.

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Table **2:** Patient demographic dat*

Variable	N	N	%
Gender	Male	116	67.8
	Female	55	32.2
	TOTAL	171	
Diagnosis	ischemic heart disease	61	35.7
	One valve disease	33	19.3
	Non isolated surgery	23	13.5
	Ascending aortic aneurysm	21	12.3
	Valve disease (more than one)	18	10.5
	Congenital disease (adults)	8	4.7
	thoracoabdominal aneurysm	3	1.8
	hypertrophic obstructive cardiomyopathy	3	1.8
	constrictive pericarditis	1	0.6
	TOTAL	171	
BMI*	Normal	30	28.8
	Overweighed	43	41.3
	Obese type I	23	22.1
	Obese type II	3	2.9
	Obese type III	5	4,8
	TOTAL		
Smoker	Non - smoker	97	56.7
	Former smoker	46	26.9
	Current smoker	27	15.8
	TOTAL	170	
Diabetes	No	109	63.7
	DM type I	6	3.5
	DM type II	55	32.2
	TOTAL	170	
Previous heart failure	No	102	59.6
	Yes	69	40.4
	TOTAL	171	
Previous Ischaemic heart disease	No	87	50.9
	Yes	84	49.1
	TOTAL	171	
Previous Cardiac Surgery	No	150	87.7
	Yes	21	12.3
	TOTAL	171	
Renal failure	No	149	87.1
	Yes	22	12.9
	TOTAL		
Hypertension	No	66	38.6
	Yes	105	61.4
	TOTAL	171	
Cerobrovascular disease	No	158	92.4
	Yes	13	7.6
	TOTAL	171	
Chronic pulmonary disease	No	107	62.8
	Yes	164	37.2
	TOTAL	171	
Peripheral vascular disease	No	143	83.6
	Yes	28	16.4
	TOTAL	171	
LVEF	> 50%	123	71.9
	31 - 50%	30	17.5
	21 - 30%	11	6.4
	≤ 20%	7	4.1
	TOTAL		
NYHA congestive heart failure class	I	48	28.1
	II	77	45
	III	39	22.8
	IV	7	4.1
	TOTAL		
Anaemia	♂ Yes	43	37.1
	♂ No	73	62.9
	♂ TOTAL	116	
	♀ Yes	19	34.3
	♀ No	36	65.5
	♀ TOTAL	55	

*BMI: Indicates Body Mass Index; LVEF: Left Ventricular Ejection Fraction; NYHA: New York Heart Association.

Table 3: Component transfusion by gender.

		TRANSFUSION		Total (Transfused/ % not Transfused)	*p*
		YES	NO		
Gender	Male	98	18	116 (84.5%/ 15.5%)	0.002
	Female	55	0	55 (100%/ 0%)	
		153	18	171 (89.5%/ 10.5%)	

Table 4: Red cell concentrate transfusion by units and sex.

RCC units	N (%)	Sex	N (%)	*P*
≤ 2	76 (44.4)	Male	63 (82.9)	< 0.001
		Female	13 (17.1)	
> 2	95 (55.6)	Male	53 (55.8)	
		Female	42 (44.2)	
≤ 4	117 (68.4)	Male	83 (70.9)	0.201
		Female	34 (29.1)	
> 4	54 (31.6)	Male	33 (61.1)	
		Female	21 (38.9)	

RCC: Red Cell Concentrate.

received RCC transfusion compared with 87 out of 141 male patients (61.70%) (Table 5).

A total of 690 units of RCCs were used, the average units of RCC transfused, FFP and PP was for the overall group 4.04; 1.02 and 1.12 respectively. Women received more RCC (5.07) than men (3.54; $p < 0.05$) (Table 6). Ninety-five patients received more than 2 units of RCC, 45.7% (53/116) of the men and 76.4% of the women (42/55) (Table 4).

A total of 58 patients received FFP (33.9%), and 15 of these patients received more than 1 unit of FFP (8.8% of the total and 25.8% of those who received FFP). Overall, 71 patients received platelet transfusions (41.5%) and 37 (21.6%) received more than one platelet pool. The distribution of the number of units of FFP, platelets, and RBC transfused is shown in table 5.

Among patients who received RCC transfusions were significantly more women. PP and FFP transfusion was more common when patients had received RCC.

Taking into account diagnosis patients undergoing surgery for hypertrophic obstructive cardiomyopathy received statistically less red cell units than ischemic heart disease (0.57 *vs* 3.18, $p = 0.018$), non-isolated surgery (0.57 *vs* 5.30 $p < 0.001$) or one valve disease (0.57 *vs* 3.48, $p = 0.010$), valve disease (more than one) (0.57 *vs* 5.67, $p = 0.001$). Male patients undergoing more than one valve surgery tended to be transfused with more RCC than the ones with ischemic heart disease (7.13 *vs* 2.96; $p = 0.064$; Table 7).

Transfused and non-transfused patient populations didn't differ significantly as regards weight, Body Mass Index (BMI), platelet count, Prothrombin Time (PT), Partial Thromboplastin Time (PTT) and fibrinogen. Associated co morbidity percentages were comparable in transfused and non-transfused groups, including current smoking, diabetes mellitus, hypertension, cerebrovascular disease, chronic obstructive pulmonary disease, and peripheral vascular disease.

RCC transfused patients had lower height and preoperative haemoglobin; urea levels, Apache II score and Euro SCORE (logistic and standard 1 and 2) were higher and left ventricular ejection fraction was worse. A TRUST score higher than 2 was able to predict RCC transfusion. A Hb decrease greater than 50% and Hb nadir level lower than 7 were associated with transfusion. CPB was used in 95.7%

(132/138) of transfused patients and in 80% (24/30) of non-transfused patients ($P = 0.003$). CPB mean time was higher and redo surgery was more common if transfused. RCC transfusion was associated with longer hospital and Critical Care Unit stay (Table 8). Perioperative myocardial infarction, neurologic dysfunction, pneumonia, or other complications didn't show a significant association with transfusion.

All variables showing a statiscally significant trend were evaluated by multivariate logistic regression analysis to aid in determining the most useful factors in predicting blood transfusion. By multivariate regression analysis, the strongest predictors of blood transfusion were CPB nadir haemoglobin, preoperative haemoglobin, and transfused plasma units ≥ 2 (Table 9).

Ten out 171 (6.2%) patients died in the perioperative period; two women and eight men. Among the 18 non-transfused patients none died while in the transfused group 10 patients died (10/153; 6.5%) this difference was not significant ($p = 0.264$). Deceased female patients received more FFP units than those who survived (1.04 *vs* 5, $p = 0.028$). Patients who survived received fewer RCC units than those who died (3.69 *vs* 9.60, $p = 0.015$), this difference remained significant in the male group (Table 10).

The mean haemoglobin preoperative level was 13.09 g/ dL; 12.28 for women and 13.47 for men ($p < 0.05$). We also analysed different haemoglobin levels (threshold to be transfused, during CPB, after surgery, at critical care discharge and finally at hospital discharge; (Table 11).

Non-transfused patients had higher nadir (9.48 vs 7.42; $p < 0.001$), post-surgery (10.50 *vs* 9.42; $p < 0.001$) and hospital discharge (11.22 g/dL *vs* 10.34; $p = 0.005$) haemoglobin levels (Table 12).

At hospital discharge 94.5% of the patients were anaemic, only 5.5% had haemoglobin above normal levels, there was no difference by gender (Table 13). When trying to correlate anaemia at discharge and other parameters we compared it with different haemoglobin levels at different moments and blood components received (Table 14). Patients with anaemia at this moment received the same units of blood component as the non-anaemics but showed less haemoglobin figures preoperatively (13.01 *vs* 14.58; $p = 0.001$) and at critical care discharge (9.70 *vs* 10.7 $p = 0.007$). We also analysed anaemia at discharge taking into account gender to know in which group differences were significant: preoperative haemoglobin was different for anaemic women at discharge compared with the rest; nadir haemoglobin differed between anaemic women and anaemic men and finally haemoglobin at critical discharge was different between anaemic and non-anaemic women (Table 15).

Analysing the whole group (men and women) anaemic patients (62) were more transfused than non-anaemic patients (109) receiving a mean of 5.37 RCC *vs* 3.28 RCC (p=0.004). Men with preoperative haemoglobin level less than 13 g/ dL (OMS definition of anaemia for men) were transfused significantly more red blood cell units (4.53 *vs* 2.96, $p = 0.037$) this difference was not observed for the other blood components. Women with preoperative levels of haemoglobin less than 12g/ dL (OMS definition of anaemia for women) received more RCC (7.26 *vs* 3.92, $p = 0.032$; Table 16).

We checked if with other increased cut-off Haemoglobin values (14 and 15 for men; 12.5 and 13 for women) the resulting groups were still different for the number of transfused units. The differences remained for men for the number of RCC transfused (4.49 *vs* 2.49, $p = 0.006$ and 4.04 *vs* 1.63, $p = 0.007$) but not in women (5.74 *vs* 4.21, $p = 0.31$ and 5.55 *vs* 3.80, $p = 0.30$).

We also analysed the relationship between preoperative anaemia and different haemoglobin levels: extracorporeal pump, post-surgery, at critical care discharge and finally at hospital discharge (Table 17). Patients with preoperative anaemia had a lower nadir and postoperative haemoglobin level and were discharged from hospital with less haemoglobin level; in the case of men 10.81 g/ dL when there was no preoperative anaemia and 9.98 when there was anaemia ($p = 0.001$); this difference was also observed for women 11.06 vs 10.01 ($p = 0.003$). Differences were still significant for nadir, postoperative and hospital discharge haemoglobin levels with a 14 g/ dL cut-off in men (7.16 *vs* 8.58; $p < 0.001$, 9,43 *vs* 9.90; $p = 0.028$ and 10.04 *vs* 11.02; $p < 0.001$ respectively) and with a 12.5 g/ dL and a 13 g/ dL in women (for nadir haemoglobin 6.29 *vs* 7.03; $p = 0.001$ and 6.43 *vs* 7.13; $p = 0.005$ respectively and for haemoglobin level at hospital discharge 10.00 vs

Table 5: Transfused patients by component and sex.

Component	Transfused	N	Sex	N (%)	*p*
RCC	Yes	141 (82.5%)	Male	87 (61.7)	< 0.001
			Female	54 (38.3)	
	No	30 (17.5%)	Male	29 (96.7)	
			Female	1 (3.3)	
FFP	Yes	58 (33.9%)	Male	39 (67.2)	0.9
			Female	19 (32.8)	
	No	113 (66.1%)	Male	77 (68.1)	
			Female	36 (31.9)	
PP	Yes	71 (41.5%)	Male	53 (74.6)	0.10
			Female	18 (25.4)	
	No	100 (58.5%)	Male	63 (63.0)	
			Female	37 (37.0)	

RCC: Red Cell Concentrate; FFP: Fresh Frozen Plasma; PP: Platelet Pool.

Table 6: Transfused Units by component and sex.

Blood component	Group	N	Mean	S.D.	Min	Max	*p*
RCC	Whole	171	4.04	4.56	0	40	0.04
	♀	55	5.07	5.55	0	40	
	♂	116	3.54	3.95	0	22	
FFP	Whole	171	1.02	2.04	0	14	0.24
	♀	55	1.18	2.52	0	14	
	♂	116	0.94	1.77	0	12	
PP	Whole	171	1.12	2.72	0	22	0.82
	♀	55	1.05	3.15	0	22	
	♂	116	1.16	2.51	0	18	

Table 7: RCC transfused by diagnosis and sex .

	Whole group		♂		♀	
DIAGNOSIS	N	Mean	N	Mean	N	Mean
Thoracoabdominal aneurysm	3	19.67	1	13	2	23.00
Valve disease (more than one)	18	5.67	8	7.13	10	4.50
Mixed pathology	23	5.30	14	4.79	9	6.11
Ascending aortic aneurysm	21	3.62	19	3.37	2	6.00
One valve disease	33	3.48	14	3.14	19	3.74
Ischemic heart disease	61	3.18	53	2.96	8	4.63
Congenital disease (adults)	8	2.50	4	2.00	4	3.00
Hypertrophic obstructive cardiomyopathy	3	0.57	2	0.50	1	1.00
Constrictive pericarditis	1	0	1	0	0	-

Table 8: Preoperative patients' characteristics, operative surgical data, and post - operative outcome data.

Variable		Total	Transfusion	No transfusion	*P* value
Gender	Male	116 (67.8%)	87 (61.7%)	29 (96.7%)	0.001
	Female	55 (32.2%)	54 (38.3%)	1 (3.3%)	
Age (years)	Mean ± SD	66.46 ± 13.30	67.34 ± 12.25	62.36 ± 17.06	0.138
	≤ 65	60 (35.1%)	46 (32.6%)	14 (46.7%)	0.143
	> 65	111 (64.9%)	95 (67.4%)	16(53.3%)	
Height (cm.)	Mean ± SD	166.75 ± 10.14	165.88 ± 12.23	169.83 ± 17.06	0.026
BMI	Mean ± SD	28.22 ± 4.96	28.05 ± 4.71	28.83 ± 5.81	0.508
	≤ 4	30 (28.8%)	24 (29.6%)	6 (26.1%)	0.741
	> 4	74 (71.2%)	57 (70.4%)	17 (73.9%)	
Hb (g/dL)	Mean ± SD	13.09 ± 1.78	12.68 ± 1.65	14.98 ± 0.98	< 0.001
	Anaemic	62 (36.3%)	62 (44%)	0 (0%)	< 0.001
	Non - anaemic	109 (63.7%)	79 (56%)	30 (100%)	
Creatinine (mg/dL)	Mean ± SD	1.00 ± 0.50	1.02 ± 0.54	0.92 ± 0.15	0.066
	≤ 1.36	150 (87.7%)	120 (85.1%)	30 (100%)	0.027
	> 1.36	21 (12.3%)	21 (14.9%)	0 (0%)	
Urea	Mean ± SD	44.65 ± 20.16	35.67 ± 7.26	46.40 ± 21.39	0.001
Diagnosis	Isolated surgery	148 (86.5%)	120 (85.1%)	28 (93.3%	0.230
	Non-isolated surgery	23 (13.5%)	21 (14.9%)	2 (6.7%)	
EuroSCORE 1	Mean ± SD	8.49 ± 4.01	8.79 ± 4.10	7.1 ± 3.27	0.036
Logistic EuroSCORE	Mean ± SD	17.44 ± 18.46	18.57 ± 19.69	12.13 ± 9.50	0.009
EuroSCORE 2	Mean ± SD	5.12 ± 8.03	5.67 ± 8.73	2.62 ± 2.16	< 0.001
Apache II	Mean ± SD	14.95 ± 5.59	15.40 ± 5.6	12.87 ± 5.13	0.024
LVEF (%)	≤ 30%	18 (10.5%)	18 (12.8%)	0 (0%)	0.045
	> 30%	153 (89.5%)	123 (87.2%)	30 (100%)	
TRUST score	< 3	73 (59.3%)	49 (50%)	24 (96%)	< 0.001
	≥ 3	50 (40.7%)	49 (50%)	1 (4%)	
CPB	yes	156 (92.9%)	132 (95.7%)	24 (80%)	0.003
	No	12 (7.1%)	6 (4.3%)	6 (20%)	
CPB mean time (minutes)	Mean ± SD	134.43 ± 56.66	139.3 ± 54.74	109.5 ± 61.26	0.041
CPB nadir Hb (g/dL)	Mean ± SD	7.44 ± 1.36	7.07 ± 1.01	9.2 ± 1.42	0.036
	< 7	67 (42.1%)	67 (51.1%)	0 (0%)	< 0.001
	≥ 7	92 (57.9%)	64 (48.9%)	28 (100%)	
Hb decrease (%)	Mean ± SD	42.82 ± 8.74	43.81 ± 8.36	38.18 ± 9.14	0.002
	< 50%	127 (79.9%)	100 (76.3%)	27 (96.4%)	0.016
	≥ 50%	32 (20.1%)	31 (23.7%)	1 (3.6%)	
Post-surgery Hb (g/dL)	Mean ± SD	9.54 ±1.13	9.36 ± 1.06	10.35 ± 1.10	< 0.001
FFP (units)	Mean ± SD	1.02 ± 2.04	1.18 ± 2.19	0.27 ± 0.69	< 0.001
	< 1	113 (66.1%)	87 (61.7%)	26 (86.7%)	0.009
	≥ 1	58 (33.9%)	54 (38.3%)	4 (13.3%)	
FFP (units)	Mean ± SD	1.02 ± 2.04	1.18 ± 2.19	0.27 ± 0.69	< 0.001
	< 2	118 (s69%)	92 (65.2%)	26 (86.7%)	0.021
	≥ 2	53 (31%)	49 (34.8%)	4 (13.3%)	
PP (units)	Mean ± SD	1.12 ± 2.72	1.27 ± 2.95	0.43 ± 0.77	0.004
	< 1	100 (58.5%)	79 (56%)	21 (70%)	0.158
	≥ 1	71 (41.5%)	62 (44%)	9 (30%)	
Hospital length of stay (days)	Mean ± SD	19.22 ± 15.55	20.35 ± 16.66	13.9 ± 6.48	0.001
	≤ 23	136 (79.5%)	108 (73.6%)	28 (93.3%)	0.039
	> 23	35 (20.5%)	33 (23.4%)	2 (6.7%)	
Critical Care Unit length of stay (days)	Mean ± SD	5.84 ± 7.62	6.29 ± 8.30	3.78 ± 1.99	0.007
	≤ 8	111 (86.7%)	88 (83.8%)	23 (100%)	0.041
	> 8	17 (13.3%)	17 (16.2%)	0 (0%)	
Redo surgery	No	155 (90.6%)	125 (88.7%)	30 (100%)	0.039
	Yes	16 (9.4%)	16 (11.3%)	0 (0%)	

LVEF: Left Ventricular Ejection Fraction; CPB: Cardiopulmonary Bypass; Hb: Haemoglobin; FFP: Fresh Frozen Plasma; PP: Platelet Pool.

10.69; $p = 0.033$ and 10.01 *vs* 11.06; $p = 0.003$ respectively) and for nadir haemoglobin in men with a 15 g/ dL cut-off (7.59 *vs* 8.81; $p < 0.001$).

DISCUSSION

Blood management has been cited as one of the 10 key advances in transfusion medicine over the past 50 years [17]. Transfusion medicine is in development with continuous implementation of new concepts such as PBM. PBM is a multimodal World Health Organization–endorsed concept based on three pillars aimed at reducing or eliminating the need for allogeneic blood products to improve patient outcome. The three pillars are:

- Detect and treat preoperative anaemia

- Reduce perioperative blood loss, and
- Harness and optimize patient-specific physiologic reserve of anaemia (including restrictive haemoglobin transfusion threshold) [18].

The American Society of Anaesthesiologists defines PBM as a concept related to perioperative (pre, intra, and postoperative) blood transfusion (blood, blood components and plasma products) and adjuvant therapies (drugs and techniques to reduce or prevent blood loss and the need of allogeneic blood) [19].

Blood use has been a major consideration for open heart procedures (valve operations, CABG, and others) since the beginning of cardiopulmonary bypass. Over the years, advances in cardiopulmonary circuits and blood management have led to reduced blood use, by for example, promoting the use of crystalloid prime or reinfusion of unprocessed residual blood from the cardiopulmonary bypass. Nevertheless, many patients undergoing cardiac surgery receive blood transfusions [20]. Perioperative haemorrhage requiring allogeneic blood product transfusion is ubiquitous in cardiothoracic surgery, leading to an estimated consumption of 10% to 20% of the blood supply [20,21]. Currently it has been estimated that in the UK, adult cardiac surgery utilises approximately 4% of all red cell transfusion [22]. In the past decade, the increased awareness of blood conservation techniques substantially reduced perioperative allogeneic blood transfusion [23-25]. In cardiac surgical patients, marked variability in transfusion practice exists between centres in

Table 9: Multivariate logistic regression of perioperative variables and RCC transfusion.

Variables	Odds ratio (95% CI)	*p*
CPB nadir haemoglobin	- 0.133 (-0.176 – -0.091)	< 0.001
Preoperative haemoglobin	- 0.041 (-0.073 – -0.008)	0.015
Plasma transfused units	0.113 (0.010 – 0.215)	0.031

Table 10: Blood components transfused by survival and gender.

Blood component	Gender	Status	N	Mean	S.D.	*P*
RCC	Whole group	Alive	161	3.69	1.89	**0.01**
		Death	10	9.60	3.24	
	♀	Alive	53	4.85	5.47	0.125
		Death	2	11.00	5.65	
	♂	Alive	108	3.12	3.35	**0.036**
		Death	8	9.25	6.67	
FFP	Whole group	Alive	1s61	0.90	1.89	0.08
		Death	10	2.90	3.24	
	♀	Alive	53	1.04	2.32	**0.028**
		Death	2	5	5.65	
	♂	Alive	108	0.83	1.64	0.139
		Death	8	2.38	2.72	
PP	Whole group	Alive	161	0.91	2.21	0.10
		Death	10	4.50	6.29	
	♀	Alive	53	1.00	3.18	0.51
		Death	2	2.50	2.12	
	♂	Alive	108	0.87	1.54	0.156
		Death	8	5.00	6.99	

Table 11: Haemoglobin level in different moments grouped by having been transfused or not.

Haemoglobin measured at	Transfused	N	Mean	S.D.	*P*
Preoperative	No	18	14.84	0.98	< 0.001
	Yes	153	12.88	1.74	
		171	13.09	1.78	
Nadir	No	17	9.48	1.62	< 0.001
	Yes	142	7.42	1.10	
		159	7.44	1.36	
Post-surgery	No	18	10.50	1.03	< 0.001
	Yes	152	9.42	1.09	
		170	9.54	1.13	
Critical care discharge	No	18	10.22	1.30	0.053
	Yes	147	9.70	1.03	
		165	10.43	1.27	
Hospital discharge	No	18	11.22	1.45	0.005
	Yes	146	10.34	1.21	
		164	10.43	1.27	

Table 12: Haemoglobin level in different moments grouped by having been transfused RCC or not.

Haemoglobin measured at	transfused	N	Mean	S.D.	*P*
Preoperative	No	30	14.98	0.98	< 0.001
	Yes	141	12.68	1.65	
		171	13.09	1.78	
Nadir	No	28	9.28	1.38	< 0.001
	Yes	131	7.05	0.98	
		159	7.44	1.36	
Post-surgery	No	30	10.35	1.10	< 0.001
	Yes	140	9.36	1.06	
		170	9.54	1.13	
Critical care discharge	No	30	10.14	1.14	0.029
	Yes	135	9.67	1.04	
		165	10.43	1.27	
Hospital discharge	No	30	10.85	1.35	0.049
	Yes	134	10.34	1.23	
		164	10.43	1.27	

Table 13: anaemia at hospital discharge by gender.

Anaemia	Gender		Total (%^)	χ^2
	♂ (%*/%^)	♀ (%*/%^)		
Yes	108 (96.4/ 69.7)	47 (90.4/ 30.3)	155 (94.5)	*P* = 0.114
No	4 (3.6/ 44,4)	5 (9.6/ 55.6)	9 (5.5)	
Total (%)*	112 (68.3)	52 (31.7)	164	

*% within each gender
^% within presence or absence of anaemia

Table 14: Anaemia at hospital discharge by blood components transfused and haemoglobin levels at different moments.

Variable	Anaemia	N	Mean	SD	*p*
RCC	Yes	155	3.75	4.28	0.548
	No	9	2.89	1.76	
FFP	Yes	155	0.88	1.87	0.718
	No	9	1.11	2.02	
PP	Yes	155	0.94	2.23	0.615
	No	9	0.56	1.33	
Preoperative Hb (g/ dL)	Yes	155	13.01	1.78	**0.001**
	No	9	14.58	0.96	
Postoperative Hb (g/ dL)	Yes	154	9.49	1.03	0.160
	No	9	10.41	1.77	
Nadir Hb (g/ dL)	Yes	145	7.45	1.28	0.346
	No	8	7.92	2.64	
Threshold Hb (g/ dL)	Yes	129	7.63	1.15	0.559
	No	8	7.87	0.52	
Critical care discharge Hb (g/ dL)	Yes	155	9.70	0.93	**0.007**
	No	9	10.70	2.41	

various countries and suggests differences in perioperative practice patterns as well as possible inappropriate use. In an audit carried out in England the variation was indicated by a three-fold range (from 22% to 66%) in the percentages of patients receiving a RBC transfusion after undergoing primary CABG surgery [26]. This enormous range may be attributed partially to a subjectively based instead of an evidence-based practice and may indicate unnecessary transfusion, however, may also be influenced by differences in patient

Table 15: Anaemia by gender at hospital discharge by haemoglobin levels at different moments.

At hospital discharge		N	Mean	S.D.	*P*
Preoperative Hb (g/ dL)	Anaemic ♀	47	12.03	1.47	
	Anaemic ♂	108	13.44	1.74	< 0.001
	Non-anaemic ♀	5	14.50	1.25	0.010
	Non-anaemic ♂	4	14.70	0.57	0.013
Postoperative Hb (g/ dL)	Anaemic ♀	46	9.18	1.01	
	Anaemic ♂	108	9.62	1.01	0.073
	Non-anaemic ♀	5	10.52	1.53	0.342
	Non-anaemic ♂	4	10.27	2.28	0.784
Nadir Hb (g/ dL)	Anaemic ♀	44	6.59	0.83	
	Anaemic ♂	101	7.83	1.26	< 0.001
	Non-anaemic ♀	5	6.84	0.67	0.865
	Non-anaemic ♂	3	9.73	3.95	0.610
Critical care Hb (g/ dL)	Anaemic ♀	47	9.47	0.92	
	Ansaemic ♂	108	9.80	0.92	0.446
	Non-anaemic ♀	5	10.80	2.93	< 0.049
	Non-anaemic ♂	4	10.57	2.02	0.279

Table 16: Blood components transfused by gender and preoperative haemoglobin level.

Gender	Blood component	Pre Hb level (g/ dL)	N	Mean	S.D.	*p*
♂	RCC	< 13	43	4.53	3.53	**0.037**
		≥ 13	73	2.96	4.08	
		< 14	61	4.49	3.56	**0.006**
		≥ 14	55	2.49	4.11	
		< 15	92	4.04	3.93	**0.007**
		≥ 15	24	1.63	3.44	
	FFP	< 13	43	1.14	2.13	0.353
		≥ 13	73	0.82	1.52	
		< 14	61	1.05	1.91	0.485
		≥ 14	55	0.82	1.60	
		< 15	92	1.05	1.85	0.173
		≥ 15	24	0.50	1.35	
	PP	< 13	43	0.95	1.96	0.509
		≥ 13	73	1.27	2.78	
		< 14	61	1.03	1.85	0.582
		≥ 14	55	1.29	3.08	
		< 15	92	1.12	2.13	0.766
		≥ 15	24	1.29	3.65	
♀	RCC	< 12	19	7.26	8.21	**0.032**
		≥ 12	36	3.92	2.96	
		< 12.5	31	5.74	6.75	0.314
		≥ 12.5	24	4.21	3.36	
		< 13	40	5.55	6.25	0.302
		≥ 13	15	3.80	2.73	
	FFP	< 12	19	1.26	3.19	0.864
		≥ 12	36	1.14	2.14	
		< 12.5	31	0.84	2.55	0.256
		≥ 12.5	24	1.63	2.46	
		< 13	40	0.93	2.62	0.221
		≥ 13	15	1.87	2.16	
	PP	< 12	19	1.74	5.01	0.247
		≥ 12	36	0.69	1.43	
		< 12.5	31	1.06	3.97	0.979
		≥ 12.5	24	1.04	1.65	
		< 13	40	1.03	3.54	0.911
		≥ 13	15	1.13	1.84	

Table 17: Haemoglobin level measured at certasin moments by gender and preoperative anaemia.

Gender	Haemoglobin	Pre Hb level (g/ dL)	N	Mean	S.D.	s
♂	Nadir	< 13	40	6.92	0.82	< 0.001
		≥ 13	67	8.40	1.37	
		< 14	55	7.16	0.95	< 0.001
		≥ 14	52	8.58	1.41	
		< 15	84	7.59	1.32	< 0.001
		≥ 15	23	8.81	1.24	
	Threshold	< 13	42	7.51	0.91	0.221
		≥ 13	49	7.84	1.52	
		< 14	56	7.61	0.88	0.468
		≥ 14	35	7.82	1.75	
		< 15	81	7.72	1.00	0.491
		≥ 15	10	7.43	2.71	
	Post-surgery	< 13	43	9.34	0.96	0.025
		≥ 13	73	9.83	1.18	
		< 14	61	9.43	0.95	0.028
		≥ 14	55	9.90	1.26	
		< 15	92	9.55	1.09	*0.062*
		≥ 15	24	10.03	1.20	
	Critical care discharge	< 13	41	9,76	0.96	0.590
		≥ 13	71	9.87	0.98	
		< 14	59	9.72	0.92	0.216
		≥ 14	53	9.75	1.02	
		< 15	89	9.72	0.91	0.019
		≥ 15	23	10.25	1.10	
	Hospital discharge	< 13	41	9.98	1.12	0.001
		≥ 13	71	10.81	1.33	
		< 14	59	10.04	1.08	< 0.001
		≥ 14	53	11.02	1.38	
		< 15	89	10.39	1.27	*0.073*
		≥ 15	23	10.94	1.43	
♀	Nadir	< 12	17	6.21	0.80	0.012
		≥ 12	35	6.81	0.75	
		< 12.5	29	6.29	0.74	0.001
		≥ 12.5	23	7.03	0.71	
		< 13	38	6.43	0.79	0.005
		≥ 13	14	7.13	0.65	
	Threshold	< 12	17	7.50	0.80	0.505
		≥ 12	35	7.64	0.70	
		< 12.5	29	7.52	0.78	0.439
		≥ 12.5	23	7.68	0.67	
		< 13	38	7.51	0.76	0.183
		≥ 13	14	7.82	0.58	
	Post-surgery	< 12	18	9.05	1.16	0.260
		≥ 12	36	9.42	1.08	
		< 12.5	30	9.21	1.12	0.545
		≥ 12.5	24	9.40	1.11	
		< 13	39	9.26	1.01	0.707
		≥ 13	15	9.33	1.40	
	Critical care discharge	< 12	18	9.16	1.07	*0.068*
		≥ 12	35	9.82	1.29	
		< 12.5	30	9.41	1.05	0,209
		≥ 12.5	23	9.85	1.45	
		< 13	39	9.45	0.97	0.140
		≥ 1 3	14	10.02	1.79	
	Hospital discharge	< 12	18	9.85	0.82	0.025
		≥ 12	34	10.52	1.24	
		> 12.5	30	10.00	1.04	0.033
		≥ 12.5	22	10.69	1.20	
		< 13	38	10.01	1.01	0.003
		s≥ 13	15	11.06	1.20	

population among the study centres, including comorbidities as well as other patient-related factors such as age, body size, or preoperative anaemia. Additionally, there are several surgical, procedure-related factors that is, cardiopulmonary bypass duration, urgency and type of surgery or redo surgery, and most importantly, intra- and postoperative blood loss, that trigger perioperative blood transfusion. The extent of blood loss depends for the most part on surgical skill. The use of Point of Care (POC) transfusion and coagulation management algorithms based on viscoelastic tests in combination with POC platelet function tests have been shown to be associated with reduced allogeneic blood transfusion requirements and improved outcomes in cardiac surgery [27]. The use of cell-saver devices and other blood conservation strategies, however, as well as the use of antifibrinolytics are also relevant factors. Low priming volumes of the extracorporeal circulation and restrictive fluid management can prevent extensive hemodilution, which may be a cause for transfusion of blood products. The transfusion thresholds, that is, the specific cut-off points of laboratory values that indicate the necessity for the transfusion of blood products to the treating physician, are crucial and may vary between centres as well as between individual surgeons and anaesthesiologists [28]. Although transfusion has currently been reduced for patients undergoing cardiac surgery many patients continue to require transfusion due to patients' condition, surgical complications with repeat cardiac surgery procedures and excessive bleeding due to anticoagulant therapy and hypothermia. Previous audits of blood use in cardiac surgery have demonstrated significant variation in the percentage of patients transfused with red cells and other blood components for similar operative procedures in apparently similar groups of patients [29-32]. For example, the mean number of Red Blood Cells (RBC) transfused in CABG ranges from 0 to 6.3 units per patient, and the frequency of transfusion ranges from 16% to 100% [33].

In low risk patients, 27% to 92% of patients were transfused with packed red blood cells; 0% to 36% of patients received platelets; 0% to 36% received FFP [34]. The effect of a specific hospital on transfusion practice has been attributed to institutional differences that, through reasons of training or hierarchy, become ingrained in hospitals [35]. Such variation persisted in the late 1990s with reports ranging from 0% to 100% for various blood components [26].

Thus, it appears that transfusion guidelines are not uniformly applied and that informal institutional-specific standards, local conditions (e.g., availability of blood products, national medical standards), and individual physicians continue to drive transfusion practice [28]. The wide range of transfusion practice found in many audits, and lack of evidence that this practice is linked to clinical benefit, merits further investigation. Whilst both mechanical and pharmacological techniques have reduced the risk of exposure to red cell transfusion in routine, low risk elective cardiac surgery patients still receive red cells and other blood components.

Prophylactic platelet and plasma therapy is unnecessary in cardiac surgery, despite the hemodilution and associated platelet function defect, this has led to a reduction in platelet and plasma transfusion in many centres [20]. Though most guidelines, conclude that the administration of FFP is only indicated for urgent reversal of warfarin therapy, correction of coagulation factor deficiencies, or control of microvascular bleeding when the prothrombin and/ or partial thromboplastin times are more than 1.5 times normal, perioperative transfusion practice for FFP is highly variable (0-98%). Therefore, a wide range of frequency and volume of FFP transfusion probably indicates a lack of application of the established guidelines or may be related to differences in case severity, surgical skill and experience, or institutional transfusion practices [28,29].

Most guidelines agree that the use of PLT is only required if the PLT count is less than 50 x 10^9 per L or in the case of clinically significant PLT dysfunction. The frequency of PLT transfusion varies from 0 to 51 percent. These observations might be due to various transfusion triggers such as a preoperative low PLT count or prior use of PLT aggregation inhibitors. Although the use of extracorporeal circulation may additionally consume PLTs, it has been stated that numerous PLT transfusions are not necessarily therapeutic in the presence of excessive bleeding, but rather prophylactic to prevent bleeding events. It has been reported that PLT transfusion is associated with infections, vasopressor and respiratory medication use, stroke, and death in patients undergoing CABG surgery. Thus, the increased risk for serious adverse events after PLT transfusion underlines the importance of the correct use of this blood product, following published guidelines[28].

Blood transfusion remains the mainstay of management of severely anaemic patients. The role of red blood cells has been addressed assessing the impact of nadir Haemoglobin (Hb) during bypass, a Hb level greater than 6 was deemed adequate to prevent adverse outcomes, however, few controlled trials have been conducted to validate recommended transfusion thresholds in cardiac surgery [20]. Currently available transfusion guidelines often indicate transfusion at Haemoglobin (Hb) levels below 6 g/ dL (or below 7-8 g/ dL depending on other conditions), while acknowledging the limitations of reliance on a laboratory variable to make this important clinical decision [36]. In 2002, Carson and colleagues published their study on a cohort of 300 patients with postoperative Hb level of not more than 8 g/ dL who refused blood transfusion and reported that for every 1-g drop in postoperative Hb level below 8 g/ dL, the odds of death could increase 2.5 times [37]. In a recent study conducted by Hogervorst et al. [38] including patients with moderate to severe blood loss, found that low haemoglobin is associated with more postoperative complications but the authors were reluctant to conclude that this may have consequences for settings of a transfusion threshold.

A number of observational studies have demonstrated an increased risk of death and major complications in patients receiving transfusions around the time of cardiac surgery [39,40]. Rogers et al found that for those receiving allogeneic blood, the odds of death during hospitalisation were elevated nearly fivefold with elective surgeries. Analysing our data, death was linked to more RCC transfused for the whole group and for men, and to plasma transfusions in female patients. It is obvious that this fact can be justified by a worse condition of the patient and may be difficult to say that transfusions contribute to death. But it has been described more complications with more transfused units, for every 1% increase in the rate of transfusion a 0.13% increase in the probability of infection has been shown [15].

The inappropriate use of blood components in cardiac surgery may increase the risk of complications to patients and is a waste of a scarce and costly resource. In that way, blood transfusion outcomes should be regarded as quality indicators for clinical services by improving patient outcomes and reducing blood costs [41].

In our institution, at the time of analysis there was a high transfusion rate in patients undergoing cardiac surgery (89.5%); this

rate was most striking in women (100%), for RCC the rate is 82.5%, for FFP 33.9% and for PP 41.5%.

The high number of patients requiring blood products may possibly be explained by the following factors:

This sub-study evaluated not only intraoperative blood product use but the postoperative period also when blood products may be commonly administered

The study included not only isolated elective CABG-only procedures

General practice patterns for use of blood products were not adapted to this group of patients

Overall, 30% of the variability in transfusion practices after CABG surgery has been attributed to hospital site [15]. This fact and our analysis reassure us on the need of the development and implementation of a blood saving protocol in this particular subgroup of patients. Protocols should include preoperative measures to optimize haemoglobin levels, the triggers for transfusion, the use of intra-operative cell salvage, the use of anti-fibrinolytic drugs, the implementation of POC to guide transfusion, and the assessment and management of bleeding. For therapeutic blood transfusions, there is now considerable Level 1 evidence from key clinical trials that more restrictive transfusion practices are associated with equivalent or improved patient outcomes, when compared to more liberal transfusion practices [41]. The methods employed in providing bloodless medical care are an example of the paradigm shift that has been described in the field of transfusion medicine, away from the component-centric model, toward the patient-centric approach [42].

It has been demonstrated improved blood utilization after implementation of a plan based on education outreach and audits with a reduction in percentage of patients transfused and the mean number of RBC units per patient for a series of diagnosis related groups [14].

Given the variation in blood transfusion during cardiac surgery, it would be advantageous to identify patients requiring greater than the standard number of blood components during surgery [29]. Analyzing our data, female gender, lower height, low hemoglobin level, renal insufficiency, high EuroSCORE (1, logistic or 2), high Apache II score, low LVEF percentage, a TRUST score greater than two, on pump procedures, prolonged cardiopulmonary bypass time, low nadir hemoglobin level, low post surgery hemoglobin level, more than one FFP transfused, prolonged critical care and hospital stay and redo surgery were associated with an increased risk of peri-operative transfusion of RBC. These findings are consistent with those found in previous studies; decreased preoperative Hb and renal insufficiency or failure have all been associated with excessive bleeding [33].

Previous reports have also identified abnormal coagulation studies, type 1 diabetes mellitus, decreased platelet count, decreased albumin and the number or type of bypass grafts with excessive bleeding or increased risk of RBC transfusion during cardiac surgery, whereas our study did not. Other factors previously associated with increased risk of RBC transfusion or excessive bleeding include: cardiogenic shock, first treatment or episode of transmural myocardial infarction, lower core temperature, duration of surgery, large-volume intraoperative transfusion of salvaged RBC [8], urgent or emergent surgery, and catheterization-induced coronary occlusion [33]. Multivariate studies suggest that patient age and red blood cell volume are independent patient-related variables that predict excessive blood product transfusion after cardiac procedures [43], other factors include, type of operation, and physician over transfusion [44], female sex, urgency of surgery [8], weight, preoperative creatinine, previous cardiac surgical procedure and nonisolated procedure [12]. It seems obvious that knowing the risk factors for transfusion and mitigating those risks wherever possible is recommended.

In 18 large observational studies encompassing over 650,000 surgical patients, the mean prevalence of pre-operative anaemia was around 35%, varying between 10.5% and 47.9% [45]. Perioperative anaemia is common in cardiac surgery, in a study conducted by David et al. [46] overall prevalence of preoperative anaemia was 25.2%, greater in males than females (27.6 *vs* 19.9%, $P < 0.01$) similar results were reported by Kim et al. [47] where 28.1% of the patients were anaemic. Our anaemia population was higher with an overall prevalence of 36.3% but without differences male-female (37.1% *vs* 34.5%). Perioperative anaemia is responsible for increased postoperative morbidity and mortality and was found to be an independent risk factor for death in several studies [48]. Anaemia impacts significantly on morbidity and mortality after cardiac surgery, with less improvement over time compared to patients without anaemia. Preoperative correction of anaemia, when feasible, could potentially help to improve cardiac surgery outcomes [49].

Anemic patients received significantly more RCC; 4.53 *vs* 2.96 in the case of men and 7.26 *vs* 3.92 in women. It remains to be established the optimal preoperative hemoglobin cutoff in men but it seems that higher figures than 13 g/ dL significantly decrease the number of units transfused. We could not see any difference in women with a cut-off value above 12.

As can be seen from the results described in our series women entering the operating room not only are more transfused but also receive more RCC, they tend to receive more than two units. This fact could be attributed in part to the increased frequency of presurgery anemia in women but it is not the case the proportion by sex is similar what is different is the preoperative Hemoglobin level, lower in women, reflecting perhaps that the threshold to transfuse is not gender based but only hemoglobin based. In patients more heavily transfused (more than four units) no difference by sex could be observed. As it may seem obvious hemoglobin levels were lower for transfused patients in all points measured. It drew our attention that 94.5% of the patients left the hospital anemics without difference by sex or by RCC units transfused, but they have lower level of preoperative hemoglobin and at critical care discharge. These data highlight the importance of optimizing the hemoglobin preoperatively not only to avoid transfusions but also to improve quality of life after leaving the hospital.

Traditional quality indicators for blood utilization have included monitoring crossmatch-to-transfusion ratios, RBC unit out-date expiration rates, and RBC units wasted, these are important variables for laboratory assessment of blood ordering practices and blood inventory management but they do not assess the appropriateness of transfusion or the clinical patient outcomes related to transfusion. Rather, blood transfusion as assessed by percentage of patients transfused over a threshold Hb, more directly assesses utilization. Additionally, data on patients short and long term outcomes, would assist in studies of the efficacy of transfusion [41].

The excessive use of blood components not only results in unnecessarily increased costs but also exposes patients to enhanced

perioperative risks due to transmission of infectious diseases, volume overload, transfusion-related acute reactions, immunomodulation, pneumonia, and transfusion-related acute lung injury. Associations between the number of RBCs transfused and longer Intensive Care Unit (ICU) and hospital stay, as well as increased mortality, have been described. Similarly, in our study, transfused patients showed longer ICU and hospital stay. Moreover, it has been described a dose-response relationship between the amount of FFP or PLT administered and exposure to transfusion-related morbid risks, as well as increased subsequent mortality [28].

We also observed that transfusion was related to diagnosis, hypertrophic obstructive cardiomyopathy received statistically less red cell units than ischemic heart disease, non-isolated surgery or valve disease and male patients undergoing more than one valve surgery tended to be transfused with more RCC than the ones with ischemic heart disease. Findings consistent with Moskowitz and colleagues, who reported that the type of surgery is a primary determinant for use of RBCs [28].

Importantly, an analysis of the EuroSCOREs demonstrated a correlation between EuroSCOREs and transfusion, this has not been proven by others [28].

In conclusion, this study demonstrates a high perioperative use of RBCs, FFP, and PLTs persists in our hospital, resulting from varying practice patterns that probably reflect misuse and/or overuse of these blood products in cardiac surgical patients. This supports the implementation of measures to reduce the use of blood components in these patients through interdisciplinary consensus protocols. As a consequence efforts ensued to educate and influence physicians caring for cardiac surgery patients to follow expert opinion-based protocols are warranted. Continued reevaluation of local perioperative practice patterns, including transfusion algorithms, seems necessary.

We agree with the Rogers et al and think that safety of patients undergoing cardiac surgery will likely be improved if hospitals carefully review current guidelines on allogeneic blood transfusion, closely adhere to such guidelines, and institute interventions to reduce inappropriate use of blood transfusions [15].

Knowing the data helps us to limit excessive blood transfusion after surgery by:

- Recognizing the causes of excessive transfusion
- Establishing a quality management program (survey of transfusion practices, physician education and availability of real-time laboratory testing to guide transfusion therapy)
- Adopting a multimodal approach protocol; and 4) continually reassessing blood product use and analyse the cost-benefits of blood conservation interventions.

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