Original Article

Transfusion of Blood Components and Postoperative Outcomes in Patients Undergoing Cardiac Surgery

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ABSTRACT

Background: Blood transfusion is needed in patients following open-heart surgery; however, it may lead to the incidence of infection, increased mortality, and longer hospitalization. This study was designed to evaluate the outcome of blood transfusion in patients who underwent cardiac surgery.

Methods: The present study enrolled 784 candidates for open-heart surgery at our tertiary care center between April 2012 and 2013. The study outcomes were defined as sepsis, mediastinitis, pneumonia, mortality, extubation times more than 8 hours after surgery, and intensive care unit (ICU) lengths of stay of more than 3 days.

Results: There was a significant association between packed cell transfusion and the incidence of pneumonia, sepsis, prolonged intubation times, surgical site infections, and prolonged lengths of ICU and hospital stay ($P < 0.05$); however, there was no significant association between packed cell transfusion and mortality ($P = 0.2$). There was a significant relationship between fresh frozen plasma transfusion and the incidence of all types of surgical complications, mortality, and prolonged ICU and hospital lengths of stay ($P < 0.05$).

There was a significant association between platelet transfusion and the incidence of pneumonia, mediastinitis, prolonged intubation times, surgical site infections, and prolonged lengths of ICU and hospital stay ($P < 0.05$); nonetheless, there was no significant association between platelet transfusion and mortality ($P= 0.1$). In the multiple logistic regression, an association was observed between age, sex, and complications following adjustments for packed cell transfusion, fresh frozen plasma, and platelet.

Conclusions: The administration of blood and hemo-components was associated with the development of postoperative complications such as sepsis, mediastinitis, pneumonia, mortality, prolonged intubating times, and prolonged lengths of ICU and hospital stay.

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KEYWORDS: Blood transfusion, Postoperative complication, Mortality, Cardiac surgery

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A significant amount of blood and hemo-component transfusion is issued to patients undergoing cardiac surgery because it is expected to correct physiological abnormalities, reduce morbidity or mortality, and improve patient outcomes. [1] However, it can lead to acute or late complications such as the development of postoperative infections, transfusion reactions, risk of immunosuppression, and the development of mediastinitis in some patients. [2]

A growing body of evidence suggests that patients who receive 1 or 2 units of erythrocytes have a 29% increased odds of death and a 40% to 90% increased odds of pulmonary or thromboembolic complications, as well as sepsis and wound. [3] Red blood cell (RBC) transfusion can induce tolerance in the host immune system, resulting in higher rates of postoperative and nosocomial infections and cancer recurrence. It appears that blood transfusion is associated with the increased risk of infectious events such as mediastinitis, respiratory infection, and sepsis, as well as increased lengths of intensive care unit (ICU) and hospital stay. [2]

Despite the frequent use of blood components for patients undergoing cardiac surgery, the evidence to guide transfusion therapy is limited, particularly for components other than RBCs. There have been only a few studies on the optimal triggers for RBC transfusion, and these have been mostly in other clinical settings. [4] Studies on the use of fresh frozen plasma (FFP) and platelets (PLT) in cardiac surgery are also limited, with varying results regarding outcomes. [5, 6] Be that as it may, previous studies have used heterogeneous populations that include candidates for open-heart surgery for valvular heart disease or coronary artery bypass grafting (CABG). [7]

Accordingly, in the present study, we assessed the outcome of blood and blood-product transfusion in candidates for open-heart surgery to determine post-transfusion complications and to help reduce unnecessary transfusion.

METHODS

The current investigation recruited 786 candidates for open-heart surgery in Rajaei Cardiovascular, Medical, and Research Center between 2012 and 2013. The inclusion criteria consisted of age under 18 years, hemoglobin levels of below 11 mmol/dL, any infection before surgery, obstructive pulmonary disease, and having intra-aortic balloon pumps. The use of blood and blood products was carried out by an anesthesiologist or surgeon based on the patient's need. The number of units of blood components related to the development of intraoperative and postoperative complications was calculated.

The study outcomes were defined as sepsis, mediastinitis, pneumonia, mortality, extubation times more than 8 hours after surgery, and ICU lengths of stay of more than 3 days.

The effect of the preoperative and intraoperative variables on the development of postoperative complications was assessed on an individual basis. These variables were as follows:

1) Preoperative factors: age, sex, hypertension, diabetes mellitus, hyperlipidemia, hypothyroidism, body mass index (BMI), cardiac ejection fraction, and hemoglobin levels at baseline
2) Intraoperative factors: the type of surgery (CABG, valve replacement, or mixed), the time of cardiopulmonary bypass circulation, the duration of intubation, and blood transfusions (RBC concentrates, FFP, and PLT)
3) Postoperative factors: the transfusion of blood components, prolonged

intubation times, and ICU and hospital lengths of stay

The study protocol was approved by our local ethics committee according to the Helsinki Declaration of the World Medical Association (2000) and written informed consent was obtained from the entire study population.

Statistical Analysis

The continuous variables were presented as the mean ± the standard deviation or the median. The Student *t*-test or the Mann–Whitney *U* test was used to compare the quantitative variables and the χ^2 test to compare the categorical variables. A multivariate regression test was applied to remove the confounding effects of the variables. The confounding variables were excluded or controlled through the application of statistical methods. Adjustments were made for the potential confounding factors with the use of linear regression analysis. SPSS, version 18.0 (Chicago, USA), was used for all the statistical analyses.

RESULTS

In the present study, 784 patients (474 male) at a mean age of 59.69 ± 13.80 years underwent open-heart surgery. The patients' demographic data and clinical characteristics are depicted in Table 1. The mean preoperative hemoglobin level in the whole study population was 13.7±1.4 g/dL. The most common type of surgery was CABG (67.9%).

Table 1: Demographic and clinical data characteristics

Variable	Mean±SD/ N (%)
Age (y)	56.69±13.805
Sex (male)	474 (60)
Hb g/dL	13.737±1.411
EF %	44.89±10.246
BMI	26.349±4.678
HLP	227 (28.9)
DM	228 (29)
HTN	283 (36.1)
CVA	27 (3.4)
Hypothyroidism	20 (5.2)
Type of Surgery CABG	533 (67.9)
tricuspid repair	65 (8.3)
aortic repair	156 (19.9)
mitral repair	220 (28)
pulmonary repair	43 (5.5)
ventricular septal surgery	7 (0.9)
atrial septal surgery	9 (1.1)
Duration of bypass (min)	103.76±40.892
Mechanical ventilation (h)	13.51±17.439
ICU stay (d)	4.31±2.533
Hospital stay (d)	7.08±4.638

HTN, Hypertension; Hb, Hemoglobin; EF, Ejection fraction; BMI, Body mass index; DM, Diabetes mellitus; CVA, Cardiovascular accident; ICU, Intensive care unit; CABG, Coronary artery bypass graft; EF, Ejection fraction

The associations between the infusion of packed cells, FFP, and PLT and the incidence of outcomes are shown in Table 2. There was a significant association between packed cell transfusion and the incidence of pneumonia, sepsis, prolonged intubation times, surgical site infections, and prolonged ICU and hospital lengths of stay ($P < 0.05$); nonetheless, there was no significant association between packed cell transfusion and mortality ($P = 0.2$).

The results also revealed a significant relationship between FFP transfusion and the incidence of all types of surgical complications, mortality, and increased ICU and hospital lengths of stay ($P < 0.05$) (Table 2).

Additionally, a significant association was demonstrated between PLT transfusion and the incidence of pneumonia, mediastinitis, prolonged intubation times, surgical site infections, and prolonged lengths of ICU and hospital stay ($P < 0.05$); nevertheless, there was no significant association between PLT transfusion and mortality ($P = 0.1$).

The logistic regression tests for all types of complications and packed cell, FFP, and PLT transfusion are illustrated in Table 3, Table 4, and Table 5, correspondingly. Multiple logistic regression analyses adjusted for age, gender, smoking status, emergency surgery, type of surgery, and the hemoglobin level at baseline were performed. In the analysis, an association was observed between age and sex and complications after adjustments for packed cells, FFP, and PLT (Tables 3, 4 & 5). Cardiopulmonary bypass (Exp [B] = 1.007, 95% CI: 1.001 to 1.013; *P* = 0.022) was also associated with complications in packed cell transfusion (Table 3).

Table 2: Association between the infusion of PC, FFP, and PLT and the incidence of the outcomes

		Without Infusion	With Infusion	*P* value
PC	**Pneumonia**	0(0%)	25(3.9%)	0.005
	Sepsis	1(0.2%)	22(3.4%)	0.010
	Mediastinitis	0(0%)	10(1.6%)	0.124
	Delayed extubation	50(34%)	438(68.7%)	<0.001
	Surgical site infection	0(0%)	22(3.4%)	0.022
	Mortality	0(0%)	7(1.1%)	0.233
	ICU stay	3.31±0.82	4.54±2.71	<0.001
	Hospital stay	5.76±2.90	7.38±4.90	<0.001
FFP	**Pneumonia**	2(0.5%)	23(5.9%0	<0.001
	Sepsis	1(0.3%)	21(5.4%)	<0.001
	Mediastinitis	1(0.3%)	9(2.3%)	0.01
	Delayed extubation	189(47.6%)	299(77.1%)	<0.001
	Surgical site infection	0(0%)	22(5.7%)	<0.001
	Mortality	0(0%0	7(1.8%)	0.007
	ICU stay	3.63±1.20	5.01±3.24	<0.001
	Hospital stay	6.16±3.40	8.01±5.47	<0.001
PLT	**Pneumonia**	6(1.3%)	19(5.9%)	<0.001
	Sepsis	9(1.9%)	13(4%)	0.08
	Mediastinitis	1(0.2%)	9(2.8%)	0.002
	Delayed extubation	241(52.1%)	247(76.7%)	<0.001
	Surgical site infection	6(1.3%)	16(5%)	0.002
	Mortality	2(0.4%)	5(1.6%)	0.10
	ICU stay	3.83±1.48	5.00±3.42	<0.001
	Hospital stay	6.55±3.83	7.83±5.51	<0.001

P < 0.05 was defined as the level of significance.
PC, Packed red blood cells; FFP, Fresh frozen plasma; PLT, Platelet; ICU, Intensive care unit

Table 3: Multivariate analysis of the postoperative complications due to packed cell transfusion

	B	Exp(B)	*P* value	95% CI for EXP(B)
Age	0.034	1.035	0.009	1.009-1.062
Sex	-0.819	0.441	0.011	0.234-0.832
Cardiopulmonary bypass	0.007	1.007	0.022	1.001-1.013
Smoking	0.123	1.131	0.767	0.500-2.561
Hemoglobin levels at baseline	-0.047	0.954	0.679	0.765-1.191
Emergency surgery	0.567	1.762	0.221	0.712-4.363
Type of surgery	-0.194	0.823	0.580	0.413-1.640
Packed cells	2.405	20.113	<0.0001	8.210-47.512

Table 4: Multivariate analysis of the postoperative complications due to platelet transfusion

	B	Exp(B)	*P* value	95% CI for EXP(B)
Age	0.039	1.040	0.003	1.014-1.067
Sex	-1.019	0.361	0.002	0.187-0.698
CPB	0.006	1.006	0.066	1.000-1.012
Smoking	0.100	1.105	0.814	0.482-2.534
Hemoglobin levels at baseline	-0.146	0.864	0.208	0.688-1.085
Emergency surgery	0.294	1.342	0.531	0.535-3.364
Type of surgery	-0.153	0.858	0.669	0.425-1.731
Platelet	1.307	3.696	<0.0001	2.078-6.573

Table 5: Multivariate analysis of the postoperative complications due to fresh frozen plasma transfusion

	B	Exp(B)	*P* value	95% CI for EXP(B)
Age	0.037	1.037	0.006	1.011-1.065
Sex	-1.033	0.356	0.003	0.180-0.703
CPB	0.003	1.003	0.312	0.997-1.009
Smoking	0.167	1.182	0.701	0.503-2.779
Hemoglobin levels at baseline	-0.149	0.862	0.217	0.681-1.091
Emergency surgery	0.106	1.111	0.829	0.427-2.895
Type of surgery	-0.037	0.963	0.921	0.460-2.018
Fresh frozen plasma	2.909	18.344	<0.0001	6.487-51.875

DISCUSSION

The transfusion of RBCs and other blood products is lifesaving therapy and has made complex surgical treatments possible; however, this therapy has undesirable effects on the immune system. Transfusion both improves inflammation and suppresses immunity. [2] Patient risk for a variety of clinical outcomes can be predicted based on the volume of transfusion. In a large population of mixed non-trauma, non-cardiothoracic surgical procedures, the transfusion of even 1 unit of packed cells predicted postoperative morbidity (pneumonia, sepsis, and overall morbidity) and mortality. The transfusion of 2 units of packed cells is thought to be associated with even greater morbidity (surgical site infections plus additional heightened risks of pneumonia and sepsis) and higher mortality, supporting the need for the use of strategies aimed at reducing the transfusion of packed cells. [1, 4]

In our study, the incidence of all surgical complications such as pneumonia, sepsis, mediastinitis, prolonged intubation times, surgical site infections, and prolonged lengths of ICU and hospital stay in the patients who received blood or blood component transfusion was significantly high in comparison with the patients who did not receive blood or blood component transfusion.

Several studies are in line with our study and confirm our findings. [8-11] Gerber et al [11] found a significant association between RBC transfusion and pneumonia. Taylor et al [12] reported an incidence rate of about 3.61 of pneumonia after cardiac surgery among the patients that had received packed cells or FFP.

Previous research has shown an association between the transfusion of RBCs or other blood components and the development of mediastinitis and sepsis in patients undergoing cardiac surgery. A previous study demonstrated that the transfusion of

more than 3 units of packed cells or 2 or more units of plasma was associated with mediastinitis and sepsis. The results also showed that although the prevalence of mediastinitis after heart surgery was low, the main risk factor of mediastinitis was blood transfusion. [4]

We did not find any relationship between blood transfusion and the mortality rate in our study. In contrast, Spiess et al [13] reported their patients who received transfusion following open-heart surgery had a greater chance of mortality than their group without any transfusion.

In the current study, a prolonged intubation time and also prolonged lengths of ICU and hospital stay were significantly associated with blood transfusion. Shahbazi et al and Spiess et al reported the same findings in their studies. [10, 13]

Our results indicated a significant association between RBC transfusion and the development of infection in our patients undergoing cardiac surgery. However, we lack consistent study findings to make strong practice recommendations at this time. Randomized controlled trials are usually recommended to provide the highest level of evidence. Still, to randomize cardiac surgery patients to transfusion or no transfusion a priori would be unethical. In the present study, we assessed the outcome of blood transfusion after open-heart surgery and its association with complications and found that among all confounding factors—including age, sex, smoking, urgent surgery, type of cardiac surgery, and the duration of cardiopulmonary bypass—there was a significant association between age, sex, and the duration of cardiopulmonary bypass and the incidence of complications after surgery. The mortality rate has been previously reported to be associated with longer ventilator dependency, longer hospitalization, and the high cost of treatment in patients with infectious diseases. [13] Therefore, with regard to the result of our study and the significant association between complications and transfusion, we recommend that patients with higher risks of disease be carefully followed to avoid the incidence of postoperative complications.

CONCLUSIONS

The results of the present study on a sample of candidates for open-heart surgery indicated that blood transfusion was associated with an increased risk of mediastinitis, sepsis, pneumonia, surgical site infections, and prolonged intubation times. Blood transfusion increased the length of ICU and hospital stay but not mortality in these patients.

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