IJHOSCR

Original Article

International Journal of Hematology-Oncology and Stem Cell Research

Blood Products Utilization Status in Off-Pump Cardiac Surgery Patients

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Received: 13, May 2021
Accepted: 01, May, 2022

ABSTRACT

Background: Transfusion support has a vital role in coronary artery bypass graft (CABG). The time-honored gold standard for CABG is the on-pump procedure (ONCAB); however, off-pump coronary artery bypass (OPCAB) is also a safe, cost-benefit procedure with fewer blood transfusion requirements. This study was performed to evaluate transfusion patterns in OPCAB due to the diversity of transfusion practices.

Materials and Methods: This retrospective study was performed to determine the transfusion rate and triggers in OPCAB patients. Medical files of all patients undergoing OPCAB surgery at Sanandaj Tohid Hospital in 2014 were reviewed. Patients' demographics data, preoperative laboratory tests (PT, aPTT, Hb, Hct, Platelet count), underlying medical conditions, and their possible relation to further transfusions and the ward department in which the transfusion had taken place were extracted. SPSS 16 Chicago software, T-student Test, One Way Anova, and χ2 exam were applied for data analysis. P values ≤0.05was considered significant.

Results: Among 91 elective OPCAB patients: 28(30.8%) women and 63(69.2%) men with mean age of 64.80±9.02 years, 63(69.23%) received a blood product. Mean utilization of PRBC, FFP, Platelet, and Cryoprecipitate were 2.17±2.044, 2.46±2.86, 2.86±3.80 and 0.40±2.10 units, respectively. ICU revealed the highest consumption rate for all products. Female sex ($p<0.001$), Hypertension ($P=0.002$), and low hemoglobin($P=0.004$) were noted as predictive factors for transfusion.

Conclusion: This study concluded that the transfusion rate in OPCAB is still very high in Iran (regarding a study in a countryside hospital) and that the highest utilization rate is seen in the ICU.

Keywords: Cardiac surgical procedure; Blood transfusion; Coronary artery bypass; Off-pump

INTRODUCTION

Cardiac surgery is one of the most blood products consuming operations. Transfusion rate in cardiac surgery is reported to be as %40-90[1]. Transfusion is also considered as the most common therapeutic medical approach in all surgical departments accounting for about 20% of the 13.8 million units of whole blood and red blood cells of all types and 2.2 million units of Platelets, 3.9 million units of Plasma, 1.1 million units of Cryoprecipitate, transfused in the United States annually [2].

Cardiac surgery also by itself is a major risk for excessive bleeding because of operation-induced iatrogenic injury, as well as acquired hemostatic defects and impaired platelet function due to cardiopulmonary bypass (CPB) employment in the on-pump coronary artery bypass (ONCAB) procedure and preoperative antiplatelet drug therapies and all may lead to surgical re-exploration. Thus, packed red blood cells (PRBCs), fresh-frozen plasma (FFP), and platelets (PLTs) are commonly ordered and transfused for the treatment of bleeding in these settings[3].

The time-honored gold standard for coronary artery bypass graft (CABG) cardiac surgery was an on- pump procedure with CPB; however, off-pump coronary artery bypass (OPCAB) is also a safe, cost effective procedure with a rather similar 30-day mortality. It is probably due to fewer blood transfusions, shorter intubation periods, and shorter ICU and hospital stays attributed to OPCAB[4]. It is still unclear which particular patient population would benefit mostly from OPCAB, but recent studies have shown that patients with higher risks may benefit more. Hospital management structure, surgeons' technical skills (surgeon identifiers), and number of OPCABs performed in a center may have an actual role. OPCAB has also been associated with a significant reduction in adverse events [5, 6].

Since employment of CPB and Heparin administration is associated with persistent micro vascular bleeding in cardiac surgery patients, FFP and Platelets are frequently prescribed empirically in this setting [7]. Additionally, the rate of transfusion varies greatly in national and international settings (in spite of implemented guidelines) [3], in different institutions (inter institutional)[8] and among surgeons with divergent surgical skills and experiences[9]. The variation in transfusion rates indicates a lack of general agreement on the indication for transfusion triggers in certain clinical conditions[7]. Perioperative transfusion practice patterns for red blood cells (RBCs), fresh-frozen plasma (FFP), and platelets (PLTs) prescription shows a discrepancy in different countries and institutes as well [9].

At present, cardiac surgery in Iran is routinely performed nationwide. Given that OPCAB procedure might require less transfusions and according to the diversity of transfusion practice among different surgeons and various hospitals (according to their type and location), we performed a descriptive study to evaluate the rate and pattern of transfusion practice.

MATERIALS AND METHODS

Medical files of all patients undergoing elective CABG during the entire year of 2014 at Sanandaj Tohid Hospital were investigated in a descriptive, retrospective study. No strict intraoperative protocol and/or autologous transfusion method was implemented for the duration of the study. All information, including patients' demographic data such as age, sex, preoperative laboratory tests related to transfusion (PT, aPTT, Hb, Hct, Platelet count), and the number of transfused PRBC, FFP, Platelet, and Cryoprecipitate units, underlying medical conditions, and baseline clinical characteristics (such as the history of Hypertension, Diabetes Mellitus, Acute Myocardial Infarction(MI<4wks), Hypercholesterolemia, Stroke, Congestive Heart Failure(CHF), Chronic Obstructive Pulmonary Disease (COPD), End Stage Renal Disease (ESRD, Creatinine>1.7mg/dl), and their possible relation to further transfusions) were investigated. Moreover, the ward department in which the transfusion had taken place (operation room, ICU, cardiac surgery ward) was extracted. Patients were assessed as receiving perioperative transfusion or not. We also categorized our patients, according to their preoperative Hb level and Platelet counts, into three groups; For Hb: (Hb<8g/dl, Hb 8-10g/dl, and Hb more than10 g/dl), and for Platelet counts: (Plt <100 x 10^3 /µl, Plt 100-150 x 10^3 /µl and Plt>150x 10^3 /µl) to evaluate perioperative blood products utilization rate.

Statistical analysis

SPSS 16 Chicago software was applied for data analysis. Results were presented as absolute and relative frequency, mean, and standard deviations. T-student Test, One Way Anova, and χ^2 exam were applied to compare mean and standard deviation, proportion of categorical variables were compared in contribution to the transfusion administration, respectively. P values ≤0.05 were considered statistically significant.

RESULTS

Files of 91 elective off-pump cardiac surgery patients, 28 (30.8%) women and 63 (69.2%) men with a mean age of 64.80±9.02 years were evaluated for blood products utilization status (PRBC, Platelet concentrate, FFP, and Cryo precipitate). Of 91 cardiac surgery patients, 63(69.23%) received at least one blood product. Therefore, 55 patients received PRBC, 44 received FFP, 33 received Platelet, and five received Cryoprecipitate (Cryo) in general.

Number of transfused PRBC units ranged between 1 to 9 units. The total mean of PRBC utilization was 2.17±2.04 units (2.46±2.04 units in women and 2.00±2.05 units in men) (p=0.8). Mean utilization in the operating room, ICU, and cardiac surgery ward were 0.86±1.24, 1.13±1.46 (p=0.2), and 0.19±0.56 units, respectively (P<0.001).
Number of transfused Platelet units ranged between 3 to 21 units. The total mean of platelet utilization was 2.86±3.80 units (2.00±3.28 units in women and 3.38±4.05 units in men) (P=0.2). Platelet utilization in the operating room, ICU, and cardiac surgery ward were 2.66±3.15, 3.20±4.60, and 0.11±0.67 units, respectively (P<0.001).
Number of transfused FFP units ranged between 2 to 13 units, and the total transfused units mean and standard deviation was 2.46± 2.86 units (1.96±3.38 units in women and 2.77±2.49 units in men) (p= 0.2). FFP utilization in the operating room, ICU, and cardiac surgery ward were 2.18± 2.69, 2.49±3.26 (p= 0.5), and 0.10±0.44 units (p<0.001), respectively. Regarding the findings of our study, FFP utilization was utmost in the ICU, followed by the operation room, and only one patient received FFP in the cardiac surgery ward.
Finally, the number of transfused Cryoprecipitate units ranged between 2 to 18 units, and the mean of Cryoprecipitate transfusion was found as 0.40±2.10 units. One patient had received 10 units of cryoprecipitate in the operating room, four patients had been transfused by 18, 3, 5, and 4 units of cryoprecipitate in the ICU, and there were no patients receiving cryoprecipitate in the cardiac surgery ward. Total transfusion rates based on demographic characteristics and underlying diseases are presented in Table 1. Moreover, the transfusion rates were compared based on the preoperative laboratory findings, including PT, aPTT, Hb, and Platelet counts, and the results are provided in Table 2.
We noticed that females and hypertensive patients were at higher risk for transfusion needs, and preoperative Hb level was accounted as a predictor for transfusion in general.
Patients were categorized according to their preoperative Hb level and Platelet counts into three groups: For Hb: Hb<8g/dl, Hb 8-10g/dl, and Hb more than10 g/dl were classified as Severe, Moderate, and Mild Anemia, respectively. The prevalence of Anemia is presented in Table 3.
For Platelet count: Plt<100 x 10^3 /µl, Plt 100-150 x 10^3 /µl, and Plt>150x 10^3 /µl were classified as class 1 to 3, respectively, and transfusion rates were compared. Results are shown in Table 4.
Moreover, Table 5 illustrates the overview of the whole transfusion pattern in one year, focusing on the number of transfused patients attributed to the number of each blood product.

Table 1: Variables associated with all transfused products

Variable	Total	Transfused	Non-Transfused	p
Age	64.8±9.02	64.8±8.8	64.6±9.3	P=0.9
(Sex)Female/Male	28/63(42%)	24/39(61%)	4/24(16%)	p<0.001
Diabetes Mellitus	21/70(30%)	16/47(34%)	5/23(21%)	p=0.2
Hypertension	36/55(65%)	28/35(80%)	8/20(40%)	P=0.002
Hypercholesterolemia	3/88(3.4%)	3/60(5%)	0/28(0%)	p=0.2
COPD	6/85(7%)	5/58(8.6%)	1/27(3.7%)	P=0.4
CVA	1/90(1.1%)	1/62(1.6%)	0/28(0%)	p=0.5
MI<4 weeks	12/79(15%)	9/54(16.6%)	3/25(12%)	P=0.57
CHF	5/86(5.8%)	5/58(8.6%)	0/28(0%)	P=0.11
ESRD	4/87(4.5%)	2/61(3.2%)	2/26(7.6%)	P=0.3
Hypothyroidism	2/89(2.2%)	2/61(3.2%)	0/28(0%)	P=0.3
variable	Total	Transfused	Non-Transfused	p-value
Age	64.8±9.02	64.8±8.8	64.6±9.3	P=0.9
(Sex)Female/Male	28/63(42%)	24/39(61%)	4/24(16%)	p<0.001
Diabetes Mellitus	21/70(30%)	16/47(34%)	5/23(21%)	p=0.2
Hypertension	36/55(65%)	28/35(80%)	8/20(40%)	P=0.002
Hypercholesterolemia	3/88(3.4%)	3/60(5%)	0/28(0%)	p=0.2
COPD	6/85(7%)	5/58(8.6%)	1/27(3.7%)	P=0.4
CVA	1/90(1.1%)	1/62(1.6%)	0/28(0%)	p=0.5
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ESRD	4/87(4.5%)	2/61(3.2%)	2/26(7.6%)	P=0.3
Hypothyroidism	2/89(2.2%)	2/61(3.2%)	0/28(0%)	P=0.3

Table 2: Preoperative lab findings in Off-pump cardiac surgery patients

Lab Findings	Mean Preoperative PT/s	Mean Preoperative PTT/s	Preoperative Hb gr/dl	Preoperative Platelet count/μl
Transfused	12.9±1.4	42.2±17.7	11.82±2.05	196.00±67.00x10^3
Reserve	12.80±1.60	39.40±17.80	13.20±2.10	208.28±67.5x10^3
P	P=0.7	P=0.4	P=0.0046	P=0.4

Table 3: Preoperative Hb levels in transfused patients

Utilization	Preoperative Hb level			Total	P
	Less than 8 mg/dl	**8-10 mg/dl**	**More than 10 mg/dl**		
Reserve	0	0	28	28	
Transfused	2	11	50	63	0.01
Transfusion rate	100%	100%	64.1%	69.1%	
Total	2	11	78	91	

Table 4: Preoperative platelet count in transfused patients

Utilization	Preoperative Platelet Count			Total	P value
	Less than 100x10^3 /µl	100 -150 x 10^3 /µl	More than 150 x 10^3 /µl		
Reserve	0	0	28	28	
Transfused	2	11	50	63	
	100%	100%	64.1%	69.2%	0.01
Transfusion rate	2	11	78	91	
Total	0	0	28	28	

Table 5: One-year pattern of transfused blood products

Transfused product unit	Number of patients	Percent
PRBC units:		
0	7	11.1
1	21	33.3
2	21	33.3
3	5	7.9
5	3	4.8
6	2	3.2
7	2	3.2
9	2	3.2
Total	63	100
FFP units:		
0	28	44.4
2	5	7.9
3	10	15.9
4	8	12.7
5	6	9.5
6	1	1.6
7	1	1.6
8	2	3.2
11	1	1.6
13	1	1.6
Total	63	100
Platelet units:		
0	31	49.2
3	6	9.5
4	10	15.9
5	8	12.7
6	1	1.6
7	1	1.6
8	2	3.2
9	1	1.6
11	1	1.6
12	1	1.6
21	1	1.6
Total	63	100

DISCUSSION

The present survey evaluated blood product utilization in 91 off-pump CABG patients in a countryside hospital in Iran. No method and protocol of autologous transfusion intraoperatively was implemented during the study. Among all 91 cardiac surgery patients, 63(69.23%) were transfused with at least one blood product.

According to the present study, the mean transfused PRBC, regardless of where the transfusion had taken place was 2.17±2.04 units, with the ICU showing the highest PRBC transfusion rate (mean 1.13±1.46 units).

In addition, the mean of Platelet, FFP, and Cryo utilization were 2.86±3.80, 2.46± 2.86, and 0.40±2.10 units, respectively. All these products have also been consumed at the highest rate in the ICU (3.20±4.60, 2.49±3.26, and 0.30±1.95 units).

Patient characteristics and underlying preoperative medical conditions play a vital role in transfusion; however, we declare that among several investigated background variables, only the female sex ($p<0.001$) and Hypertension ($P=0.002$) proved to show a significant relation to blood product transfusion requirements. Moreover, the only preoperative laboratory test that seemed to have a significant relationship with the probability of needing a blood transfusion, intra, and post-operation period, was hemoglobin level ($P=0.004$).

The results of the study showed preoperative severe anemia (Hb<10g/dl) in 13 patients (14.3%) and thrombocytopenia (Plt<100x10^3µl) in 2 (2.2%) of 91 patients. The rate of RBC, platelet, FFP, and cryoprecipitate utilization was 1-9, 3-21, 2-13, and 2-18 units, respectively.

As CPB and aortic manipulation have deleterious effects on patients, interest in off-pump coronary artery bypass (OPCAB) is increasing (since 1980), while the majority of CABG worldwide is still performing as on-pump (ONCAB). It is still unclear which patient population will benefit mainly from OPCAB, but recent studies have shown that higher-risk patients may benefit more. Hospital policies, the technical skills of surgeons, number of OPCABs performed in a center may have an actual role in blood product utilization. OPCAB has been associated with a significant reduction in adverse events such as the risk of operative mortality, acute myocardial infarction, stroke, acute renal failure, morbidity, and length of hospital stay compared to ONCAB in many studies, especially in high-risk patients [5, 6, 9,10]. On the other hand, Zubarevich et al. reported that ONCABG was superior to OPCAB because of shorter procedure time and less severe adverse effects in cases of multi-vessel coronary artery revascularization[11].

The American College of Cardiology/American Association for Thoracic Surgery recommended OPCAB in renal insufficiency patients. In addition, they considered reducing perioperative bleeding and the need for transfusions in this specific group of patients[12]. In this regard, in some countries such as Japan, most CABG procedures are now performed by OPCAB rather than ONCAB, the frequency ranging from 65 to nearly 100%, according to the institution[13].

However, Lamy A. et al. showed that OPCAB reduced the rate of blood product transfusion, reoperation for perioperative bleeding, acute renal injury, and respiratory complications, and it was associated with an increased rate of early repeat revascularizations[14]. Apart from mortality benefits, OPCAB was associated with lower cardiac enzyme release, fewer transfusions, and shorter lengths of hospital stay in comparison to low and high-risk patients[15].

Off-pump surgery is also associated with reduced or eliminated blood product transfusions. Hematocrit level usually remains more stable postoperatively in the OPCAB procedure. Finally, conventional CABG characterizes by higher postoperative drainage, possibly due to more serious coagulation abnormalities. Furthermore, the same study showed the mean RBC utilization as 2.31 ± 0.18 units per patient and the mean FFP utilization of 1.13 ± 0.13 units in 84 elective off-pump CABG patients. Twelve (14%) patients received no transfusion [16]. In the present research, we obtained mean RBC and FFP transfusion utilization of 2.17±2.04 and 2.46± 2.86 units among our patients, respectively. Additionally, 28(30.7%) of our patients did not transfuse any blood product.

In a study on 113 OPCAB patients by Chung et al., 65(57.5%) received RBC transfusions (mean 2.2±3.2

Units), 27 received intraoperative (mean 0.52±1.23 units), and 55 received postoperative (mean 1.74±2.8 units) transfusion. RBC transfusion was related to underlying patient diseases, including Diabetes Mellitus, low preoperative Hb level, renal failure, low body weight, and surgical factors[17]. Compared to our study, we obtained a mean intra-operative, ICU, and post-ICU (cardiac surgery ward) RBC transfusion rate of 0.86±1.24, 1.13±1.46, and 0.19±0.56, respectively, which seems to be close to the results of the abovementioned study, with low Hb level and hypertension presenting as patient factors for transfusion.

A retrospective study on 1055 OPCAB patients by Chen et al. surgeons' expertise revealed a reduction in transfusion rate from 74% to 41% over ten years[9].

EACTA (European Association of Cardiothoracic Anesthesiology) has reported that OPCAB may be associated with lower perioperative bleeding and reduced transfusion. It might be due to lower dosing of heparin, hemodilution, and blood trauma caused by CPB in ONCAB [18].

In an RCT by Puskas on 19101 patients comparing off-pump and on-pump CABG, RBC, and blood product transfusion rates were significantly lower in off-pump patients[19]. Concerning blood products other than RBC, FFP is also frequently utilized in cardiac surgery to reduce intensive bleeding. British guidelines clearly emphasize limiting FFP usage unless there are documented coagulation disorders[20]. In a study by Randal Covin et al. 1133 (37.3%) of 3034 patients undergoing CABG received a blood component transfusion. Of whom, 261(8.6%) received FFP, and 101(3.3%) patients received more than two units. However, in another study by Cote et al. on 4,823 CABG patients, 1,929 (40.0%) received postoperative RBC transfusions, and 889 (46.1%) received one or more units of FFP, PLT, or cryo. Compared to these studies, FFP utilization in our survey was much higher (2.46± 2.86). Most FFP units are generally used in the ICU, and their administration is to ensure hemodynamic stabilization. This high rate of FFP usage might be due to the prophylactic prescription of FFP[21], the retrospective nature of our study.

Boldt et al. conducted an RCT on 40 patients who received two prophylactic FFP units. Volume and intensity of bleeding and drainage, Hb, Hct, platelet count, PT, PTT Fibrinogen level, and Elastase evaluated on different occasions, including before anesthesia, 30 minutes before and 5 and 10 minutes, and 5 hours after CPB employment. [22].

In a study by Consten et al., three units of FFP were transfused to 50 cardiac surgery patients at the end of the operation, and Hb, Hct, platelet count, PT, PTT Fibrinogen level, and bleeding intensity were evaluated on occasions including pre-anesthesia,2,6,24 hours, and five days after protamine injection[23]. Consten also compared the infusion of 3 units of FFP with Gelofusine, and Wilhelmi compared to 4 units of FFP with Hydroxi ethyl starch [24]. The findings of 6 studies revealed no difference between blood loss with or without FFP transfusion, with a combined standardized mean difference reported as: -0.01 (95%CI: -0.22-0.20)[21]. In other studies, such as RCT by Boldt et al., patients receiving FFP showed lower PT levels, with a standardized mean difference of 0.14 (95%CI:-0.48-0.76) [24].

According to present guidelines, prophylactic FFP usage is not recommended in Cardiac surgery; however, FFP could be used in case of bleeding, coagulation disorders or following Heparin injection in this set of patients[25]. Among 6 RCTs targeted on clinical evaluation of prophylactic FFP usage, only 5 had an appropriate control group.

In these studies, FFP administration was entirely prophylactic; the amount of bleeding and coagulation tests did not consider following FFP transfusion[23,26]. In Martinowitz's study, FFP was administered following RBC [27].

Finally, no clinical trial was found to show the benefit of prophylactic FFP usage. Reviewed trials had small sizes and weak designs, and large sizes of well-qualified trials should be conducted [20].

The concentration of coagulation factors changes following cardiac surgery with CPB. It is reported that factors VIII and IX are decreased, possibly due to haemodilution. In addition, thrombin production capacity significantly decreases following cardiac surgery. Ex-vivo clot stability following plasma derived Fibrinogen injection is similar to administration of its recombinant form [28].

Point-of-care tests are helpful in the early detection of coagulation abnormalities, especially Fibrinogen level abnormalities. These tests will guide physicians in choosing the right product or drug intervention as needed [29].

FFP transfusion in cardiac surgery was associated with increased mortality in some studies[30]. In a prospective study in Australia on 25000 cardiac surgery patients, there was a significant difference in blood product usage of all types among different surgeons; however, differences among hospital types (private vs. public or with academic affiliation vs. otherwise) did not prove to be significant. Also, the pattern of PRBC utilization (Liberal vs. Restrictive) directly influenced other blood product usage[31] .

More recently introduced endoscopic atraumatic coronary artery bypass (endoACAB) technique, which is less invasive than OPCAB, has shown to be even less blood consuming than OPCAB, however it has been reported to be associated with a non-statistically significant higher incidence of revascularization procedures in patients treated with this technique[32].

Finally, we observed that blood product consumption in off-pump cardiac surgery patients in our study was much higher than expected. Ghavidel et al. showed that among 153 cardiac surgery patients, only 3.2% did not receive any blood product in their pre-operative course. This study also revealed much higher blood utilization in CABG patients compared to other countries[33]. It is essential to use standard transfusion protocols, guidelines, and patient blood management (PBM) programs. Moreover, the present study was affected by some limitations. The limitation of this study was its retrospective nature, negatively influencing active data gathering. In addition, we might not have considered some variables that may affect our decision to perform a transfusion on a patient. Besides, although we studied all patients undergoing off-pump-CABG during the study period, our sample size was not large enough.

CONCLUSION

This study revealed that 63 out of 91 OPCAB patients were transfused by a blood product, with a total transfusion rate of 69.23%. Total PRBC utilization in our patients was 2.45±2.02 units, with the highest rate noted in ICU (1.29±1.49 units). Meanwhile, the mean Platelet, FFP, and Cryo utilization was 2.86±3.80, 2.46± 2.86, and 0.40±2.10 units, respectively, all showing the highest utilization rate of usage in ICU. Female sex ($p<0.001$), hypertension ($P=0.002$), and low Hb level ($P=0.004$) could be mentioned as predisposing factors for being transfused. Severe anemia was detected in 13(14.3%) and thrombocytopenia in 2(2.2%) patients.

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