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Comparison of the effects of autologous and non-autologous blood transfusions on the advantages, disadvantages, extubation time and bleeding after coronary bypass

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ABSTRACT

Purpose: Blood transfusion; is considered an organ transplant. In coronary bypass surgery, large volumes of homologous blood transfusion may be required due to excessive bleeding. The large number of use of homologous blood transfusion in open heart surgery and the awareness of its various harmful effects have prompted researchers to conduct research on the use of autologous blood. With autologous transfusion, blood diseases, incompatibility, immunosuppression and organ damage can be prevented and the patient can be extubated earlier in the postoperative period.

Methods: Between January 2020 and January 2016, a total of 176 patients, 56 in the treatment group (with autologous blood transfusion) and 120 in the control group, whose information could be reached from hospital records were investigated retrospectively.

Results: No statistical difference was found between the mean intubation SO2 and PO2 values of the groups. On the contrary, considering the mean intubation times in the intensive care unit of both groups, the patients who underwent autologous blood transfusion were extubated at a statistically significant earlier time.

Conclusion: Autologous blood transfusion is a safe method in selected patients as well. Thanks to this method, patients are protected from complications associated with homologous blood transfusion. It is believed that performing autologous blood transfusion in selected patients undergoing open-heart surgery can decrease the number of postoperative transfusions, frequency of transfusion-related complications (especially in the lungs), and mean intubation times.

1. Introduction

The use of heparin in open-heart surgery may cause excessive intra- or postoperative bleeding [1]. Because of massive bleeding during coronary bypass surgery, large amounts of blood may be required through homologous blood transfusion. Blood transfusions are important, in that they prevent anemia, protect erythrocyte mass, and minimize blood loss [2]. Homologous blood transfusions are known to have side effects such as infection, immunosuppression, transfusion reactions, and organ damage. Blood transfusions have negative effects on postoperative mortality and morbidity because of their possible complications [3]. The widespread use of

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Abbreviations, Acronyms, and Symbols

ABG	arterial blood gas
CABG	coronary artery bypass graft
CPB	cardiopulmonary bypass
DM	diabetes mellitus
ECMO	extracorporeal membrane oxygenator
EF	ejection fraction
Hg	hemogram
Htc	hematocrit
LDL	low-density lipoprotein
Plt	platelet
PO2	partial oxygen pressures
SO2	oxygen saturation
TRALI	transfusion-related acute lung injury

homologous blood transfusion in open-heart surgery, despite its various harmful effects, has led researchers to investigate the use of autologous blood transfusion. A variety of methods have been developed to reduce the need for blood transfusions. One of these is autologous blood transfusion, which is the collection of blood from the patient prior to surgery and then transfusing it back to the same patient when needed. This method can easily be performed in many centers and can reduce the side effects that may occur in patients prone to excessive bleeding during surgery. It can also prevent blood diseases, incompatibility, immunosuppression, and organ damage. With this technique, the number of blood transfusions can be reduced, and a more efficient use of existing blood stocks can be achieved.

Conducted with the approval of our hospital's scientific committee, this study aimed to compare hematocrit (Htc) values and postoperative tube drainage, homologous blood transfusion requirements, extubation times in the intensive care unit, and morbidity and mortality in patients undergoing coronary bypass surgery with and without autologous blood transfusion. Specifically, it examined the effect of autologous blood transfusion on decreasing the need for postoperative blood transfusion and extubation times in the intensive care unit.

2. Materials and methods

The study data were obtained by searching retrospective patient files and hospital data, with the permission of the ethics committee. We investigated the data gathered from the hospital records of patients admitted for surgery between January 2016 and January 2020. There were 176 patients in all, 56 in the treatment group (with autologous blood transfusion) and 120 in the control group.

2.1. Study design

This study was retrospective and involved two groups. All patients had undergone coronary bypass surgery in our hospital's cardiovascular surgery clinic. As noted above, the treatment group comprised 56 patients whose inclusion criteria are detailed below. The control group comprised 120 random patients who underwent coronary bypass surgery without autologous blood transfusion. In the treatment group, a hematocrit value of over 35% and an ejection fraction (EF) value of 40% or more were determined as the basic criteria for inclusion in the study; patients who did not meet these criteria were not investigated. These criteria were not applied to the control group.

Criteria for inclusion in the treatment group: The inclusion criteria for the treatment group, which involved patients undergoing autologous blood transfusion, were set as an Htc value of 35% or above and an EF value of at least 40%.

One unit of whole blood was collected from each of the patients in the treatment group in a controlled manner the day before surgery, and the collected blood was stored in the blood center for use the next day. Arterial catheterization was performed in the patients who were anesthetized in the operating room. Then, the patients' autologous blood was collected as one unit of whole blood (two units of whole blood in total) within approximately 20 min by checking their systolic blood pressure at frequent intervals and taking into account their level of vital signs. The collected blood was then stored in the required storage conditions. Care was taken to maintain systolic blood pressure higher than 90 mmHg during autologous blood collection. Following decannulation, heparin neutralization, and surgical closure in the treatment group, the collected autologous blood was transfused to the patients through the central venous route.

All coronary bypass procedures were performed according to standard surgical methods by a surgical team with the same educational background. Patients who had intraoperative complications, needed ECMO support, underwent an intervention other than coronary bypass surgery, had to undergo cardiopulmonary bypass (CPB) again, had more than expected bleeding and thus underwent massive transfusion, or who could not tolerate blood collection were excluded from the study. Likewise, those who underwent revision surgery for any reason during the postoperative period were excluded.

The pre-, intra-, and postoperative intensive care values of the patients were noted. Their postoperative follow-up and treatment continued in the cardiovascular surgery intensive care unit. During intensive care follow-up and treatment, no homologous blood transfusions were performed unless Htc values fell below 30%. Htc values, tube drainage, homologous blood transfusion requirements, hospitalization times, extubation times, oxygen values (oxygen saturation [SO2] and partial oxygen pressures [PO2]), and comorbidities affecting the morbidity and mortality of patients in the intensive care unit were recorded and compared. The effect of autologous blood transfusion on reducing the need for blood transfusion and extubation time in the postoperative period was examined.

2.2. Definitions

Autologous transfusion was defined as the collection and reinfusion of the patient's own blood. Extubation time was defined as the time taken for the patient to be anesthetized and intubated in the operating room and extubated in the cardiovascular surgery intensive care unit. Coronary artery bypass graft (CABG) surgery was defined as a surgical procedure that creates a new pathway for blood to flow around an occluded or partially blocked artery in the heart. Bleeding was defined as a decrease or loss of blood volume detected in patients after a coronary artery bypass graft operation. The *P*-value is used in the context of null hypothesis testing to quantify the of a result, the result being the observed value of the chosen statistic. EuroSCORE is the European System for Cardiac Operative Risk Evaluation, a risk model that allows the calculation of the risk of death after a heart operation. Body mass index (BMI) is a value derived from mass (weight) and height of a person. The BMI is defined as the body mass divided by the square of the body height and is expressed in units of kg/m2, resulting from mass in kilograms and height in metres.

2.3. Statistical analysis

Statistical analyses were performed by using SPSS 21.0 (IBM Statistical Package for Social Sciences version 21.0, Chicago, IL, USA). The student's t-test was used for numerical values with normal distribution. Descriptive data were expressed as mean ± standard deviation (SD), median (min-max), or number and frequency. Group comparisons of numerical data were made with the Mann-Whitney *U* test, and group comparisons of categorical data were made using the chi-square test. A two-way *p*-value of less than 0.05 was considered a statistically significant difference.

3. Results

3.1. Treatment group

Among the patients in this group, 38 (67%) were male and 18 (33%) were female. The mean age was 60.7 ± 5.9 years, the mean BMI was 27.4 ± 4.2 kg/m^2, and the mean EF was 54.2 ± 6.4%. The most prevalent accompanying risk factors were recorded as smoking (n = 40, 71%), hypertension (n = 28, 50%), and diabetes mellitus (DM; n = 22, 39%). The mean EuroSCORE of the patients was calculated as 3.4 ± 2.0. Preoperative laboratory values were as follows: creatinine: 1.1 mg/dl; low-density lipoprotein (LDL): 138 ± 34 mg/dl; hemogram (Hg): 15.6 ± 0.4 g/dl; Htc: 45.1 ± 3.2; and platelets (Plt): 296,000. Intraoperative values were as follows: mean number of graft anastomoses: 2.8 ± 0.5; mean CPB time: 125.8 ± 20.4 min; mean aortic clamp time: 66.8 ± 14.4 min; and mean bleeding amount: 600 ± 180 ml. Postoperative intensive care values were as follows: mean number of transfusions performed: 2.4 ± 0.4; mean amount of drainage: 875.4 ± 350.5 ml; and mean length of stay in the intensive care unit: 3.6 ± 1.8 days.

A total of two units of whole blood were collected from all patients during the preoperative period. The extubation times and PO2 values of the patients who underwent autologous blood transfusion were as follows: the mean extubation time was 345 ± 45 min; the mean SO2 and PO2 values in arterial blood gas (ABG) at the first hour of intubation in the intensive care unit were 98% and 85 mmHg, respectively; the mean SO2 and PO2 in ABG before extubation were 98% and 88 mmHg, respectively; and the mean SO2 and PO2 in ABG 15 min following extubation were 96% and 80%, respectively.

3.2. Control group

Among the patients in this group, 84 (70%) were male and 36 (30%) were female. The mean age was 59.3 ± 5.4 years, the mean BMI was 28.4 ± 2.2 kg/m2, and the mean EF was 50.8 ± 7.2%. The most prevalent accompanying risk factors were recorded as smoking (n = 77, 64%), hypertension (n = 45, 38%), and DM (n = 34, 28%). The mean EuroSCORE of the patients was calculated as 4.0 ± 2.2. Preoperative laboratory values were as follows: creatinine: 1.1 mg/dl; LDL: 152 ± 28 mg/dl; Hg: 13.2 ± 0.8 g/dl; Htc: 37.6 ± 3.0; and Plt: 284,000. Intraoperative values were as follows: mean number of graft anastomoses: 2.9 ± 0.4; mean CPB time: 130.2 ± 18.2 min; mean aortic clamp time: 70.0 ± 24.8 min; and mean bleeding amount: 720 ± 200 ml. Postoperative intensive care values were as follows: mean number of transfusions performed: 2.6 ± 0.8; the mean amount of drainage: 950.8 ± 420.2 ml; and mean length of stay in the intensive care unit: 4.0 ± 1.6 days.

The extubation times and PO2 values of the patients in the control group were as follows: the mean extubation time was 385 ± 35 min; the mean SO2 and PO2 values in ABG at the first hour of intubation in the intensive care unit were 98% and 88 mmHg, respectively; the mean SO2 and PO2 values in ABG before extubation were 98% and 85 mmHg, respectively; and the mean SO2 and PO2 values in ABG 15 min after extubation were 96% and 78%, respectively.

3.3. Comparison of groups

No statistical differences were found between the groups' mean intubation SO2 and PO2 values. On the contrary, considering the mean intubation times in the intensive care unit of both groups, those patients who underwent autologous blood transfusion were extubated at a statistically significant earlier time. Table 1 presents both groups' demographic characteristics and preoperative data, Table 2 shows intraoperative data, Table 3 shows postoperative data, and Table 4 shows Htc values at four different times.

4. Discussion

The vital value of blood has been well-known since ancient times. Blood transfusion can be regarded as organ transplantation. It should be performed if deemed unavoidable after careful assessment. The most critical purpose of blood transfusion is to prevent the insufficiency of cardiopulmonary compensation mechanisms due to anemia. The recent increase in the number of centers performing coronary artery surgery, technological opportunities, and the number of patients undergoing surgery has led to an increase in the number of blood transfusions. This increase in the number of transfusions has also increased the frequency of side effects. In hospitals, surgery departments are the units where blood transfusions are most often performed. Because of the known complications of homologous blood transfusion, inexpensive and reliable alternatives have been investigated. Many methods are used to reduce the bleeding caused by complex mechanisms; one of these is autologous blood transfusion. Autologous blood transfusion is the only blood transfusion method that does not cause transfusion-related complications.

As is the case in all surgical interventions, the surgeon must protect the patient as much as possible from known complications during CABG surgery. CABG is one of the surgeries in which multiple blood transfusions are performed. One way to protect the patient from complications related to blood transfusions is to use as few homologous blood transfusions as possible, or to use autologous blood transfusions as much as possible, if certain criteria are met. In this study, we investigated the effects of autologous blood transfusion on blood loss and extubation time and the advantages and disadvantages of autologous blood transfusion compared to non-autologous blood transfusion in patients who underwent CABG surgery. We examined whether an autologous blood transfusion is beneficial in patients who underwent CABG. The results demonstrated that autologous blood transfusion has significant benefits in patients undergoing CABG and protects them against many transfusion-related complications. The amount of bleeding after the operation is low, extubation time is short, there is less organ damage, the duration of stay in the intensive care and hospital are reduced, and mortality rates are lower because the morbidity and complication risks are reduced.

This study demonstrated that the donation of autologous blood is an effective practice for reducing allogeneic blood transfusions in cardiac surgery at an acceptable cost. With autologous blood transfusion, the risks and complications associated with allogeneic blood transfusion are reduced, as are the costs associated with blood products. This contributes to the preservation of the blood pool for patients in need of blood transfusion. The advantages of autologous blood transfusion and the complications of homologous blood transfusion are presented in Table 5.

Autologous blood transfusion aids in the conservation of blood in blood bank stores and, consequently, the use of these stores by patients requiring blood transfusion. Despite the availability of several methods to reduce the number of blood products needed during open-heart surgery, the use of homologous blood remains quite common, even though using large amounts of homologous blood can increase the number of complications that may occur after cardiac surgery. In recent years, positive results have been obtained with an increasing number of autologous blood transfusions, which has been the subject of growing interest.

Bleeding occurring after coronary bypass surgery is a serious condition and typically leads to a large number of blood transfusions. Given that homologous transfusions are foreign material initially belonging to someone else, treating patients who need them requires medical professionals to be ready for any related problems that may arise. Although standard tests are performed, blood stored in blood banks may still carry the risk of transmitting infections. A study by Siraj et al. [4] examined the blood collected from 60,236 donors and

Table 1
Demographic characteristics and preoperative data of the patients.

Parameters	Treatment group ($n = 56$)	Control group ($n = 120$)	p
Age (years)	60.7 ± 5.9	59.3 ± 5.4	0,329
Gender:			
Male, n (%)	38 (67)	84 (70)	0,314
Female, n (%)	18 (33)	36 (30)0,354	
BMI (kg/m^2)	27.4 ± 4.2	28.4 ± 2.2	0,289
Smoking, *n* (%)	40 (71)	77 (64)	0,147
Hypertension, *n* (%)	28 (50)	45 (38)	0,089
DM, *n* (%)	22 (39)	34 (28)	0,105
EF (%)	54.2 ± 6.4	50.8 ± 7.2	0,254
Creatinine (mg/dl)	1.1 ± 0.2	1.1 ± 0.3	0,836
LDL (mg/dl)	138 ± 34	152 ± 28	0,156
Hemogram (g/dl)	15.6 ± 0.4	13.2 ± 0.8	0,072
Hemotocrit (%)	45.1 ± 3.2	37.6 ± 3.0	0,039
Platelet	296,000 ± 75,000	284,000 ± 92,000	0,198
EuroSCORE	3.4 ± 2.0	4.0 ± 2.2	0,056

BMI: body mass index, DM: diabetes mellitus, EF: ejection fraction, LDL: low-density lipoprotein.

Table 2
Intraoperative data of the patients.

Parameters	Treatment group	Control group	p
Distal anastomosis (*n*)	2.8 ± 0.5	2.9 ± 0.4	0,836
CPB time (minutes)	125.8 ± 20.4	130.2 ± 18.2	0,542
Aortic clamp time (minutes)	66.8 ± 14.4	70.0 ± 24.8	0,418
Bleeding amount (ml)	600 ± 180	720 ± 200	0,132

CPB: cardiopulmonary bypass.

Table 3
Postoperative data of the patients.

Data	Treatment group	Control group	p
Drainage in the ICU (ml)	875.4 ± 350.5	950.8 ± 420.2	0.238
Blood transfusion (*n*)	2.4 ± 0.4	2.6 ± 0.8	0.076
Length of stay in the ICU (days)	3.6 ± 1.8	4.0 ± 1.6	0.128
Mean intubation time (minutes)	345 ± 45	385 ± 35	0,045
Intubation in the ICU:			
First hour (SO2, PO2)	98% ± 2%, 85 ± 10 mmHg	98% ± 2%, 88 ± 8 mmHg	0.872,0.894
Before extubation (SO2, PO2)	98 ± 2%, 88 ± 10 mmHg	98% ± 2%, 85 ± 10 mmHg	0.898,0.810
After extubation (SO2, PO2)	96% 3%±, 78 ± 12 mmHg	96% ± 3%, 75 ± 10 mmHg	0.876,0.754

ICU: intensive care unit, SO2: oxygen saturation, PO2: partial oxygen pressure.

Table 4
Hematocrit data of the patients in four different periods.

Hematocrit values (g/dl)	Treatment group	Control group	p
Preoperative	42.1 ± 3.2	37.2 ± 2.4	0.372
Intraoperative	20.4 ± 4.0	25.5 ± 3.5	0.256
Postoperative	30.2 ± 2.8	27.6 ± 3.2	0.182
ICU	30.6 ± 2.2	28.2 ± 2.4	0.094

ICU: intensive care unit.

Table 5
Advantages of autologous blood transfusion and complications of homologous blood transfusion.

Advantages of autologous blood transfusion	Complications of homologous blood transfusion
-No risk of incompatibility	-Febrile reactions
-No risk of alloimmunization	-Allergic reactions
-No risk of immunosuppression	-Circulatory overload
-No risk of infection	-Hemolytic transfusion reactions
-Donor blood is used in patients requiring blood transfusion	-TRALI
-More economical	-Immunological complications

TRALI: transfusion-related acute lung injury.

reported the presence of multiple infections in 0.1% of the blood in subsequent examinations, even though serology tests had yielded clean results. Blood transfusion must be performed carefully. Transfusions increase postoperative mortality and morbidity in patients undergoing bypass surgery [5]. In the present study, we found that an increased number of transfusions also increased the level of risk for patients. Early mortality increases after blood transfusion, and infections and renal, neurological, and cardiological complications are more common during the postoperative period [6]. Still, performing as many blood transfusions as is necessary during coronary bypass surgery can be effective for reducing the development of many complications [7]. Donor blood has a limited life span and may deteriorate gradually when stored. Some studies [8] have reported that receiving even one unit of transfused blood can lead to many complications. Another study that investigating techniques to reduce blood use in cardiac surgery compared the results of autologous transfusion with those of the control group and found no significant differences in surgical outcomes, complications, and other outcomes [9]. However, in this study; we found that the extubation times were shorter in patients who received autologous blood transfusion and this was statistically significant. Techniques such as perioperative plasmapheresis —returning blood from the patient's tube drainage to the patient—and hemofiltration are among the cost-effective methods that reduce the need for homologous blood transfusion [9].

Another important side effect of homologous blood transfusion is transfusion-related acute lung injury (TRALI), which occurs following transfusion. Because it is a little-known complication, its diagnosis is often missed. TRALI is a serious complication. Its

prevalence is greatest in patient populations at risk (in patients with multiple blood transfusions) especially those who are critically ill. Although its exact prevalence is not known, it is estimated to occur in between 1/5000 and 1/300 patients. This complication, with a mortality rate of 10%, is the most prevalent cause of transfusion-related death after a hemolytic reaction [10]. It usually occurs within the first 4–6 h following the start of transfusion. TRALI's common symptoms include fever, hypotension, tachypnea, dyspnea, and pulmonary infiltrates visible on a chest radiograph. Respiratory problems are a result of increased pulmonary vascular permeability and subsequent pulmonary edema. Although its etiopathogenesis is not fully known, there are two theories; the most accepted is that donor-derived *anti*-HLA antibodies react with the recipient's blood cells, causing the release of many inflammatory mediators and endothelial cell damage [11]. TRALI should also be considered in mechanically ventilated patients, when there is an acute, unexplained worsening of the respiratory state associated with blood transfusion [12]. No specific laboratory test is available for TRALI. A diagnosis requires the immediate discontinuation of homologous blood and blood products and supportive treatment. In a majority of cases, side effects are corrected by increasing ventilator support [13]; therefore, extubation times are prolonged in patients who undergo surgery.

In the present study, when preoperative data were compared, we noted a statistical difference between groups in terms of intubation time; however, there was no statistical difference in patients' demographic characteristics, accompanying risk factors, laboratory findings, EF, or EuroSCORE. Further, there was no statistically significant difference in intraoperative data, such as the number of distal anastomoses, CPB time, aortic clamp time, and amount of drainage. In addition, no statistically significant differences were found in the postoperative data, such as the amount of drainage, number of transfusions performed, or length of stay in the intensive care unit. No mortality was detected in either group. Considering the Htc values in all processes, we concluded that autologous blood transfusion failed to reduce the amount of blood transfusion needed in the postoperative period at a statistically significant level. No statistical differences were found between the mean intubation SO2 and PO2 values of the groups. By contrast, considering the mean intubation times in the intensive care unit patients in the two groups, those patients who underwent autologous blood transfusion were extubated at a statistically significant earlier time. When hospitals carefully review their existing guidelines on allogeneic blood transfusion and reduce the use of inappropriate blood transfusions in CABG recipients by increasing the number of autologous blood transfusions, postoperative safety and the comfort of patients undergoing CABG will likely be increased and complications will be reduced.

5. Conclusions

Autologous blood transfusion has gradually been attracting more attention, due to the increasingly prominent problem of blood transfusion safety and blood shortages in recent years. Autologous blood transfusion is a safe method in selected patients. With autologous blood transfusion, patients are protected from the complications associated with homologous blood transfusion. We also conclude that it is more effective than non-autologous transfusion for reducing the possibility of bleeding while in the intensive care unit, reducing the need for blood, it leads to earlier extubation, and provides high partial O2 values, thus causing facilitating mobilization and protecting the patient from serious lung damage. Further, autologous blood transfusion should be beneficial for reducing hospital costs. The use of the patient's own blood will also help to maintain the stock pool among patients who need blood and blood products. We recommend autologous blood transfusion, as we have determined that it can seriously reduce morbidity and mortality when applied in patients who meet the appropriate criteria, and it will have positive effects on the patient's early mobilization and postoperative comfort. Autologous transfusion appears to be a safe procedure for patients undergoing CABG surgery.

5.1. Limitations and strengths

The strengths of the study are that the surgical treatments were performed by a team with the same experience, and therefore the surgical procedures in the two groups were of the same standard, and there were no demographic differences between the study and control groups. The limitations of the study are that it is retrospective, data were obtained from hospital records and it is a single-center study.

Scientific consent

Scientific permission was obtained from the ethics committee of our hospital with registration number 2014/05–10. In studies conducted with the permission of the ethics committee in our country, the data of the patients are obtained from patient files and hospital data retrospectively.

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Authors contributions

Ziya Yıldız: Conceived and designed the experiments; Performed the experiments; Analyzed and interpreted the data; Contributed reagents, materials, analysis tools or data; Wrote the paper.

Mehmet Ali Kayğın: Conceived and designed the experiments; Performed the experiments; Analyzed and interpreted the data;

Contributed reagents, materials, analysis tools or data.

Data availability statement

Data included in article/supp. Material/referenced in article.

Additional information

No additional information is available for this paper.

Declaration of competing interest

We have no conflict of interest to declare.

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