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Impact of Pre-bypass Autologous Blood Collection on Blood Transfusion Rates

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Abstract: Pre-bypass acute autologous donation (PAAD) is a method of blood conservation that reduces exposure of blood to the cardiopulmonary bypass (CPB) circuit and may prevent the contact activation of platelets and clotting factors. The purpose of this study was to evaluate the impact of PAAD on product transfusion rates in cardiac surgical patients. This is a retrospective study of patients undergoing cardiac surgery between 2015 and 2017 for either a coronary artery bypass (CABG), valve replacement, or a combined valve/CABG procedure. PAAD was performed by removing blood from the venous line of the bypass circuit immediately before the institution of CPB. The amount of PAAD volume was determined during the surgical time-out. This was based on patient size, baseline hemoglobin, and type of case. Poisson logistic regression was used to determine whether PAAD was a significant predictor for blood product transfusion. After obtaining institutional review board approval, we reviewed 236 records on (n = 154, 65.3%) who received PAAD and (n = 82, 34.7%) with no blood withdrawal before CPB. The median PAAD volume in the PAAD group was 750 mL. Patients undergoing PAAD had a 14.3% red blood cell (RBC) transfusion rate (.27 ± .91 units), and without PAAD, the RBC transfusion rate was 62.2% (1.56 ± 1.79 units). The significant ($p < .05$) odds ratios (ORs) for RBC transfusion were as follows: baseline hemoglobin .617 (.530–.719), PAAD .998 (.997–.999), CPB time 1.009 (1.003–1.015), age 1.034 (1.013–1.055), and BSA odds ratio (OR) .326 (.124–.857). PAAD could not be used in all patients. However, using the OR in the Poisson logistic regression model, a one-unit reduction in RBC transfusion is predicted for each 500 mL of PAAD. PAAD was also associated with a significant reduction in fresh frozen plasma and platelet transfusion. **Keywords:** autologous donation, coagulation, cardiac surgery, cardiopulmonary bypass. *J Extra Corpor Technol. 2019;51:140–6*

INTRODUCTION

Despite the advancements made over the last several decades, cardiac surgery may be associated with significant blood loss requiring allogeneic blood transfusions (1,2). There are many documented risks connected directly with giving blood, including acute hemolytic transfusion reactions, transfusion-related acute lung injury (TRALI), transfusion-associated circulatory overload (TACO), and transfusion-transmitted viral infections (3–6). Transfusions can also influence postoperative factors such as prolonged ventilator time, length of stay, renal failure, stroke, heart failure, and mortality (5,7,8).

Blood conservation techniques have been developed to reduce the risks of blood transfusion. Techniques that reduce hemodilution on cardiopulmonary bypass (CPB) have also been proven to be useful in decreasing blood transfusion, including retrograde autologous prime, miniaturized circuits, and bloodless cardioplegia systems, together with the use of autotransfusion (8). The Society of Thoracic Surgeons guidelines recommend a combined approach of these several blood-saving techniques to best prevent blood loss and transfusion (9,10).

One technique to help minimize blood use is the removal of patient blood volume before bypass, often referred to as acute normovolemic hemodilution (ANH). ANH is performed by the anesthesiologist by slowly removing blood and replacing it with an equal amount of crystalloid or colloid (11). One of the

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main advantages of this hemodilution is that any blood that is lost during the case has lowered red cell volume, and therefore less is wasted (9). The hemodilution also creates a lowered blood viscosity, which can have increased benefits in terms of oxygen delivery through small blood vessels (12).

Another method of blood conservation is pre-bypass acute autologous donation (PAAD), which involves removing blood from the venous line after the surgeon has cannulated the aorta and right atrium. Unlike ANH, where the anesthesiologist replaces the patient's blood with crystalloid or colloids, the PAAD blood volume is not replaced. Many patients who are hemodynamically unstable are unable to tolerate ANH. These include patients with unstable angina, tight coronary lesions, or low ejection fractions (5). ANH is limited to patients with high hemoglobin levels, larger weight or body surface area (BSA), and without coagulopathies (13). These restrictions highlight the main difference between PAAD and ANH, which is the ability to immediately go on bypass if the patient cannot tolerate an acute decrease in blood volume. These patients may benefit most from the use of PAAD (9). Because PAAD volume is removed just before the onset of bypass, this provides a safety net that allows removal of blood volume in a larger population of patients. If the anesthesia team is unable to maintain adequate pressure or the patient becomes unstable, then PAAD is immediately stopped and bypass is initiated. Although not as slow as the typical withdrawal of ANH, PAAD is still removed gradually to avoid a decrease in arterial blood pressure.

Both PAAD and ANH reduce exposure of the patient's blood to the bypass circuit (9,14). Platelet activation normally occurs as the blood is circulated through the oxygenator, arterial filter, and tubing during bypass, and this reduces their number and functionality (5,6,15,16). Sparring the blood from this contact activation and mechanical stress may decrease in the need for platelet transfusion, result in better hemostasis, and decrease postoperative bleeding. The purpose of this retrospective study was to evaluate the impact of PAAD on product transfusion rates of all blood products in cardiac surgical patients.

METHODS

Following Institutional Review Board approval, data were collected on adult patients undergoing cardiac surgery between 2015 and 2017 on CPB. Baseline data included patient demographic data (height, weight, age, and gender), hemoglobin, and case type. Preoperative laboratory data reviewed included platelet count, fibrinogen, prothrombin time (PT), and activated partial thromboplastin time (PTT) within 48 hours of their surgery.

The amount of PAAD volume to be withdrawn was determined during the surgical time-out. The PAAD volume was based on the patient size, baseline hematocrit, and type of operative procedure. The formula for calculating the patient's dilutional hematocrit included estimated patient blood volume, pump prime, estimated anesthesia volume before bypass, and PAAD volume. If the resulting hematocrit after bypass initiation is calculated at 26% or lower, PAAD was not performed.

$$\mathrm{Hct_{Dil}} = \frac{\mathrm{Hct_{base}} \times (\mathrm{CBV\text{-}PAAD\ vol})}{(\mathrm{CBV} + \mathrm{Anes\ vol} + \mathrm{Prime\ vol})}.$$

The bypass circuit consisted of a Terumo System I heart-lung machine and Terumo Capiox FX15 with integrated arterial filter (or FX25 for larger patients), and a Terumo centrifugal pump head. The bypass circuit tubing is 3/8-inch Terumo X-coating (Terumo Cardiovascular Group, Ann Arbor, MI). The bypass circuit was primed with 1200 mL Plasma-Lyte A (Baxter, Deerfield, IL), 10,000 units of heparin, and 50 mEq of sodium bicarbonate.

PAAD was taken after a full loading dose (300 units/kg) of heparin was administered to the patient. As soon as the surgeon was fully cannulated and ready to go on bypass, the perfusionist slowly sequestered the blood while maintaining systolic blood pressure >90 mmHg. The patient's whole blood was removed by gravity using a ¼ inch tubing line connected to the venous line via a stopcock, draining into an empty, sterile blood transfer bag (Fenwal, Lake Zurich, IL). It was then stored at room temperature without agitation until ready to be transfused.

Before the initiation of bypass, retrograde autologous priming (RAP) was performed by drawing blood from the aortic cannula via an open sampling manifold and into the reservoir. Next, clear prime was drained into the venous reservoir and pumped into an empty intravenous solution bag used during priming. After RAP, the remaining priming volume was 600 mL. Mild hypothermia of greater than 34°C was maintained on all patients and patients were rewarmed to at least 36.5°C before separation from bypass.

After the termination of bypass, protamine was administered at a ratio of 1:1 with heparin. The PAAD bag was disconnected from the bypass circuit and handed to anesthesiologist and reinfused to the patient. Extra protamine was given as needed for elevated activate clotting times (ACTs) because of the fully heparinized PAAD blood. The entire PAAD volume was returned to the patient before leaving the operating room (OR) and another blood gas and ACTs were checked.

Intraoperative data that were collected included all blood product administration, lowest hemoglobin, and pump and cross-clamp times. Washed autologous red cell volume from the Fresenius CATS was recorded as the total milliliter processed during the entire case and given back to the patient before leaving the OR.

Postoperative transfusion of blood products, chest tube output, PT, PTT, and platelet count results was documented

in the surgical intensive care unit. Bleeding from chest tubes was recorded for 6 and 12 hours postoperatively.

Statistical Analysis

The primary outcome of this study was the total number of blood product transfusions. Data were tested for normality using the Kolmogorov–Smirnov test. All statistical analyses were conducted using IBM SPSS Statistics software for Windows (Version 24; IBM Corporation, Armonk, NY). Using a power of 80% and a p value of $<.05$ and estimating a 10% reduction in red blood cell (RBC) transfusion rate after PAAD transfusion, a minimum sample size of 78 patients was required. Spearman's rho or Pearson's correlation tests were used to determine the relationship between continuous variables. Using significant variables from the correlation tests, Poisson regression was performed to determine if PAAD and other variables were significant predictors of blood product use.

RESULTS

There was a total of 236 patients in the study, PAAD (n = 154, 65.3%) or no blood withdrawal (n = 82, 34.7%). The mean age was 62.7 ± 10.3 years, most of the patients were male (n = 170, 72%) with an average BSA of 2.01 ± .25 m^2. Most cases were coronary artery bypass grafts (n = 172, 72.9%), followed by valves (n = 42, 17.8%) and then combination valve/CABG cases (n = 22, 9.3%). The average pump run was 102 ± 37 minutes, with a 70 ± 32 minutes cross-clamp time.

Univariate Analysis

Patients were divided into two groups depending on whether they received PAAD. There was no significant difference in age, baseline platelet count, or bypass time between the two groups of PAAD. Patient receiving PAAD had a significantly higher BSA, were primarily male, and had a higher baseline hemoglobin, as seen in Table 1. Univariate analysis was also performed to determine significant correlations between variables and blood product administration (Table 2).

Table 1. Comparison of PAAD and non-PAAD patients.

Variable	No PAAD n = 82	PAAD n = 154	p Value
PAAD volume (mL)	0	750 (400)	.00
Age (years)	66 (12)	62 (14)	.10
Gender	63% Male	77% Male	.03
Weight (kg)	80 (26.5)	89 (27)	.00
BSA (m^2)	1.94 ± .23	2.05 ± .25	.00
Procedure	66% CABG	77%CABG	.08
Baseline hemoglobin (gm/dL)	11.1 ± 1.9	13.2 ± 1.7	.00
Baseline platelet count ($\times 10^{-9}$/L)	196 (100)	208 (75)	.81
Baseline TEG Coagulation Index	3.69 (1.28)	3.65 (1.28)	.46
CPB time (min)	99 (47)	93 (36)	.40

TEG, thromboelastograph.

The amount of PAAD taken off before bypass varied according to baseline patient parameters mentioned in our formula. If PAAD was withdrawn from a patient, the median amount taken was 750 mL or approximately 12% of the patient's estimated circulating blood volume. PAAD was given on bypass in 24 cases (15.6%) with an average volume returned of 342 mL (±232). The lowest intraoperative hemoglobin and the post-bypass hemoglobin were both significantly positively correlated with PAAD volume removal ($r = .54$, $p = .00$ and $r = .59$, $p = .00$, respectively).

Whether PAAD volume was taken did not correlate to the amount of blood loss and autologous washed red cells given back during the case. The lowest intraoperative hemoglobin was significantly higher in patients with PAAD removed. Higher post-protamine hemoglobin was also correlated with that of PAAD patients. However, PAAD patients showed no significant difference in chest tube output, regardless of the amount of volume removed.

Transfusion Rates

Patients undergoing PAAD had a 14.3% RBC transfusion rate (mean .27 ± .91 units) and those without PAAD had the RBC transfusion rate of 62.2% (mean 1.56 ± 1.79 units). Transfusion rates include total amounts of products given to the patient any time intraoperatively and up to 12 hours postoperatively (see Table 3).

Multivariate Poisson Regression Logistic Analysis

The significant ($p < .05$) predictors for RBC transfusion included the following: baseline hemoglobin OR .617 (.530–.719), PAAD volume OR .998 (.997–.999), CPB time OR 1.009 (1.003–1.015), age OR 1.034 (1.013–1.055), and BSA OR .326 (.124–.857) (see Table 4).

The significant ($p < .05$) predictors for platelet transfusion included the following: PAAD volume OR .999 (.999–1.000), CPB time OR 1.006 (1.001–1.010), autologous washed red cells OR 1.001 (1.000–1.002), and baseline platelet count OR .994 (.990–.998).

The significant predictors for fresh frozen plasma (FFP) transfusion include the following: PAAD volume .999 (.998–1.000), CPB time 1.012 (1.006–1.018), autologous washed red cells volume OR 1.002 (1.001–1.003), and baseline PT OR 1.213 (1.000–1.472).

The significant predictors for cryoprecipitate transfusion include: autologous washed red cells OR 1.002 (1.000–1.004), baseline PT OR 1.217 (.987–1.500), and baseline platelet count OR .993 (.986–1.000). PAAD was not significant in this model.

DISCUSSION

Because this study is a retrospective review of clinical practice, there was an expected reduction in blood usage in

Table 2. Univariate analysis of preoperative, intraoperative, and postoperative variables for each type of blood product.

		Demographics/Pre-operative							
		Total RBC Units Transfused		Total Platelet Units Transfused		Total FFP Units Transfused		Total Cryo Units Transfused	
Variable	Mean ± SD, Median (IQR) or n (%)	Slope, Mean, or Median (IQR)	*p* Value	Slope, Mean, or Median (IQR)	*p* Value	Slope, Mean, or Median (IQR)	*p* Value	Slope, Mean, or Median (IQR)	*p* Value
Age (years)	63.5 (15)	.155	.02	.078	.24	.039	.55	.088	.18
BSA (m^2)	2.01 ± .25	−.255	.00	−.093	.16	−.119	.07	−.092	.16
Weight (kg)	88 (28)	−.35	.00	−.121	.07	−.136	.04	−.114	.08
Gender	–	–	.00	–	.57	–	.93	–	.10
Male	170 (72%)	.59 ± 1.4	–	.46 ± .87	–	.32 ± 1.0	–	.180 ± .63	–
Female	66 (28%)	1.05 ± 1.4	–	.48 ± .77	–	.26 ± .82	–	.25 ± .56	–
Operative procedure	–	–	.00	–	.27	–	.00	–	.00
Procedure % CABG	172 (73%)	.48 ± .998	–	.42 ± 7.9	–	.18 ± .74	–	.11 ± .38	–
Procedure % non-CABG	64 (27%)	1.37 ± 2.05	–	.59 ± .96	–	.62 ± 1.36	–	.43 ± .96	–
Baseline Hgb (gm/dL)	12.5 ± 2.1	−.503	.00	−.97	.14	−.088	.18	−.128	.05
Baseline PLT ($\times 10^{-9}$/L)	202 (84)	−.003	.97	−.267	.00	−1.02	.20	−.204	.01
Baseline PT (sec)	12 (1)	.225	.01	.124	.16	.155	.08	.203	.02
Baseline PTT (sec)	33.1 (19)	−.145	.10	−.88	.32	−.06	.50	−.011	.90
Baseline TEG CI	3.66 (1.28)	.048	.47	−.046	.49	−.012	.86	−.039	.56
Intraoperative									
PAAD volume (mL)	555 (1,000)	−.54	.00	−.199	.00	−.18	.01	−.154	.02
Lowest Hgb (gm/dL)	8.5 (2.5)	−.632	.00	−.209	.00	−.216	.00	−.235	.00
CPB (min)	95 (42)	.229	.00	.181	.01	.288	.00	.193	.00
Autologous washed red cells (mL)	350 (210)	.057	.39	.159	.02	.132	.05	.194	.00
Postoperative									
1 hour post-op Hgb (gm/dL)	11.3 ± 1.7	−.291	.02	−.263	.03	−.281	.02	−.145	.23
1 hour post-op PLT ($\times 10^{-9}$/L)	174 (63)	−.272	.02	−.246	.04	−.282	.02	−.265	.03
1 hour post-op PT (sec)	13.1 (1.8)	0.3	.01	.149	.22	.266	.03	.185	.13
1 hour post-op PTT (sec)	29.1 (8.9)	.168	.166	0.2	.10	.188	.12	.149	.22
6 hour post-op Hgb (gm/dL)	10.6 ± 1.7	−.443	.00	−.325	.00	−.293	.00	−.321	.00
6 hour post-op PLT ($\times 10^{-9}$/L)	162 (75)	−.213	.00	−.063	.37	−.144	.04	−.199	.00
6 hour post-op PT (sec)	13 (2)	.25	.00	.141	.05	.204	.00	.164	.02
6 hour post-op PTT (sec)	30 (7)	.312	.00	.131	.07	.227	.00	.287	.00
1 hour post-op fibrinogen (mg/dL)	238 (94)	−.089	.19	−.008	.91	−.037	.59	−.008	.91
6 hour chest tube output (mL)	259 (153)	.273	.00	.262	.00	.149	.02	.172	.01
12 hour chest tube output (mL)	395 (248)	.231	.00	.247	.00	.158	.02	.143	.03

CI, coagulation index; Hgb, hemoglobin, PLT, platelet; TEG CI, thromboelastograph coagulation index.

Table 3. Blood product transfusion rate between PAAD and non-PAAD patients.

Blood Products	PAAD (n = 153)	No PAAD (n = 80)	*p* Value
RBC	0 (0)	1 (2)	.00
% Transfused RBC	21 (14%)	49 (61%)	.00
Platelets	0 (0)	0 (1)	.01
% Transfused platelets	35 (23%)	32 (40%)	.01
FFP	0 (0)	0 (0)	.00
% Transfused FFP	12 (8%)	17 (21%)	.00
Cryoprecipitate	0 (0)	0 (0)	.10
% Transfused cryoprecipitate	15 (10%)	14 (18%)	.10

the patients who received PAAD. The significant difference found between baseline hemoglobin and BSA is not surprising, given the dilutional formula was used to determine the eligibility of PAAD. Patients with low baseline hemoglobin would typically not withstand the decrease in hemoglobin from the removal of blood, and, therefore, PAAD was not used on those patients.

Using Poisson regression, we developed a model to predict blood product transfusions based on preoperative and intraoperative factors. After controlling for other significant factors, the impact of PAAD was primarily seen with the transfusion of RBCs. The significant OR of .998 can be used to predict a reduction in red cell transfusion. The OR is a nonstandardized effect size and must be multiplied by the covariate to determine the true effect size. If we multiply the .002 reduction in red cell transfusion by 500 mL of the PAAD volume, then that equals 1 unit of blood reduction. In this study, the median PAAD was 750 mL, which predicts a red cell transfusion reduction of 1.5 units, meaning that for each 750 mL of the PAAD volume removed, there was a predicted reduction in 1.5 units of packed red cell transfusion. The actual mean reduction in the PAAD group was 1.56 − .27 = 1.29 units.

Table 4. Poisson regression model of each type of blood product.

	B	*p* Value	OR (CI)
Predictors for Number of RBC Units Transfused			
Baseline Hgb	−.483	.00	.617 (.530−.719)
Baseline PT	.012	.74	1.012 (.944−1.084)
PAAD (mL)	−.002	.00	.998 (.997−.999)
CPB (min)	.009	.01	1.009 (1.003−1.015)
Age (years)	.033	.00	1.034 (1.013−1.055)
BSA (m^2)	−1.121	.02	.326 (.124−.857)
Case type	.062	.80	1.064 (.661−1.712)
Gender	.073	.74	1.076 (.704−1.646)
Predictors for Number of Platelet Units Transfused			
PAAD (mL)	−.001	.01	.999 (.999−1.000)
CPB (min)	.005	.03	1.006 (1.001−1.010)
Autologous washed red cells (mL)	.001	.03	1.001 (1.000−1.002)
Baseline PLT	−.006	.00	.994 (.990−.998)
Predictors for Number of FFP Units Transfused			
PAAD (mL)	−.001	.01	.999 (.998−1.000)
CPB (min)	.012	.00	1.012 (1.006−1.018)
Autologous washed red cells (mL)	.002	.00	1.002 (1.001−1.003)
Baseline PT	.193	.05	1.213 (1.000−1.472)
Predictors for Number of Cryoprecipitate Units Transfused			
PAAD (mL)	−.001	.08	.999 (.998−1.000)
Autologous washed red cells (mL)	.002	.02	1.002 (1.000−1.004)
Baseline PT	.196	.07	1.217 (.987−1.500)
Baseline PLT	−.007	.06	.993 (.986−1.000)

After controlling for other significant factors, PAAD also had a significant impact of the reduction in FFP and platelet transfusion with ORs of .999. Using the .001 reduction times, the 797 average PAAD volume equals a .7-unit predicted reduction in each of those products. The actual reduction in mean platelet transfusion in the PAAD group was .69 − .35 = .34 units of platelets and FFP was .55 − .17 = .38 units.

In addition to sparing the patient from the risks often associated with blood transfusions, the patient and hospital could save money as well. Our hospital pays $203 for a unit of RBC, $513 for a unit of platelets, and $52 for FFP. Using the aforementioned numbers, a 1.29-unit reduction in RBC, and .38-unit reduction in platelet (PLT) and FFP, there is a $262, $190, and $20 reduction in cost, respectively. This implies that for every patient receiving PAAD, there is a $472 reduction in cost in blood transfusions, not accounting for processing, and any incurred length of stay or infection costs.

Some of the previously mentioned ANH articles list their blood withdrawal as a percentage of patient circulating blood volume, so our data were also analyzed with this calculation to observe potential differences (17,18). Our study found that taking off large amounts of PAAD or volume as a percentage did not correlate with returning blood prematurely. PAAD was removed based on the expected dilutional hemoglobin calculation rather than solely on a circulating blood volume.

Another major difference with the PAAD method because the blood is withdrawn after cannulation is that it is fully heparinized. Because the blood is given back after bypass, more attention should be given to the post-bypass ACT to ensure a return to baseline levels. Extra protamine may need to be administered to achieve a desired ACT, otherwise the PAAD could prolong postoperative bleeding. Heparin is not the typical anticoagulant used when storing autologous blood, many hospitals use citrate-phosphate-dextrose (CPD); however, such a brief storage time and room temperature should not affect PLT quality (6). A study by Sherman et al. (19), that used heparin as the anticoagulant and found no significance in postoperative bleeding, stated that heparin was unlikely to be the cause of his lack of results. Kaplan et al. (20)

reported a significant increase in PLT count after infusion of autologous blood stored with heparin compared with CPD and even noted small clots formed in the CPD-bag groups.

All techniques of autologous blood collection have the same goal to decrease postoperative bleeding and thereby reduce the number of patient exposures to FFP and PLTs. Some studies have seen a decrease in chest tube output, as a measure of postoperative bleeding, and reduction in blood product usage (5,6,10). Other hospitals have a similar procedure of taking the volume off the venous line comparable to PAAD, but they hemodilute the patient by replacing the volume that is removed. They reported an increased postoperative PLT count, decreased PT, and PTT (5,20). A study by Ochsner reported decreased PLT and fibrinogen levels after bypass but were significantly increased after transfusion of autologous blood, although not as high as baseline (6). Other studies that used ANH or preoperative donation were not as successful and recorded no difference in chest tube output or PLT count (14,17,18). Using a similar method of withdrawing from the pump circuit after cannulation, Sherman and his colleagues were unable to find a significant difference in blood usage between their autologous and control groups (19).

Bryson and associates performed a meta-analysis that indicated most institutions with a set protocol were less likely to see significant results, revealing that differences seen by other studies may only be due to observational bias (21). To prevent against this influence, a formula was used to determine eligibility such that patients who were deemed too sick to receive PAAD were not included in our study, as most of them were anticipated to receive blood because of low baseline hemoglobin levels, which would have falsely skewed our results.

To prevent against this bias, patients with low baseline hemoglobin, that after pump dilution, would have an on-bypass hemoglobin (Hgb) of eight or less, were not selected for PAAD. These patients are still in the study and hemoglobin levels will be considered when analyzing the blood transfusion rate. By using a regression model, we determined the predictors for blood transfusion. This method allowed us to predict how PAAD reduces the number of transfused blood products. Kaplan et al. reported that patients after autologous transfusions showed a significant increase in PLTs similar to patients who received banked products (20). Some studies produced greatest results with only mild ANH removal (2,17). However, other studies concluded that more is better, demonstrating greater reduction in transfusions from patients with larger amounts (>800 mL) of blood withdrawn (22).

Choosing whether to give back the PAAD blood or transfuse allogenic blood due to patient hemodynamic instability is another issue to be addressed. If there is insufficient volume on bypass to maintain adequate flows and pressures, or the hemoglobin level or the cerebral oximetry drops too low, should the PAAD be given back first instead of donor blood? For instance, in the event of lower-than-expected Hgb and the need to transfuse, could the PAAD volume be withheld in an attempt to spare the PLTs and clotting factors if only the red cells are needed, thereby giving packed cells even though PAAD volume was available. This decision was left to the surgeon preference. However, one study found that giving blood transfusions on bypass while autologous blood was available leads to an increased use of transfusions throughout the patient's hospital stay (14).

Another issue which can complicate PLT loss and hemostasis is blood lost to the cell salvage. Although the cell salvage machine is very useful in returning autologous washed red cells and raising the hematocrit, it removes all the patient's clotting factors and PLTs. If some of the PLTs can be removed via PAAD, there are less to be lost to autologous cell washing, supporting the same theory of hemodilution for ANH (5,9,14). We can use the washed cell volume as a measure of surgical blood loss for each patient. Although there are numerous intricacies that can contribute to bleeding, our study analyzes whether PAAD is an effective means of blood product conservation. PAAD should work to protect PLTs from contact activation and mechanical stress, thereby preserving PLT function, decreasing postoperative bleeding, and reducing transfusion rates.

Autologous blood has been shown to reduce the number of blood transfusions in patients undergoing cardiac surgery (10,13,14,17,21–23). Another study demonstrated a decreased transfusion rate and a decline in postoperative pulmonary infections (2). An article by Oz reported shorter hospital stays, higher cardiac output, and less inotropic support on patients receiving autologous than homologous blood (24). However, not all studies found a significant difference in transfusion rates (18,25). There remains some debate about ANH technique, particularly due to over hemodilution, and substantially, low hematocrits leave some questioning its overall effectiveness in blood conservation (12,25).

CONCLUSION

Although PAAD could not be used in all patients, there was a significant reduction in blood transfusion in the PAAD group. Using the OR in the Poisson logistic regression model and controlling for other factors, a one-unit reduction in RBC transfusion is predicted for each 500 mL of PAAD. The regression model also predicts a reduction in FFP and PLT transfusion when PAAD is used. We were unable to show a reduction in postoperative bleeding with PAAD.

Limitations

Even though the method of PAAD allows us to take volume off patients who would be considered too sick to withstand ANH, patients who have too low of a hemoglobin are also not eligible for PAAD and did not receive the benefit. This still leaves a patient population without a pre-bypass conservation option.

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