Autologous Blood Transfusion in Cardiac Surgery

*K MOHANDAS FFARACS
**YAHYA AWANG FRCS
***G DURAISAMY FRCPA
*V KATHIRESAN MBBS

*Department of Anaesthesiology
**Department of Cardiothoracic Surgery
***National Blood Bank Services
 General Hospital
 Kuala Lumpur

Summary: Two hundred patients were selected and comprised two statistically balanced group of 100 each. Group one received whole bank blood and plasma following extracorporeal circulation and again when further blood replacement was necessary. Group two received autologous transfusion following extracorporeal circulation and homologous bank blood and plasma when further blood replacement was necessary. There was a significant decrease in the total requirement of blood and plasma in group two. There was a saving of 41% in banked blood product requirements. With appropriate use of autologous blood a substantial number of patients undergoing elective open heart surgery can be managed with autologous blood alone and avoid exposure altogether to homologous blood products and transfusion related complications.

Introduction

The increasing volume of cardiac surgery has placed a large demand on our blood banks for more blood and blood products. The use of fresh autologous blood has been suggested as a means of decreasing the need for banked blood products.[1] Furthermore autologous blood transfusion decreases the incidence of transfusion reactions and transmission of diseases such as hepatitis and acquired immunodeficiency syndrome. Autologous blood transfusion also diminishes the bleeding tendency that is partly associated with the destructive action of the pump oxygenator on circulating coagulation factors.[2,3] The purpose of this study was to assess whether withdrawal of autologous blood prebypass with reinfusion postbypass and infusion of all blood remaining in the circuit and the oxygenator after the termination of cardio pulmonary bypass decreases the use of homologous blood and blood products during cardiac surgery.

Material and Methods

Patients selected comprised two statistically balanced groups of 100 each. Group two received fresh autologous blood transfusion following extracorporeal circulation and stored homologous blood and plasma when further blood replacement was necessary. Group one served as controls receiving only stored homologous blood and plasma after extracorporeal circulation and again when further blood replacement was necessary. The type of operation varied but were similarly distributed in the two groups (Table 1). The time during which extracorporeal circulation was used did not differ between the two groups averaging one hr – 51 minutes. Patients who exhibited abnormal clotting mechanism, impaired renal or hepatic function or decreased haematocrit (P.C.V.) and blood volume were excluded from the study. Also excluded were those who bled postoperatively as a result of complicated operative management.

Closure atrial septal defect	30
Closure ventricular septal defect	2
Mitral valve surgery	30
Aortic Valve Surgery	7
Double valve replacement	4
Coronary Artery Bypass Grafting	15
Total Correction of Tetrology of Fallots	8
Pulmonary Stenosis	2
Atrial Myxoma	1
Ruptured Sinus of Valsalva	1
Total Number of Cases in each group	100

Table 1:
Types of Surgical Procedures

The blood for autologous blood transfusion was withdrawn from the internal jugular vein in group two patients. The amount of blood to be withdrawn was calculated taking into consideration patient's blood volume and preoperative haematocrit (P.C.V.) (Appendix 1). A haematocrit of 22% was expected during the bypass. The blood was collected under sterile condition into bags containing citrate phosphate dextrose anticoagulant. Dextrose 5% in saline or Ringers Lactate or gelatine preparations was infused during the blood collection to mantain intravascular volume and stable vital signs.

The blood was removed before heparinisation and commencement of extracorporeal circulation and stored at room temperature. No blood was removed from Group one patients. Absolute haemodilution was used and the extracorporeal circuit was primed with Plasmalyte[R] (Travenol) solution with 10,000 units of heparin. Moderate hypothermia (25-28°C) was maintained during the bypass period.

After the completion of the extracorporeal circulation and the vital signs are stable the venous and the aortic cannulae were removed in group one patients. Heparin reversal was accomplished. Homologous blood and plasma were used to maintain blood volume. In group two only the venous cannulae were removed and the aortic cannula remained in place. The contents of the oxygenator and the extracorporeal circuit were slowly emptied into the patient via the aortic cannula while monitoring the vital signs. Heparin reversal was accomplished simultaneously. Once the reinfusion of the perfusate was complete and heparin reversal achieved, the aortic cannula was removed. No blood or plasma was given during this period. The entire contents of the oxygenator and the extracorporeal circuit was emptied into 500 ml empty collecting bags under sterile conditions from the arterial side of the circuit.

The perfusate was immediately centrifuged in our blood bank and the packed cells were reinfused to the patient in the intensive care unit. In some cases the collected perfusate was transfused to the patient through the peripheral lines if the blood volume is low. In these cases 4 mg of protamine per 100 ml of perfusate was given to neutralize the additional heparin present in the perfusate. Furosemide (Lasix) 10mg. was given to induce diuresis.

18

P < 0.005

BLOOD - × 10^2 ml
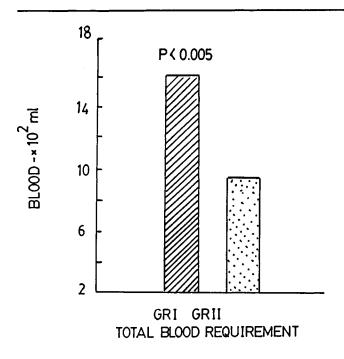
14

10

6

2

GRI GRII

TOTAL BLOOD REQUIREMENT

Fig. 1
Average amount of banked blood products required during the study.

Autologous blood was then transfused and additional homologous blood or plasma was administered if necessary to maintain stable vital signs and a post operative haematocrit of 30%. Postoperative blood loss as measured by chest tube drainage and the amount of bank blood used were recorded. All patients had their pre and postoperative Activated Clotting Time (ACT) measured to assess the adequacy of heparin reversal. Two tailed Student's t-test was used for statistical analysis. Statistical significance was achieved at $p < 0.05$ level.

Results

The average volume of autologous blood collected from group two patients was 386 ± 14 ml (Range 100 − 800 ml). The mean duration of cardiopulmonary bypass was 111 ± 7 minutes. There was no statistically significant difference in the bypass time, postoperative blood loss, postoperative blood and plasma requirement and haematocrit values between the two groups.

There was a significant ($p < 0.05$) decrease in the use of blood and plasma in group two during surgery. The autologous group two received 239 ± 38 ml of banked blood and 121 ± 19 ml of plasma, whereas control group one received 693 ± 60 ml and 200 ± 29 ml of blood and plasma respectively. The total blood bank requirements were significantly less for the autologous group two ($p < 0.05$) (fig. 1). There was a saving of 41% of banked blood and plasma compared to the control group one (Table II). Because the volume of autologous blood withdrawn was replaced with colloids and crystalloids and because non-blood prime was used the haematocrit levels fell to 20% during the extracorporeal circulation in group two. These levels returned towards normal after re-infusion of auto-logous blood and diuresis.

	Group One	Group two
Volume of autologous blood withdrawn	0	386 ± 14
Cardiopulmonary bypass time (min)	115 ± 8	107 ± 7
Postoperative blood loss (ml)	580 ± 74	512 ± 51
Intraoperative replacement of:		
Blood	693 ± 60	239 ± 38[@]
Plasma	200 ± 29	122 ± 19[@]
Postoperative replacement of:		
Blood	429 ± 52	363 ± 38
Plsma	281 ± 36	219 ± 27
Total amount of blood products	1603 ± 112	943 ± 60[@]
Post operative Haematocrit	30.5 ± 0.5	30.4 ± 0.7

Table 2:
Group characteristics blood loss and blood products Requirements of groups one and two (mean +/− S.E.)

[@]$p < 0.05$ from control group

None of the patients studied had to be brought back to the theatre for post-operative bleeding. One patient died in group two. Neither haemodilution nor the use of autologous blood was implicated as contributing to the death.

Discussion

The effect of autologous transfusion on postoperative blood loss and blood bank requirements during cardiac surgery is still controversial. Hallowell[1] documented a 25 percent saving in the blood bank requirement after open heart surgery. Kaplan[4] did a comparative study on the methods of anticoagulation in auto-transfusion. He concluded that blood removed after heparin administration led to significant improvement in platelet count and partial thromboplastin time after reinfusion and that a 18 percent savings in the blood bank requirement resulted. Lawson[5] showed a 50 percent reduction in banked blood products. Their patients' coagulation studies were within normal limits following autologous blood, where-as their control group had abnormal clotting studies after bypass. The autologous blood produced a mean increase of 28,000 platelets per cubic millimeter. Further support for autologous blood transfusion comes from the study by Wagstaff, Clarke and Jackson,[6] which showed both improvement in platelet counts and decreased postoperative blood loss. Pliam et al,[7] however, demonstrated an increase in blood loss and subsequent bank blood requirements when autologous blood transfusion was used. It is noteworthy that in their series, the blood was withdrawn under high negative pressure, and acid citrate dextrose blood was used routinely as one third the priming mixture.[8] Similarly Sherman[9] found little benefit from autologous transfusion. They showed a decreased need for blood intraoperatively but not for the total hospital stay.

Our data support the majority of previous studies showing that autologous blood transfusion does reduce the banked blood requirements during cardiac surgery. The autologous group received 660 ml of blood products less than the control group. This represents a 41 percent saving of banked blood products which is similar to Lawson's figure of 50 percent. In our study, blood drawn from the internal jugular vein and stored in citrate phosphate dextrose bags at room temperature were free from any clots contrary to the findings of Kaplan. In their study the coagulation parameters were not significantly improved in the group

that received autologous blood stored in citrate phosphate dextrose bags, probably because of the clots seen in some of these bags, which used up some of the clotting factors in the autologous blood.[4] During our study we only monitored the activated clotting time.

Empirical withdrawal of 20 percent of an individual's blood volume as done by various authors in their studies cannot be applied to our patients due to the lower body weights and haematocrit values. The smaller blood volume gets diluted in the fixed prime volumes of the extracorporeal circuit resulting in lower haematocrits than compared to the western patients. The amount of blood that can be withdrawn must be calculated for every patient. We used the formula shown in appendix 1 and calculated the amount of blood that can be safely withdrawn that would result in a haematocrit of 22 percent during cardiopulmonary bypass. The haematocrit often fell as low as 20 percent during bypass in group two patients. Dilution of the packed cell volume to values as low as 15 percent has not been recognized as a cause of perfusion hypoxia.[10]

At a haematocrit of 20 percent systemic transport of oxygen is still 90 percent (fig 3). There is little evidence that haemodilution is detrimental to tissue oxygenation. Acute normovolemic anaemia actually improves the nutritional flow to the tissues and the distribution of Po_2 values throughout tissues becomes more homogenous as the haematocrit decreases to 20 percent.[11] The success of haemodilution in wide clinical experience suggest this observation. This success may be attributed to decreased blood viscosity and hypothermia.

Return of oxygenator contents to the patient immediately after cardiopulmonary bypass is widely practised as part of the crystalloid prime haemodilution technique. Obligatory diuresis during this period not only averts significant pulmonary dysfunction and postoperative oedema but also allows infusion of autologous blood haemoconcentrates the infused pump perfusate. Left heart failure is not an infrequent result of overzealous transfusion of oxygenator contents, usually in the setting of an insufficiently brisk diuresis.[12] The technique of collecting the oxygenator contents, centrifuging and then transfusing only the packed cells prevents this complication. This also results in significantly less sodium, potassium and heparin being returned to the patient and avoids additional protamine administration.
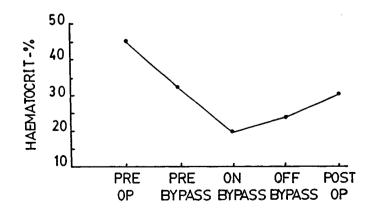

Fig. 2
Haematocrit levels during operation employing non blood perfusate and autologous blood transfusion in Group two patients.

OPERATIONS	NO
Coronary Artery Bypass Grafting	2
Closure of Ventricular Septal Defect	1
Closure of Atrial Septal Defect	11
Mitral Valve Surgery	3
Total correction of Tetrology of Fallot	3
Aortic Valve Surgery	1
Double Valve Replacement	2
Total	23

Table 3:
Cases in Group two done with autologous blood transfusion only

Despite the differences in the requirement of banked blood products the two groups of patients exhibited comparable postoperative haematocrit values and post-operative bleeding. The transfusion of additional volume of packed cells recovered after centrifugation of the oxygenator contents and improved clotting mechannism after the transfusion of autologous blood increased the postoperative haematocrit values in group two patients.[4],[12]

CONCLUSION

This study shows that prebypass withdrawal of autologous from the internal jugular vein into CPD solution bags is an easy and safe technique. Infusion of autologous blood combined with the transfusion of the entire contents of the oxygenator including the extracorporeal circuit decreases the use of banked blood products by 41 percent during cardiac surgery. Nearly one fourth of the routine cardiac operations could be conducted without transfusion of homologous blood products. (Table III). This reduces the risk of transmission of transfusion related diseases and risk of transfusion reactions. Fresh frozen plasma and platelets are not routinely needed for all patients undergoing cardiopulmonary bypass. Their usage should be reserved for the occasional patients who manifests a coagulation defect correctable with these products.[4] Another important attribute of autologous transfusion is its economic advantage which means financial savings to the patient and conservation of blood resources as well as reduced workload in the blood bank. The Council on Scientific Affairs of the American Medical Association has recently endorsed the view that autologous blood transfusions is the safest form of transfusion therapy and recommends the use of this therapy.[13]

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APPENDIX I

AMOUNT OF AUTOLOGOUS BLOOD TO BE SCAVENGED

$$\text{BLOOD VOLUME} - \text{EP*} \quad \frac{\text{BLOOD VOLUME} + \text{PRIME VOLUME}}{\text{PREOPERATIVE HAEMATOCRIT}}$$

BLOOD VOLUME = BODY WEIGHT (KG)* 75 ML / KG

PRIME VOLUME = VOLUME OF PRIMING SOLUTION IN THE EXTRA CORPOREAL CIRCUIT

EP = HAEMATOCRIT EXPECTED IN THE EXTRACORPOREAL CIRCUIT DURING CARDIOPULMONARY BY PASS (20%)