INTRAOPERATIVE BLOOD PRESERVATION HALVES THE BLOOD TRANSFUSION REQUIREMENTS AFTER CARDIOPULMONARY BYPASS

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Several randomized studies on different autotransfusion techniques in patients undergoing coronary artery bypass grafting resulted in divergent findings with respect to reduction of the need for homologous blood transfusions. Most of these studies have used less strict criteria for homologous blood transfusion than applied in daily clinical practice. A prospective, randomized, controlled study involving 40 patients undergoing elective, uncomplicated coronary artery bypass grafting was performed. Twenty patients was selected as the autotransfusion group (group A) and another 20 as controls (group C). The patients in Group A had 10 ml/kg of whole blood removed before cardiopulmonary bypass (predonation) and also had intraoperative cell-saving; they had retransfusion at the termination of cardiopulmonary bypass and heparin reversal. Criteria for homologous blood transfusion were hematocrit less than 15% throughout the operation and less than 30% during the rest of the hospital stay. All of the predonated blood and the cell-saver blood was transfused in study group. In control group, 2180±389 cc of homologous blood was used versus 1202.5±283.0 cc of homologous blood used in study group (p<0.01). Autotransfusion of predonated blood and cell-saver blood in patients undergoing elective, uncomplicated coronary artery bypass grafting halves the amount of homologous blood transfused.

Key words: open heart surgery, predonation, blood transfusion

The need for blood transfusion in patients undergoing coronary artery bypass grafting has decreased during the past 20 years. Several ways of reducing the requirement for homologous blood in cardiac surgery have been actively pursued due to the concern about infections and

immunologic reactions from homologous blood transfusions. These methods include predonation of blood prior to operation, intraoperative blood withdrawal before cardiopulmonary bypass (CPB), and intraoperative plasma separation with a cell-saving device. As a prospective, controlled, randomized study, the present study was aimed at investigating whether autotransfusion of the predonated blood and using a cell-saver in patients undergoing coronary artery bypass grafting could reduce the number of patients that need homologous blood transfusion and reduce the amount of transfused homologous blood if fixed transfusion criteria were used.

MATERIAL AND METHODS

Forty consecutive patients undergoing coronary artery bypass grafting were randomized into two groups. In autotransfusion group (group A), 10ml/kg whole blood was withdrawn from the venous cannula before heparin administration and before cardiopulmonary bypass and simultaneous isovolumic replacement was performed with ringer lactate solution. This blood was stored in a reservoir bag and was retransfused to the patient when cardiopulmonary bypass was over, after heparin was neutralized with protamine.

In addition, cell-saver was used intraoperatively and obtained blood was retransfused by the end of the operation.

No blood was withdrawn from control group patients (Group C) before cardiopulmonary bypass and cell-saver was not used. Patients who underwent emergency operations, who had a serum creatinine greater than 1.5 mg/dl, poor ejection fraction (less than 0.35), significant carotid stenosis, diabetes mellitus, who were more than 75 years old, who took aspirin until the operation or patients having intravenous heparin therapy were excluded from the study. All operations were performed by the same surgical team using the same cardioplegia technique, the same operative techniques and bubble oxygenators.

Cardiopulmonary bypass was performed using a bubble oxygenator (Polystan VT-5000 Copenhagen, Denmark) primed with 1.000 ml of Isolyte S, 300 ml of 25% albumin, and 50 ml of sodium bicarbonate. The patients received 3 mg/kg heparin to maintain an activated clotting time longer than 480 seconds. An additional 1 mg/kg heparin was given in case activated clotting time was less than 450 seconds. The pump flow was maintained at 2.2 to 2.4 l/min/m2. Moderate hypothermia (26-28°C) and cold K+ cristalloid cardioplegia was used. The anesthetic management of these patients included premedication with 2 mg lorazepam. Induction was performed with a loading dose of fentanyl 20 mg/kg and pancuronium 0.1 mg/kg; anesthesia was maintained by a continuous infusion of fentanyl at 15 to 20 mg/kg/h. By the termination of cardiopulmonary bypass, protamine was used to reverse the circulating heparin by titration to the activated clotting time.

Patients received a transfusion during cardiopulmonary bypass if only their hematocrit was less than 15%. Our blood conservation protocol for both study groups included the use of a cell-saving device intraoperatively and retransfusion of all oxygenator and tubing blood content after cardiopulmonary bypass. The physicians ordering the blood component therapy were blinded to the study groups. The trigger for transfusion therapy was as follows:

1. Cardiac index less than 2.2 l/min/m2 and pulmonary capillary wedge pressure less than 18 mm Hg, or
2. Mean arterial pressure less than 60 mm Hg or
3. Urine output less than 1 ml/kg/h.

Postoperative volume therapy was performed with crystalloid solutions. Homologous blood transfusion was given in line with the following criteria:

1. Hematocrit less than 15% throughout the operation.
2. Hematocrit less than 30% during the rest of the hospital stay.

Baseline patient variables and operative variables of two groups were compared by using Student's t test or Wilcoxon rank sum test. The Wilcoxon rank sum test was also used to evaluate the difference in

postoperative chest tube drainage of and homologous blood products transfused to the two groups during their hospital stay.

RESULTS

Of the 40 patients enrolled in the study, there was one death in auto-transfusion group at postoperative 2nd day due to cardiac arrhythmia ($p<0.05$). Postoperative complications were similar in both groups.

Three patients were excluded from the study; two in control group and one in predonation group, due to being operated again for bleeding. Two patients in autotransfusion group required intra-aortic balloon pump, with causes unrelated to autotransfusion procedure. No significant differences were observed between the preoperative variables of the two groups (Table 1). The differences in perioperative variables of the two groups were not statistically significant either (Table 2). The patients received an average of one internal mammary artery graft in both groups, while mean bypass graft per patient was 3.2±1.1 in Group A, and 3.3±1.3 in Group C. In autotransfusion group, mean hematocrit level during cardiopulmonary bypass was lower due to predonation and consequent hemodilution with simultaneous isovolumic replacement. Within first postoperative18 hours, mean (±standard deviation) blood loss in group A and C were 827.5±315 ml and, 1136.7±606.3 ml, respectively; the difference was statistically significant ($p<0.05$). Homologous blood product transfusions were recorded in both groups during their overall hospital stay. As seen in Table 3, the study group required fewer packed red blood cell transfusions and fewer fresh frozen plasma transfusions as well ($p<0.01$). Total homologous blood products transfused in group A and C was 1202.5±283 ml, 2180±389.4 ml, respectively ($p<0.01$). This difference was significant at $p=0.006$ based on the Wilcoxon rank sum test. Platelet count has decreased to a similar degree in both groups postoperatively (Table 2). Hematocrit at discharge was 33-36% in both groups, indicating that blood products transfused to the patients were appropriate.

Table 1. Baseline patient variables in Groups A and C.

Variable	Group A (n=20)	GroupC (n=20)
Sex		
Male	92%	89%
Female	8%	11%
Age (v)	55.1±8.6	54.1±8.9
Weight (kg)	71.5±9.6	74.1±9.2
BSA(m^2)	1.81±0.1	1.83±0.1

Data are presented as percentage or mean ± standard deviation.

Table 2. Perioperative variables in Groups A and C.

Variable	Group A (n=20)	GroupC (n=20)
Cross-clamping time (min)	41.96±17.4	40.87±15.3
CPB time(min)	74.9±19.4	76.6±19.2
IMA / patient	1	1
Total number of bypass grafts / patient	3.2±1.1	3.3±1.3
Lowest Htc(%) during CPB	21.7±2.82	23.19±2.87
Preoperative hematocrit (%)	40.67±3.4	42.0±4.4
ICU Htc(%)	34.7±2.9	35.6±2.5
Discharge Htc(%)	42.0±1.3	38.9±2.3
Preoperative plt count (x100/L)	220.96±55.47	203.45±51.65
ICU platelet count (x100/L)	140.56±37.34	119.75±29.54

Data are presented as mean ± standard deviation.

CPB: cardiopulmonary bypass; ICU: intensive care unit; Htc:hematocrit; plt: platelet; IMA:internal mammary artery

DISCUSSION

This prospective, randomized study using clearly defined criteria for transfusion and volume replacement demonstrated that postoperative autotransfusion of predonated blood and use of cell-saver in elective, uncomplicated primary coronary artery bypass

Table 3. Units of homologous blood product transfused per patient in Groups A and C.

Blood Product	Group A (n=20)	GroupC (n=20)
PRBC (ml)	1202.5±283.0*	2180.0±389.4
Fresh frozen plasma (ml)	55.2±15.8	140.3±2.3

Data are presented as mean ± standard deviation.
PRBC: packed red blood cells, * p<0.01

grafting reduced the number of patients who need homologous blood. Our reinfusion of all of the predonated blood and blood obtained from cell-saver, resulted in a 50% reduction in exposure to homologous blood (Figure 1). In other studies showing that autotransfusion reduced homologous blood requirement, the results have not demonstrated a reduction in number of patients receiving blood transfusion (11,12). Risk of receiving homologous blood was 70%-85% in both autotransfusion and control groups (11,12). Schaff and associates (11) were able to transfuse only 50% of the obtained blood, and their criterion for transfusion was a hematocrit of less than 30% (hemoglobin concentration less than 7.3 mmol/l). Eng and co-workers (12) transfused only 40% of the obtained blood and observed the same transfusion criteria used in this study.

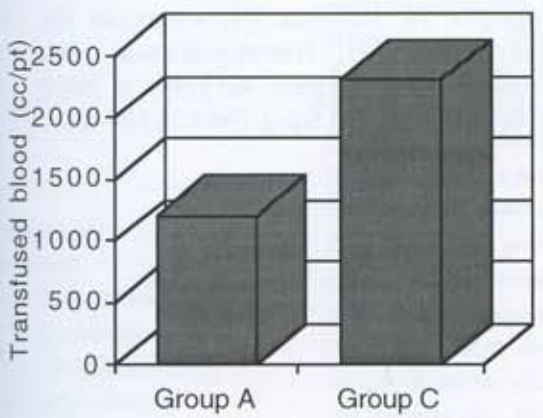

Figure 1. Total transfusion requirements in group A and C.

However, they used a higher amount of homologous blood compared to the present study, which might be explained by lower amount of autotransfusion they used.

Previously, only one randomized study (13), involving 130 patients, has shown a reduction in number of patients receiving homologous blood transfusion (from 95% in control group to 75% in autotransfusion group). No fixed criteria for transfusion and no information on hemoglobin values (or hematocrit values) before, during, and after autotransfusion were reported. The amount of autotransfusion was 1336 ml per patient (65% of postoperative bleeding). Mean homologous blood requirement per patient (2.7 units in autotransfusion and 3.3 units in control group) was much higher than that of the present study (0.5 unit in autotransfusion and 1.4 units in control group). Different results of the other randomized studies that show no reduction in need of homologous blood transfusion could be explained by difference in number of patients (14,15) and higher or no criteria for transfusion (15-18). Since there was no difference in postoperative hemoglobin or hematocrit levels during the present study, it is evident that the transfusion practice was the same in both groups. We believe that since we were able to transfuse almost all of the obtained blood and since the transfusion protocol was strictly observed, the patients receiving autotransfusion were distinctly at less risk for homologous blood transfusion. The autotransfusion of blood with fixed criteria for blood transfusion reduced average use of homologous blood which increased cost-effectiveness of the strategy. Like the other studies (11,13), in the present study as well, no clinical or laboratory signs of coagulopathy was found. There were no septic reactions, and number of sternal infections was similar in both groups.

In conclusion, autotransfusion of predonated blood and use of cell-saver in patients undergoing elective, uncomplicated coronary artery bypass grafting significantly reduces the amount of homologous blood transfused.

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