

Intraoperative Blood Preservation Reduces Blood Loss After Cardiopulmonary Bypass

İNTRAOPERATİF KAN ELEMANLARININ KORUNMASI,
KARDİYOPULMONER BYPASS SONRASI KAN KAYBINI AZALTMAKTADIR

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Summary

A combination of several techniques is necessary to minimise the transfusion requirements for open heart operations. The benefit of plasmapheresis remains in doubt because of smaller and less effective platelets obtained with this technique. Therefore, we evaluated the effects of whole blood intraoperative autotransfusion (predonation) and using a cell saver as part of a blood conservation protocol.

Sixty patients undergoing coronary artery bypass grafting operations were randomised to an autotransfusion group (group A) where predonation + cell saver was used, cell saver group (group B) where only cell saver was used and control group (group C). Group A patients had 10 mL/kg of whole blood removed before cardiopulmonary bypass; they had retransfusion at the termination of cardiopulmonary bypass and heparin reversal. Groups A and B had intraoperative cell saving and autotransfusion of intraoperative gained mediastinal blood at the end of the operation. The indications for blood transfusion were standardised, and the physicians ordering blood products were blinded to the study.

Compared with the control group, patients in group A and B had a 28 %, 8% reduction of chest tube drainage at 18 hours, respectively and the study groups had 45 %, 27,5% reduction in the total homologous blood units transfused, respectively. Autotransfusion of the predonated and intraoperative gained mediastinal blood at the end of the cardiopulmonary bypass provide benefit in addition to other techniques in reducing blood loss and the need for blood products in the postoperative period.

Key Words: Open heart surgery, Predonation, Blood conservation

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Özet

Açık kalp ameliyatları sonrasında kanama miktarını ve transfüzyon ihtiyacını azaltmak amacıyla birçok yöntem denenmiştir. Kullanılan bu yöntemler arasında predonasyon ve ameliyat sırasında celi saver kullanımı önemli bir yer tutmaktadır.

Bu çalışma koroner arter bypass grefti (KABG) ameliyatına alınan 60 hasta üzerinde yapılmıştır. A grubunda (20 hasta) predonasyon + celi saver kullanılmış. B grubunda (20 hasta) yalnız peroperatif celi saver kullanılmış. C grubu (20 hasta) ise kontrol grubu olarak alınmıştır. Tüm gruplarda post-operatif transfüzyon endikasyonları standardize edilmiş, çalışma gruplarında predonasyon kanı ve celi saverden kazanılan kan ameliyat sonunda protamin verilmesini takiben hastalara transfüze edilmiştir. Sonuç olarak kontrol grubu ile karşılaştırıldığında A grubunda drenaj % 28, transfüzyon miktarı % 45, B grubunda drenaj % 8, transfüzyon miktarı % 27,5 azalmıştır. Bu sonuçlar hem kendi aralarında hem de kontrol grubu ile karşılaştırıldığında anlamlı bulunmuştur.

Anahtar Kelimeler: Açık kalp cerrahisi, Predonasyon, Kan ürünlerinin korunması

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The risks of homologous blood transfusion are well documented and include the transmission of infectious disease and the risks of receiving incompatible blood (1,2). A variety of blood conservation techniques have evolved to minimise the transfusion requirements for open-heart operations (3-5). The technique of "blood pooling" before the onset of cardiopulmonary bypass has been shown to be

beneficial as a single technique in patients having elective operations (6-8).

Our standard blood conservation protocol includes the intraoperative use of a cell-saver device (Didcco, Mirandola, Italy) and a strict protocol for blood product transfusion. The present study was conducted to determine whether autotransfusion of the predonated and intraoperative gained mediastinal blood at the end of the cardiopulmonary bypass provide benefit in addition to these techniques in our current practices.

Material and Methods

Sixty consecutive patients having coronary artery bypass grafting were randomised into three groups. In the autotransfusion group (group A), 10 mL/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 patients after cardiopulmonary bypass once the heparin had been neutralised with protamine. Additionally, intraoperative cell saver was used and intra operative gained blood was re-transfused at the end of the operation. In group B, the cell saver group, only the cell saver was used for preservation of the mediastinal blood throughout the operation.

Group C was control group; these patients had no blood withdrawn before cardiopulmonary bypass and cell saver was not used. Patients who underwent emergency operations, serum creatinine greater than 1.5 mg/dl, significant carotid stenosis, age greater than 75 years, and poor ejection fractions (less than 0.35), diabetes mellitus, patients who took aspirin up to the time of operation or patients having intravenous heparin therapy were excluded from the study. All operations were done by the same surgical team. The same operative technique, bubble oxygenators, and cardioplegia technique was used. 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 with 3 mg/kg heparin to maintain the activated clotting time greater than 480 seconds. An additional 1

mg/kg heparin was used to treat an activated clotting time less than 450 seconds. The pump flow was maintained at 2.2 to 2.4 L/min/m². Moderate hypothermia (26-28°C) and coldIC cristalloid cardioplegia was used.

The anaesthetic 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. At the termination of cardiopulmonary bypass, protamine was used to reverse the circulating heparin by titrating to the activated clotting time.

Patients received transfusion during cardiopulmonary bypass only if their hematocrit was less than 15%. Our blood conservation protocol for both study groups included the use of a cell saving device intraoperatively and re-transfusion of all oxygenator and tubing blood contents 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 2,2L/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 accordance 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 between the groups were compared by using the two tests, Student's t test, or Wilcoxon rank sum test. The Wilcoxon rank sum test was also used to evaluate the difference in the postoperative chest tube drainage and homologous blood products transfused to the two groups of patients during their hospital stay.

Table 1. Baseline patient variables in the groups A, B and C

variable	Group A (n = 20)	Group B (n = 20)	Group C (n = 20)
Male	92.0%	88.0%	89.0%
Female	8.0%	12.0%	11.0%
Age (y)	55,1 ± 8,6	56,5 ± 9,2	54,1 ± 8,9
Weight (kg)	71,7 ± 9,6	74,1 ± 12,0	74,1 ± 9,2
BS A (m ²)	1,81 ± 0,1	1,81 ± 0,2	1,83 ± 0,1

Data are presented as percentage or mean ± standard deviation.

Results

Of the 60 patients enrolled in the study, there was one death in the auto-transfusion group at post-operative day 2 due to cardiac arrhythmia (p>0.05).

Postoperative complications were similar in the study groups. Three patients were excluded from the study; two patients in the control group and one patient in the predonation group who had reoperations for operative bleeding. Two patients in the autotransfusion group required intraaortic balloon pump, which was unrelated to the autotransfusion procedure.

Analyses of the preoperative variables in the three study groups were shown in Table 1. The average age was 55 years, the weight was 74 kg and the body surface area was 1,8 m² in all groups.

These differences were not statistically significant among the groups. The perioperative variables are shown in Table 2. The average patient received one internal mammary artery graft, and an average of three bypass grafts was performed per patient. The lowest hematocrit during cardiopulmonary bypass was in the autotransfusion group because of the predonation and the resulting hemodilution with the simultaneous isovolumic replacement. In the first postoperative 18 hours, mean (standard deviation) blood loss in groups A, B and C were 827,5±315 mL, 1060±547,5 mL and, 1136,7±606,3 mL respectively; the difference was statistically significant (group A vs B p<0.05, group A vs C p<0.01, group B vs C p<0.05). The homologous blood product transfusions were recorded in both groups of patients, during their total hospital stay; As seen in Table 3, the study groups required fewer packed red blood cell transfusions, fewer fresh frozen plasma transfusions (group A vs B p<0.05, group A vs C p<0.01, group B vs C p<0.05). The total of homologous blood products transfused in group A, B and C was 1202,5±283 mL, 1582,5±134 mL, 2180±389,4 mL respectively. This difference was significant at p = 0.006 based on the Wilcoxon rank sum test. The platelet count was reduced postoperatively to a similar degree in both groups (Table 2). The hematocrit at discharge was 33-36% in all groups, indicating that the blood products transfused to the patients were appropriate.

Table 2. Perioperative Variables in the Groups A, B and C

Variable	Group A (N=20)	Group B (N = 20)	Group C (N = 20)
Cross-clamp time (min)	41.96 ± 17,4	38.66 ± 14,3	40,87±15,3
CPB time (min)	74,9±19,4	69,5±21,8	76,6±19,2
IMA/patient	1	1	1
Total bypass grafts/patient	3,2±1,1	3,2±1,2	3,3±1,3
Lowest Htc (%) during CPB	21.7±2.82	23.69 ± 3.57	23.19 ± 2,87
Preop Htc (%)	40,67±3,4	42,8 ± 2,7	42,014,4
ICU Htc (%)	34,7 ± 2,9	35,2±2,7	35,6±2,5
Discharge Htc (%)	42,0±1,3	40,6±1,6	38,9±2,3
Preop plt (X 100/L)	220.96 ± 55.47	199.65 ± 40,55	203,45±51,65
ICU plt (X 100/L)	140.56 ± 37.34	125.80 ± 21,30	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

Table 3. Units of homologous blood product transfused per patients in the groups A, B and C

Blood Product	Group A (n = 20)	Group B (n = 20)	Group C (n = 20)
PRBC (mL)	1202,5 ± 283,0**	1582,5 ± 313,4*	2180,0 ± 389,4
Fresh frozen plasma (mL)	55,2 ± 15,8**	87,9 ± 17,5*	140,3 ± 22,3

Data are presented as mean ± standard deviation.

PRBC; Packed red blood cells

* $p < 0,05$ vs control

** $p < 0,01$ vs control

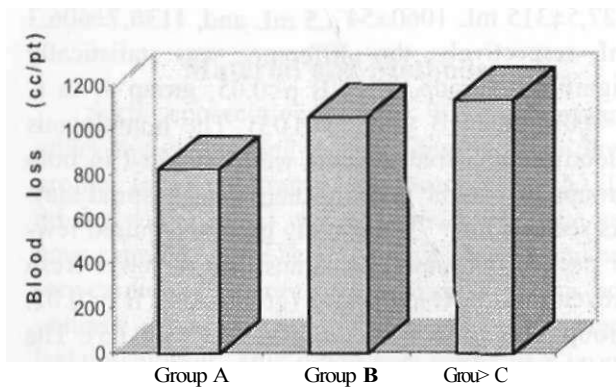


Figure 1. Chest tube blood loss at 24 hours in group A, B, C

Discussion

Although the safety of the blood supply has increased in recent years, a major fear of patients undergoing cardiac operations is the risk of contracting transmittable viral infections. Other potential risks are the occurrence of major and minor transfusion reactions (1,2).

The benefit of combining blood conservation techniques is becoming well accepted and includes predonation of blood prior to operation (9), intraoperative withdrawal of blood before cardiopulmonary bypass (10), the use of intraoperative cell saver as well as postoperative autotransfusion of chest tube drainage for salvaging red blood cells (3-5). The technique of predonation of autologous platelet-rich plasma before cardiac operations has reduced the chest tube blood loss postoperatively (11,12). However, this has not clearly proven beneficial in reducing the homologous blood product requirements postoperatively. The technique of intraoperative autotransfusion of whole blood is simple (6,7) but has not been universally used by cardiac surgeons.

Kochamba et al (13) used predonation and intraoperative cell saver in 100 consecutive patients. Their initial reports revealed that; predonation and intraoperative cell saver decreased the blood loss by 26% and the transfusion requirements by 46%. Similar results were reported by other groups (14,15)

In our study, the predonation group had 10 mL/kg whole blood removed before cardiopulmonary bypass, which resulted in modest hemodilution to an average hematocrit of 22%.

In 1 patient, the hematocrit fell to less than 18% during cardiopulmonary bypass, and half of the pooled blood was re-transfused to that patient. No neurologic event occurred as a result of hemodilution in these patients. Postoperatively, when compared to the control group, this technique reduced the chest tube drainage by 28% at 18 hours.

More important, the predonation group had 45% less homologous blood transfused during their hospital stay.

Although statistically insignificant, even usage of cell saver alone had reduced the chest tube drainage by 8% at 18 hours and had 28% less homologous blood transfused when compared to the control group during their hospital stay. The mechanism for the reduced chest tube blood loss does not appear to be a hemodilution effect, because of the absence of any significant difference in the hematocrit or the drop in platelet count postoperatively between the groups. Several authors have suggested that pooled blood retain platelet function and clotting factors by, avoiding contact with the foreign surfaces during cardiopulmonary bypass (7,8).

The goal of transfusion-free cardiac operations meets patients' expectations and is cost-effective in terms of health care cost containment.

In conclusion, our study demonstrates that, intraoperative blood preservation techniques such as predonation and usage of a cell saver device is effective when combined with other transfusion-saving techniques and should be incorporated into a standardised blood conservation protocol. This simple technique is safe, cost-effective and reduces the patient's exposure to possible complications of homologous blood transfusion.

REFERENCES

1. AuBuchon JP, Busch M, Epstein JS, et al. Increasing the safety of blood transfusions. Washington, DC: American Red Cross, 1992.
2. Huggins C. Hazards of transfusions and ways to reduce their risk: blood conservation. *Transplant Proc* 1989; 21:43-4.
3. Schaff HV, Hauer JM, Bell WR, et al. Autotransfusion of shed mediastinal blood after cardiac surgery. *J Thorac Cardiovasc Surg* 1978; 75:632-41.
4. Cosgrove DM, Amiot DM, Mescrko JJ. An improved technique for autotransfusion of shed mediastinal blood. *Ann Thorac Surg* 1985; 40:519-20.
5. Winton TL, Charrette EJP, Salerno TA. The cell saver during cardiac surgery: does it save? *Ann Thorac Surg* 1982; 33:379-81.
6. Hallock P, Bland JHL, Buckley MJ, Locvenstein E. Transfusion of fresh autologous blood in open-heart surgery: a method for reducing bank blood requirements. *J Thorac Cardiovasc Surg* 1972; 64:941-8.
7. Kaplan JA, Cannarella C, Jones EL, et al. Autologous blood transfusion during cardiac surgery. *J Thorac Cardiovasc Surg* 1977; 74:4-10.
8. Petry AF, Jost T, Sievers H. Reduction of homologous blood requirements by blood-pooling at the onset of cardiopulmonary bypass. *J Thorac Cardiovasc Surg* 1994; 107:1210-14.
9. Britton LW, Eastlund DT, Dziuban SW et al. Predonated autologous blood use in elective cardiac surgery. *Ann Thorac Surg* 1989; 47:529-32.
10. Cosgrove DM, Thurer RL, Lytic BW, Gill CC, Peter M, Loop FD. Blood conservation during myocardial revascularization. *Ann Thorac Surg* 1979; 28:184-9.
11. Jones JW, McCoy TA, Racvitscher RE, Lindsley DA. Effects of intraoperative plasmapheresis on blood loss in cardiac surgery. *Ann Thorac Surg* 1990; 49:585-90.
12. Mohr R, Sag B, Lavee J. The hemostatic effect of autologous platelet-rich plasma versus autologous whole blood after cardiac operations: is platelet separation really necessary? *J Thorac Cardiovasc Surg* 1993; 105:371-3.
13. Kochamba GS, Pfeiffer TA, Sintek CF, Khonsari S. Intraoperative blood preservation reduces blood loss after cardiopulmonary bypass. *Ann Thorac Surg* 1996; 61:900-3.
14. Modan M, Lavee J, Martinowitz U, Golan M. Transfusion of fresh whole blood stored at 4°C for short period fails to improve platelet aggregation on extracellular matrix and clinical hemostasis after cardiopulmonary bypass. *J Thorac Cardiovasc Surg* 1990; 99:354-60.
15. Owings DV, Kruskall MS, Thurer RL. Autologous blood donations prior to elective cardiac surgery, safety and effect on subsequent blood use. *JAMA* 1989; 196:3-8.