
Intra-Operative Blood Conservation During Cardiac Surgery

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Abstract

The Haemonetics Cell Saver, a device developed for the recovery of autologous blood, was evaluated at our institution. The major areas of concern in evaluating this device were: quantity of blood salvaged, reduction in blood bank usage and a possible monetary savings to the patient.

This study consists of 33 consecutive adult patients undergoing cardiac procedures requiring systemic heparinization and cardiopulmonary bypass. Of these 33 adult patients, a group of 13 patients using autotransfusion was compared to a control group of 20 cardiac patients without autotransfusion.

In the group of 13 autotransfused patients, a mean of 6.6 units of bank blood was used throughout their entire hospital stay, as compared to 9.7 units of bank blood in the nontransfused group. This is a significant reduction in blood usage and, since the cost of the Haemonetics software is recovered with two units of blood, a reduced cost to the patient was realized.

Introduction

Historically, cardiac surgery has utilized large quantities of blood,¹ with most of this blood being consumed in the heart-lung machine as its prime. Later Cooley, et al² described the advantages of autotransfusion during cardiac surgery, thereby reducing the volume of blood lost. In addition, hemodiluted prime and perfusion, as described by Gollan³ and Neptune,⁴

was responsible for the conservation of blood even further. All of these procedures were aimed at reducing the amount of blood used because of the risks of giving banked blood.⁵

Realizing the benefits due to reduced usage of banked blood, and the tremendous strain imposed on our local community's blood stores by our newly created cardiac surgery program, an effort was made to try to reduce blood usage during cardiac surgical procedures. Often, after the completion of bypass, as was also noted by Reaves, et al⁶, there would remain 1000 to 1200 cc's of hemodiluted autologous blood within the oxygenator, tubing and basins used for the procedure. On occasion this blood would be reinfused into the patient prior to decannulation and closure, resulting in such problems as volume overload without the benefit of red cell volume⁷ and, occasionally, in prolonged Celite activated clotting time and increased usage of protamine sulfate.⁷ Reaves,⁶ Moran,⁸ and their associates, concentrated this oxygenator blood volume and were able to reclaim 2-3 units of the patient's own blood.

This study describes our experiences with the Haemonetics Cell Saver* which is a system designed to make autologous blood reusable by concentrating the cells in a normal saline suspension and by removing all plasma and circulating debris.

Materials and Methods

Thirty-three consecutive adult patients undergoing cardiac surgery with systemic heparinization and

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TABLE 1
Preoperative Factors

	Age	Preoperative hematocrit (%)	Preoperative weights (kg)
Group I	62.5 ± 3.9	37.8 ± 4.8	73.7 ± 1.6
Group II	58.2 ± 1.9	37.9 ± 3.8	77.0 ± 1.4

cardiopulmonary bypass at the Baystate Medical Center were analyzed for this study. The 33 adult patients were divided into two groups. Group I (control, 20 patients) did not have their blood salvaged with the Cell Saver. In this group mean perfusion time was 112 ± 13 minutes (range 33 to 325 min) and included 4 valve operations and 16 coronary bypass procedures. Table 1 summarizes some preoperative factors. Group II (13 patients) were subjected to the Cell Saver for all of their suctioned blood. In this group mean perfusion time was 110 ± 14 minutes (range 56 to 219 min) and included 2 valves and 11 coronary bypass procedures. There was no significant difference in perfusion time between these groups ($p > 0.05$). Also, as seen from Table 1, there was no significant difference in age, weight or hematocrit prior to operation. There were no clotting abnormalities noted prior to surgery in any patient.

A Cobe II* blood oxygenator was used for all patients, in series with a Sarns 5000** console. The circuit was primed with 2000 cc of Plasmalyte 148*** with a pH of 7.4, 12.5 grams of normal serum albumin and 3000 units of beef lung heparin. The patients were anticoagulated with sodium heparin given following a regimen of 300 units/kg body weight with supplemental doses of 100 units/kg given hourly, maintaining an activated clotting time of at least 400 seconds measured by the Hemochron****. The pump flow was regulated according to the individual's needs, but generally was about 2.4 L/min/m² during normothermic conditions and about 1.6 L/min/m² during hypothermia (rectal temperature 23–25°C). The hematocrit was allowed to fall to 20%, but any further reduction resulted in administration of packed red cells at an approximate volume of 250 cc's. Cold potassium cardioplegia was administered initially upon cross-clamping and intermittently throughout the ischemic

interval, by a low-flow pump head of the Sarns console.⁹

The Haemonetics Cell Saver was used throughout surgery in 13 patients whenever suction was necessary. The unique construction of the Haemonetics suction tubing allows anticoagulation to occur at the suction tip, thus preventing the system from clotting. This aspirant is then collected in a Travenol 5M1470 Cardiotomy Reservoir***. When a sufficient volume has been collected, it is pumped into the bowl. Washing the contents of the bowl is accomplished using 750 cc of normal saline or, if the effluent is not clear, until the waste fluid is as clear as the wash solution. It has been our experience that the waste clears at about 500 cc's, so a total of 750 cc's of normal saline is generally used. This washing procedure reportedly removes the plasma, cell debris, heparin, platelets, and fat particles.¹⁰ The washed red cells are then stored in a 600 ml transfer bag***** in a blood bank refrigerator at 1–6°C. This volume of cells, approximately 300 cc's, has a hematocrit of about 55%. The unit of blood is labelled with the patient's name, hospital number, date and time of collection. The time of collection is particularly important since these cells are not stored in a solution that contains nutrients, and they should not be used if stored for over four hours.

Heparin reversal after perfusion is accomplished by the administration of protamine sulfate, the quantity of which is dictated by Hepcon***** analysis. Post-operative fluid management follows a strict protocol for these patients. The PAD (pulmonary artery diastolic pressure) is maintained between 14 and 18 torr with the CVP (central venous pressure) kept between 10 and 14 cm H₂O. Concomitant with this, the systemic blood pressure is maintained between 100 and 150 torr, with a urine output greater than 40 cc/hr. All statistical analyses are done using the method of least squares and linear regression. The Student's t-test, for comparison of mean values, is used to determine the level of significance and all values reported are the mean values plus/minus the standard error of the mean.

Results

Table 2 is a summary of the blood usage in both

* Cobe Labs, Lakewood, Colorado 80215

** Sarns Inc., Ann Arbor, Michigan 48103

*** Travenol Labs, Deerfield, Illinois 60015

**** International Technidyne Corp., Edison, New Jersey 08817

*** Travenol Labs, Deerfield, Illinois 60015

***** Fenwal Labs #4R2021, Deerfield, Illinois 60015

***** HemoTec, Inc., Englewood, Co. 80112

TABLE 2
Blood Usage for Entire Hospital Stay

Group	# Units Used 250 cc/each)	Perfusion Time	Postoperative Chest Drainage	Immediate Postoperative Hematocrit
I	9.7 ± 1.3*	112.3 ± 13.4 min	256 ± 85 cc's	31.6 ± 2.4%
II	6.6 ± 1.2*	109.7 ± 14.3 min	119 ± 3 cc's	33.5 ± 1.3%

* Significant levels of difference.

groups and, as can be seen, Group II had a significantly reduced blood usage and lower chest tube drainage. The mean savings of 3.1 units of blood per patient is a 32% decrease in blood usage for their entire hospital stay. As can be observed from Table 2, the postoperative hematocrit was not significantly different between the groups. Within Group II a mean of 1354 ± 388 cc of autologous blood per patient was transfused from the Cell Saver which would normally have been discarded in whole or in part, thus accounting for the difference in blood usage.

Conclusion

The Haemonetics Cell Saver has proved to be a valuable adjunct in this series of patients by reducing their consumption of banked blood by 32%. A matter of concern was that the Cell Saver might cause a significant amount of sublethal cell damage¹¹ which may have necessitated adding blood later, but apparently this did not occur since the postoperative usage of blood was not increased in the Cell Saver group. In fact, Group II had significantly less chest tube drainage than did Group I, a fact which may be coincidental or may reflect better clotting with less blood utilization. These data support the use of this device in clinical perfusion for conservation of blood and, since more than two units

of blood was salvaged, a reduction in cost to the patient.

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