Utilization of Donor Blood

Pauline M. MacDonald, John E. Hutchinson, III, Wilbur Herring, Thomas McAfee, and Sam Briseno
Cardiac Surgical Service
St. Luke's-Roosevelt Hospital Center and
Department of Surgery
Columbia University College of Physicians and Surgeons
New York, New York

Abstract
Due to the adoption and adaptation of known confirmed methods, donor blood requirements have decreased in the cardiac surgical patient. Eight hundred thirty-five consecutive patients were studied for donor blood requirements in 1978. A total of 1,804 units of whole blood or packed cells was utilized, averaging 2 units per patient. The average duration on cardiopulmonary bypass (CPB) was 103 minutes. During CPB, hematocrit levels were maintained at 25 ± 4%. No patients received donor blood replacement in the operating room prior to the commencement of CPB. Ten percent had homologous blood added to the prime, 76% received no blood during the conduct of CPB. Twenty percent received donor blood during perfusion. Twelve percent received donor blood during the period between completion of CPB and transfer to the recovery room. In the entire series, the average blood loss from the time of incision to completion of CPB was 513 cc's. After completion of CPB to the time of transfer to the recovery room the average blood loss was 690 cc's. In the open heart recovery room, 61% of patients received donor blood. Of the patients who received donor blood, 20% had CABG (1–5 grafts), 50% valve replacements (1–3 valves), and 38% miscellaneous procedures. A repeat thoracotomy was necessary to control post-operative hemorrhage in 10 patients (1%). The 30-day mortality for the series was 3%. No cases of hepatitis were reported. During the last decade at our institution, the donor blood requirements have decreased from 15 units availability to 4 units.

Introduction
Blood procurement, blood type, and exposure to serum hepatitis are major problems in management of the cardiac surgical patient. Clear fluid prime has lessened the demand for homologous blood in patients requiring CPB. Also, our understanding of the hemodynamics of the human body and the known and unknown mechanisms for its metabolic preservation continues to expand, enabling CPB to become more efficient in sustaining life during cardiac surgical repair. These advances are resulting in less demand for additional donor blood transfusions in the cardiac surgical patient.

A national survey reported an average of 7.9 units of blood were required for all coronary artery bypass grafting procedures employing saphenous veins as conduits, and 8.3 units for all other types of cardiac surgical repairs that required CPB. The survey stated that serious consideration should be given by surgeons and anesthesiologists to the adoption of known, confirmed methods for reducing donor blood requirement.

Due to the refinement of technical skills of the cardiac surgical team, anesthetist, perfusionist, operating room nurses, and personnel in the cardiac care units, the demand for donor blood replacement has decreased in the cardiac surgical patient in this institution, where donor blood requirement and fluid balance are carefully monitored in all cardiac surgical patients.
The following data from patients having coronary artery bypass grafts using internal mammary and saphenous veins as conduits, valve replacements, and other procedures demonstrate the results of contributing factors causing the reduction of donor blood transfusions in the cardiac surgical patient at our institution.

The contributing factors are:

1. commitment of the team to effect decreased blood usage
2. careful pre- and post-operative fluid management
3. anesthesia techniques requiring less additional volume
4. surgical techniques resulting in decreased blood loss during surgery
5. clear fluid primes eliminating the need for donor blood
6. control of fluid and medication management by the perfusionist while on CPB
7. utilization of volume remaining in oxygenator at termination of bypass
8. transfusion of donor red cells rather than whole blood whenever possible

This comprehensive study of 835 cases was undertaken to confirm our methods for blood conservation, blood employment, and to determine when during the patient’s hospital course donor blood was utilized.

**Methods and Materials**

Eight hundred and thirty-five consecutive cardiac surgical cases were studied. All were operated on in 1978 by three cardiovascular surgeons over a period of twelve months. The study included 685 males (82%), and 150 females (18%).

After premedication with appropriate analgesics, the induction of anesthesia was aided by thiopental sodium, 2.5% solution, and succinylcholine for endotracheal intubation. All patients were safely intubated, and analgesia was maintained with intravenous innovar or fentanyl.Nitrous oxide or halothane was employed. Systolic blood pressures were managed between 80 mm Hg and 110 mm Hg. Nitroglycerin was used for vasodilation, and metaraminol for vasoconstriction.

Through a mid sternum incision the pericardium was opened and the surgical site exposed. Preparation for CPB was introduced by injecting sodium heparin (4 mg/kg) into the right atrium. Aortic and vena cava cannulae were systemically placed. A left ventricular vent, when required, was inserted into the right superior pulmonary vein, then passed into the left ventricle. The vent catheter was attached to the venous line for gravity drainage to the oxygenator, thus eliminating one pump head during CPB. A Sarns 5000 roller type pump with a slightly unocclusive arterial pump head was used with a bubble oxygenator, the Bentley Temptrol Model Q-100 or Harvey H-1000. Filtration was used only upon request, in which case a Pall Ultipor Blood Filter was inserted in the suction return line.

The bubble oxygenator was primed with clear fluids except in patients whose hematocrits were less than 34%, in which case one unit of donor blood replaced the same amount of crystalloid solution. Clear fluid prime consisted of Ringer’s lactate solution with 5% dextrose for patients with normal glucose levels. Patients with diabetes mellitus received plain Ringer’s lactate solution. Added to the clear fluid or hemodiluted primes were salt poor albumin (50 gms); mannitol 10% solution (0.5 gm/kg); one ampule sodium bicarbonate (50 mEq); and 3000 units of sodium heparin. Total priming volume amounted to 1800 cc or 2100 cc when coronary perfusion was employed.

Flow was calculated by multiplying body surface area by 2.4 liters/min for high flow, and 1.6 liters/min for low flow. The flow was adjusted, after CPB was established, depending upon the body temperature (monitored via rectal and esophageal probes), the hematocrit, and the patient’s pathology.

Pressures were maintained with perfusion techniques (altering blood flow or adding fluids) and medications were used when perfusion techniques failed to provide the desired arterial pressure of 60 mm Hg to 90 mm Hg. Chlorpromazine or nitroglycerin were used for hypertensive conditions, and metaraminol for hypotension. These were administered via the oxygenator by the per-

---

* Sarns, Inc., Ann Arbor, Michigan 48103.
* Bentley Laboratories, Inc., Santa Ana, CA 92714.
* William Harvey, Division of C. R. Bard Inc., Santa Ana, CA 92705.
* Pall Corporation, Glen Cove, New York 11542.
fusionist. Anticoagulation, acid-base and fluid management were maintained by the perfusionist on CPB. A potassium chloride level of 4.0–5.5 mEq per liter was desired.

An accurate account of fluid and blood loss balance was recorded by the perfusionist and surgical nursing team, and necessary replacements were added to the circulating volume. A hematocrit of 20% was acceptable in patients at moderate hypothermia due to the expectation of hemoconcentration by diuresis. At termination of bypass a hematocrit of 25% was desirable. Volume balance of the patient was reported to the surgeon by the perfusionist at the termination of bypass. Blood remaining in the oxygenator was carefully rein­ fused via the arterial pump head according to right and left filling pressures. Blood not utilized immediately was stored in citrate-phosphate dextrose solution (CPD) blood bags or centrifuged if enough volume was available for centrifugation. The salvaged blood was then transfused, if required, during the chest closure and in the open heart recovery room. Blood transfused after centrifugation or stored in CPD blood bags was not considered donor blood replacement in this series.

Neutralization of sodium heparin with prot­ amine sulfate was calculated to 1.4 mg to 1.5 mg per mg of heparin given. This was administrated by the anesthesiologist.

Blood loss records, donor blood requirements and other parameters were studied in the open heart recovery room and in the operating room as they related to induction of anesthesia, prime solution, CPB, and the post-bypass period. Parameters recorded and studied relevant to this study are:

1. number of recipients and non-recipients
2. type of cardiovascular pathology
3. amount of red cells and whole blood utilized
4. time of utilization
5. patients receiving clear fluid or blood primes
6. duration of CPB
7. blood loss during CPB and post bypass
8. hematocrit values
9. amount of plasma and platelets used

Results

The 835 cases were arranged in their respective categories: coronary artery bypass grafts, valve replacements, and other procedures (Fig. 1). No blood was transfused from induction of anesthesia to the commencement of CPB. Of the 835 cases studied, 79 patients received a hemodilution prime (one unit of whole blood or packed cells). Of these, 44 patients did not receive donor blood

while on CPB. Donor blood was added to the oxygenator in 163 patients during CPB. The combined total of donor blood recipients who required blood on either the prime or during bypass was 198 patients.

The average time on bypass for the 835 cases was 1 hour and 43 minutes. Expected urine output was 4 ml × kg per hour with a ±20% deviation while on CPB. Blood gases were maintained within acceptable parameters. The number of coronary artery bypass grafts were 1–5 anastomoses, and 1–3 valve replacements. The average blood loss from midsternum incision to completion of bypass averaged 513 cc per patient.

Post-bypass a total of 95 patients received donor blood in the operating room. The average blood loss was 696 cc per patient from completion of bypass to closure of incisional wounds. Hematocrit value levels were 25 ± 4% when the patients were transferred to the open heart recovery room. All patients who received donor blood replace-

ment in the operating room were arranged in their respective categories (Fig. 2).

Only 791 patients of the series could be studied in the open heart recovery room due to unavailability of 44 charts. Donor blood transfusions were required in 481 patients. The range of hematocrits were 24–32% in patients requiring donor blood transfusions. Platelet counts showed 54 patients had a moderate to marked decrease postoperatively, but were back within normal range (150,000 to 300,000) in 24 hours. Post-operative hemorrhage occurred in 10 patients who required exploration. The 30-day mortality for the 835 cases was 3%. There were no reported cases of hepatitis due to donor blood replacement in the entire study.

A total of 1,804 units of whole blood and red cells were used in the 835 cases studied. This amount represented 19% of blood transfused at our institution in the twelve month period of study. The amount crossmatched, typed (whole blood or packed cells), amount used, and amount not utilized were categorized (Table I). Total amount of platelets used were 175 units. Platelets transfused averaged 0.2 units per patients. Fresh frozen plasma utilized were 164 units, averaging 0.2 units per patient. The time and amount of donor blood transfused were accounted (Table II).

At the time of this study 4 units of donor blood were ordered and made available for use preoperatively, operatively, and post-operatively for blood loss replacement. In the span of 13 years the anticipated need for 15 units per patient of donor blood was decreased to the present 4 units per patient which we attribute to the contributing factors previously stated. This amount represented a marked reduction in the need for donor blood at

**TABLE I**

<table>
<thead>
<tr>
<th>Total Units Crossmatched and Amount of Whole Blood and Red Cells Used for Surgical Cases Studied</th>
</tr>
</thead>
<tbody>
<tr>
<td>CROSSMATCHED UNITS</td>
</tr>
<tr>
<td>---------------------</td>
</tr>
<tr>
<td>1,804 units</td>
</tr>
<tr>
<td>NOT USED</td>
</tr>
</tbody>
</table>

- CABG: Coronary Artery Bypass Grafts
- VALVE: Valve Replacements
- OTHER: Other Surgical Procedures

- NO DONOR BLOOD USED
- YES - DONOR BLOOD USED
TABLE II
Blood Utilization

<table>
<thead>
<tr>
<th>Time of Transfusion</th>
<th>Whole Blood</th>
<th>Red Cells</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>C.P.B.</td>
<td>156</td>
<td>141</td>
<td>297 (16%)</td>
</tr>
<tr>
<td>Post-C.P.B.</td>
<td>78</td>
<td>78</td>
<td>156 (9%)</td>
</tr>
<tr>
<td>O.H.R.R.</td>
<td>284</td>
<td>759</td>
<td>1043 (57%)</td>
</tr>
<tr>
<td>Other*</td>
<td>114</td>
<td>194</td>
<td>308 (17%)</td>
</tr>
<tr>
<td>Total Units</td>
<td>632</td>
<td>1172</td>
<td>1804 (100%)</td>
</tr>
</tbody>
</table>

Time and amount of donor blood used for cases studied

our institution while the number of cardiac surgical cases continued to increase (Fig. 3). The average amount of whole blood or red cells utilized in the 835 cases studied averaged 2.16 units per patient.

Conclusion

Donor blood requirement in the cardiac surgical patient is a national concern, and is a universal problem. This study is indicative of the continued effort of our cardiac surgical team to decrease the need for donor blood. By employing clear fluid primes recommended by early pioneers, and using techniques proven to lessen the need for donor blood this decrease is being accomplished.

Hemodilution, as described in a recent study, also showed no apparent hemodynamic effects in our series, compared to the study of Hausman, et al. which reported an average of 6 units per patient of fresh frozen plasma. Our study revealed that we averaged 0.2 units of fresh frozen plasma per patient which was considerably less.

Since completion and submission of this report, preliminary investigation disclosed that in 1979, when the number of cardiac surgical cases increased to 1,024, an average of 2 units per patient were utilized. In 1980 an investigation revealed we utilized 1,717 units of donor blood for 1,047 cases performed, an average of 1.6 units per patient.

It was the purpose of this study to determine whether our institution could confirm the findings of other institutions. We have proven that the need for donor blood has decreased while the surgical case load has increased.

References