

ORIGINAL ARTICLE

Fresh Whole Blood versus Reconstituted Blood for Pump Priming in Heart Surgery in Infants

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ABSTRACT

BACKGROUND

In an attempt to reduce the coagulopathic and inflammatory responses seen after cardiopulmonary bypass, the use of fresh whole blood during heart operations has become the standard of care for neonates and infants at many institutions. We compared the use of fresh whole blood with the use of a combination of packed red cells and fresh-frozen plasma (reconstituted blood) for priming of the cardiopulmonary bypass circuit.

METHODS

We conducted a single-center, randomized, double-blind, controlled trial involving children less than one year of age who underwent open-heart surgery. Patients were assigned to receive either fresh whole blood that had been collected not more than 48 hours previously (96 patients) or reconstituted blood (104 patients) for bypass-circuit priming. Clinical outcomes and serologic measures of systemic inflammation and myocardial injury were compared between the groups.

RESULTS

The group that received reconstituted blood had a shorter stay in the intensive care unit than the group that received fresh whole blood (70.5 hours vs. 97.0 hours, $P=0.04$). The group that received reconstituted blood also had a smaller cumulative fluid balance at 48 hours (-6.9 ml per kilogram of body weight vs. 28.8 ml per kilogram, $P=0.003$). Early postoperative chest-tube output, blood-product transfusion requirements, and levels of serum mediators of inflammation and cardiac troponin I were similar in the two groups.

CONCLUSIONS

The use of fresh whole blood for cardiopulmonary bypass priming has no advantage over the use of a combination of packed red cells and fresh-frozen plasma during surgery for congenital heart disease. Moreover, circuit priming with fresh whole blood is associated with an increased length of stay in the intensive care unit and increased perioperative fluid overload.

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THE DELETERIOUS EFFECTS OF CARDIOPULMONARY bypass increase the morbidity and mortality associated with surgery for congenital heart disease. Children undergoing cardiopulmonary bypass face the challenge of hemodilution and platelet dysfunction, which induce a state of abnormal coagulation.^{1,2} This is particularly true in neonates, who commonly endure the equivalent of a complete exchange transfusion.³⁻⁶ Cardiopulmonary bypass also exposes a patient's blood to the nonendothelialized surface of the bypass circuit. Such exposure provokes the elaboration of cytokines and complement activation.^{7,8} This inflammatory response is associated with the development of capillary leak syndrome, generalized edema, myocardial injury, and multisystem organ failure.^{9,10}

In an attempt to mitigate the severity of the coagulopathy and inflammation seen after cardiopulmonary bypass, many cardiothoracic surgeons have insisted on the use of fresh whole blood (i.e., whole blood collected not more than 48 hours before use) to prime the cardiopulmonary bypass circuit during heart surgery in neonates and infants.^{11,12} Proponents of this approach cite two main advantages over conventional priming with packed red cells and fresh-frozen plasma: improved postoperative hemostasis and decreased systemic inflammation that results in reduced postoperative edema formation and organ dysfunction. Opponents of the use of fresh whole blood point to logistic difficulties associated with its procurement and expedited testing, as well as the loss of blood-center inventory in the form of products of blood separation.

The majority of the reported data on the use of whole blood come from studies in adults undergoing surgery for trauma or transplantation. In adults who have lost large volumes of blood, whole-blood transfusion has been found to minimize dilutional coagulopathy, reduce donor exposure (i.e., the number of donors from whom products are obtained for transfusion),¹³ and restore platelet aggregation.¹⁴ In a pediatric study, Manno et al. demonstrated that children less than two years of age who are undergoing heart surgery lose less blood postoperatively if their postsurgical transfusion requirements are met with fresh whole blood.¹⁵ Platelet aggregation, which was maintained in those who received fresh whole blood, was thought to provide the observed hemostatic benefit.

No studies have yet addressed whether priming

of the cardiopulmonary bypass circuit with fresh whole blood improves hemostasis. Likewise, the notion that priming with fresh whole blood is advantageous because it is associated with reduced inflammatory stimulation is untested. Therefore, we sought to determine, by assessing both clinical and biochemical variables, whether priming of the cardiopulmonary bypass circuit with fresh whole blood is advantageous as compared with circuit priming with component blood products in children less than one year of age who are undergoing open-heart surgery.

METHODS

STUDY DESIGN

The primary hypothesis of this prospective, randomized, double-blind, controlled trial was that the use of fresh whole blood for cardiopulmonary bypass circuit priming would decrease, by one point, the score for a composite variable consisting of survival and length of stay in the intensive care unit as compared with use of reconstituted-blood priming. One point was given for each day of postoperative recovery in the intensive care unit, up to a maximum score of 7. Patients who died before postoperative day 28 were given a score of 8. Power analysis, based on historical intensive care unit data and an α level of 0.05 and β level of 0.20, indicated that 100 patients would be required for each study group.

The investigation, conducted between January 1999 and January 2003 at Children's Medical Center, Dallas, was approved by the institutional review board at the University of Texas Southwestern Medical Center, Dallas. Written informed consent was obtained from the legal guardian or guardians of each patient before enrollment. A data safety and monitoring board composed of three pediatric subspecialists (a hematologist, an intensivist, and a cardiac intensivist) from two outside institutions performed an interim analysis of the results from the first 74 patients. After reviewing the data, the board advised that the study proceed to the planned enrollment of 200 patients. Thereafter, the board met again to review the final results of the investigation and declared the study completed.

STUDY PARTICIPANTS

Children less than one year of age with congenital heart disease who required cardiac surgery were sequentially recruited for the investigation. Only

patients who were to receive blood priming of their cardiopulmonary bypass circuit and whose surgery and perfusion were to be performed by a specific team were eligible for participation. Reasons for exclusion included the unavailability of the randomly assigned blood product, the use of donor-directed blood, objective evidence of infectious illness within two weeks before surgery, use of corticosteroids within two weeks before surgery, evidence of immunodeficiency or suspected immunodeficiency (with the exception of the DiGeorge syndrome), concurrent treatment with inhaled nitric oxide, and preoperative coagulopathy. Patients also were excluded if written informed consent had not been obtained or was withdrawn.

Participants were randomly assigned to receive either fresh whole blood or reconstituted blood products for priming of the cardiopulmonary bypass circuit. Those with single-ventricle lesions were stratified to ensure their equivalent distribution in the two study groups.

BLOOD PRODUCTS

All blood products were acquired from a standard donor pool and underwent routine screening for infectious agents, as required by the Food and Drug Administration. Nucleic acid testing was used to detect the human immunodeficiency virus (HIV) and hepatitis C virus (HCV).

Blood was collected in bags containing a citrate, phosphate, and dextrose anticoagulant-preserved solution. Units destined to be used as fresh whole blood were stored at 2°C to 6°C and released for use not more than 48 hours after the time of collection. Units divided into components underwent standard preparation. Packed red cells were treated with a preservative solution (Optisol, Terumo, or Adsol, Baxter Healthcare) and stored at 1°C to 6°C.

Packed red cells and fresh-frozen plasma for patients randomly assigned to receive reconstituted products were combined in the operating room at the time of circuit priming. A half unit of packed red cells was mixed with a half unit of fresh-frozen plasma to achieve a hematocrit of approximately 25 percent. The other half unit of packed red cells was added to the circuit at the time of rewarming. For patients randomly assigned to receive fresh whole blood, a half unit of fresh whole blood was used for circuit priming, and the other half was used during rewarming. All care providers, with the exception of the operating room perfusionist and circulat-

ing nurse, were blinded to each patient's group assignment.

CARDIOPULMONARY BYPASS

The cardiopulmonary bypass circuit was initially filled with lactated Ringer's solution. The reservoir was then drained completely and refilled with a priming infusion consisting of 25 percent albumin (10 percent of the total priming volume), mannitol at a dose of 0.5 g per kilogram of body weight, furosemide at 0.25 mg per kilogram, and methylprednisolone at 30 mg per kilogram. The randomized blood product was added to the priming infusion, and calcium chloride was then added to complete the priming process.

Blood cardioplegia was used at a blood-to-cardioplegia ratio of 4:1. Blood flow on cardiopulmonary bypass was maintained at 2.0 to 2.6 liters per minute per square meter of body-surface area, with an attempt to keep the venous oxygen saturation above 70 percent. Blood pressures were targeted to a mean arterial pressure of 40 to 60 mm Hg. A pH-stat blood-gas strategy (i.e., the addition of carbon dioxide to the ventilating gas of the oxygenator in order to achieve a blood pH of 7.40 during hypothermia) was used during cooling. During rewarming, an alpha-stat strategy (i.e., no adjustment in blood pH for hypothermia-mediated alkalosis) was used, and patients were given furosemide (0.25 mg per kilogram) and mannitol (0.5 mg per kilogram). All the patients underwent conventional ultrafiltration to achieve a hematocrit of 30 to 40 percent during rewarming.

DATA COLLECTION

On the day of surgery, a preoperative illness-severity score was assigned to each patient. One point was given for each of the following: inpatient (as opposed to outpatient) status, prostaglandin E₁ infusion, oxygen saturation below 90 percent, need for mechanical ventilation, and need for inotropic support. Preoperative prothrombin time, partial-thromboplastin time, and fibrinogen levels were also obtained. Blood samples for the measurement of lipopolysaccharide-binding protein, interleukin-6, interleukin-8, cardiac troponin I, activated complement (C3a), and tumor necrosis factor α were obtained after the induction of anesthesia and 1, 8, 24, 48, and 72 hours after the patient's return to the intensive care unit.

The degree of postoperative illness was determined at 24 hours to be either severe or nonsevere,

according to prospectively defined criteria.¹⁶ An inotropic-support score was calculated as follows, where dosages are expressed in micrograms per kilogram per minute: dopamine + dobutamine + (epinephrine × 100) + (milrinone × 10).¹⁷ Children with a net positive fluid balance of 40 ml per kilogram or higher during the first 24 hours after surgery and an inotropic score of 17 or higher and those who died perioperatively were considered to have had a severe clinical course. All determinations of clinical outcome were made by the study coordinator, without knowledge of the patient's laboratory data.

Total blood loss was assessed for 72 hours after the patient was admitted to the intensive care unit by measuring chest-tube drainage. Strict clinical guidelines for postoperative transfusion were in-

stituted to allow comparison of blood-transfusion requirements between the groups.

BIOCHEMICAL ASSAYS

The levels of tumor necrosis factor α , lipopolysaccharide-binding protein, interleukin-6, and interleukin-8 were measured by means of immunometric sandwich assays (Immulite analyzer, EURO/DPC). C3a was measured by means of an enzyme-linked immunosorbent assay at the Complement Laboratory, National Jewish Medical and Research Center, Denver.

STATISTICAL ANALYSIS

All data were analyzed on an intention-to-treat basis with SPSS for Windows statistical software. Descriptive statistics for nonparametric data are

Table 1. Baseline Characteristics of the Patients.

Characteristic	Fresh-Whole-Blood Group 1(N=96)	Reconstituted-Blood Group (N=104)	P Value
Age — days			0.49
Median	66.5	92.0	
25th percentile, 75th percentile	7.0, 178.0	8.0, 193.0	
Neonate (≤ 28 days of age) — no. (%)	39 (41)	38 (37)	0.56
Male sex — no. (%)	48 (50)	65 (62)	0.09
Weight — kg			0.38
Median	4.1	4.4	
25th percentile, 75th percentile	3.3, 5.6	3.3, 6.0	
Preoperative-illness severity score			0.23
Median	1.0	1.0	
25th percentile, 75th percentile	0, 4.0	0, 2.0	
Diagnosis — no. (%)			0.68
Transposition of the great arteries	14 (15)	16 (15)	
Hypoplastic left-heart syndrome	19 (20)	13 (12)	
Atrioventricular septal defect	13 (14)	12 (12)	
Ventricular septal defect	10 (10)	14 (13)	
Tetralogy of Fallot	9 (9)	13 (12)	
Truncus arteriosus	9 (9)	6 (6)	
Double-outlet right ventricle	7 (7)	4 (4)	
Pulmonary atresia	3 (3)	6 (6)	
Interrupted aortic arch	3 (3)	2 (2)	
Aortic stenosis	1 (1)	3 (3)	
Total anomalous pulmonary venous return	1 (1)	4 (4)	
Other	7 (7)	11 (11)	
Single-ventricle lesion — no. (%)	27 (28)	27 (26)	0.75
DiGeorge syndrome — no. (%)	6 (6)	6 (6)	1.00

presented as medians and percentiles or as proportions. Independent-sample Mann–Whitney U tests and chi-square or Fisher’s exact tests were used as appropriate. All correlational analyses were conducted with Spearman’s correlation coefficient.

RESULTS

CHARACTERISTICS OF THE PATIENTS

The guardians of 266 patients gave their written informed consent for their children’s participation in the study. Thirty-four patients were excluded be-

cause the randomly assigned blood product was unavailable. An additional 27 patients were excluded for other reasons, including the use of an asanguineous priming solution, preoperative infection, and withdrawal of the guardians’ consent. A total of 205 patients underwent randomization and received their assigned blood products for cardiopulmonary bypass circuit priming. Four patients were disqualified because the necessary preoperative laboratory data had not been obtained, and one because blinding was not maintained. Thus, a total of 200 patients were included in the inves-

Table 2. Intraoperative and Postoperative Outcomes.

Outcome	Fresh-Whole-Blood Group (N=96)	Reconstituted-Blood Group (N=104)	P Value
Intraoperative			
Duration of cardiopulmonary bypass — min			0.97
Median	73.0	74.5	
25th percentile, 75th percentile	59.0, 97.0	56.3, 95.0	
Duration of aortic cross-clamping — min			0.46
Median	56.5	53.0	
25th percentile, 75th percentile	40.0, 68.0	37.5, 66.0	
Duration of deep hypothermic circulatory arrest — min			0.24
Median	55.0	47.0	
25th percentile, 75th percentile	42.0, 63.0	39.3, 59.8	
Time from discontinuation of cardiopulmonary bypass to arrival in intensive care unit — min			0.16
Median	80.0	76.0	
25th percentile, 75th percentile	67.0, 105.5	62.5, 96.5	
Use of aprotinin — no. (%)	54 (56)	58 (56)	1.00
Use of tranexamic acid — no. (%)	3 (3)	2 (2)	0.67
Postoperative			
Death — no. (%)	11 (11)	11 (11)	1.00
Intraoperative death — no. (%)	3 (3)	2 (2)	0.67
Severe postoperative course — no. (%)	22 (23)	20 (19)	0.60
72-hr chest-tube output — ml/kg			0.73
Median	24.1	22.8	
25th percentile, 75th percentile	14.5, 42.9	13.8, 40.0	
Transfusion requirement — ml/kg			0.55
Median	6.0	5.1	
25th percentile, 75th percentile	0, 20.7	0, 16.5	
Mediastinal reexploration — no. (%)	2 (2)	7 (7)	0.11
Delayed sternal closure — no. (%)	22 (23)	18 (17)	0.38
Extracorporeal membrane oxygenation — no. (%)	6 (6)	2 (2)	0.16
Renal-replacement therapy — no. (%)	9 (9)	5 (5)	0.27
Intracranial hemorrhage — no. (%)	3 (3)	0	0.11
Cardiac arrest or need for cardiopulmonary resuscitation — no. (%)	7 (7)	6 (6)	0.77
Arrhythmia — no. (%)	2 (2)	5 (5)	0.45

tigation, 96 in the fresh-whole-blood group and 104 in the reconstituted-blood group. Demographic characteristics, diagnoses, and preoperative illness-severity scores were similar between the two groups (Table 1).

INTRAOPERATIVE DATA

There were no significant differences between the groups in intraoperative variables (Table 2). The median age of the fresh whole blood was 47.6 hours (25th and 75th percentiles, 45.8 and 50.7 hours), and the median age of the packed red cells used for the reconstituted blood was 139.5 hours (25th and 75th percentiles, 117.0 and 162.7 hours) ($P < 0.001$).

CLINICAL OUTCOMES

Among the children who received reconstituted blood, there was a trend toward a lower median score for the primary outcome variable (the composite score for survival and length of stay in the intensive care unit) than among those who received fresh whole blood (4.0 vs. 5.0, $P = 0.10$) (Fig. 1). Similarly, post hoc modification of the composite outcome variable to include days spent in the intensive care unit to postoperative day 28 (with mortality accordingly assigned a score of 29) did not reveal a significant difference between the groups (4.0 vs. 5.5, $P = 0.16$). Additional post hoc subgroup analyses, including examination of cohorts with single-ventricle lesions, cohorts with two-ventricle lesions, and cohorts grouped according to age (≤ 28 days [neonates] or > 28 days [infants]) all failed to reveal significant differences in outcome between patients who received fresh whole blood and those who received reconstituted blood.

Whereas there was only a trend toward significant differences in the primary outcome variable in favor of priming with reconstituted blood, differences in other clinical variables proved to be significant. According to intention-to-treat analysis, patients who received reconstituted blood had a shorter length of stay in the intensive care unit than did those who received fresh whole blood (70.5 hours vs. 97.0 hours, $P = 0.04$) (Fig. 1) and had a smaller cumulative fluid balance at 48 hours (-6.9 ml per kilogram vs. 28.8 ml per kilogram, $P = 0.003$) (Fig. 2), with a trend toward less fluid accumulation throughout the 72-hour study period. Furthermore, among the patients who received reconstituted blood, there was a trend toward a shorter duration of mechanical ventilation (36.3

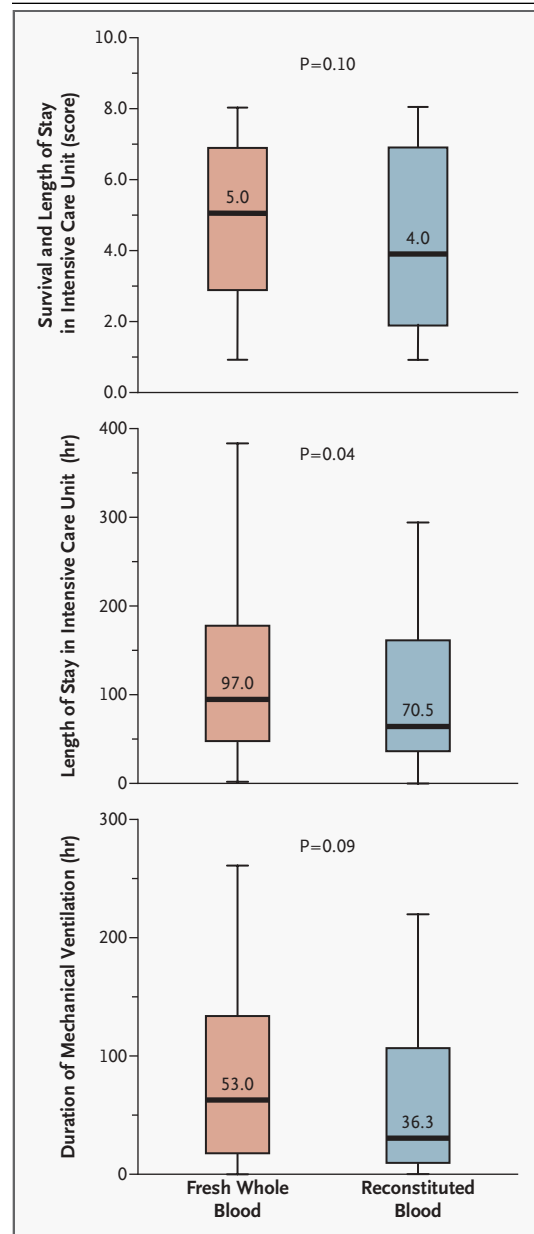


Figure 1. Clinical Outcomes in Infants Who Received Either Fresh Whole Blood or Reconstituted Blood for Priming of the Cardiopulmonary Bypass Circuit.

The lower and upper limits of the boxes indicate the 25th and 75th percentiles, and the horizontal lines and values within the boxes the medians. There was no significant difference between the groups with respect to the primary outcome variable (survival and the length of stay in the intensive care unit, up to day 7) or the duration of mechanical ventilation. However, patients who received reconstituted blood for priming had a shorter length of stay in the intensive care unit.

hours, vs. 53.0 hours among those who received whole blood; $P=0.09$) (Fig. 1).

Chest-tube output and blood-product transfusion requirements did not differ between the groups (Table 2). Correlational analyses to determine the effect of the age of the blood on both chest-tube output and the requirement for packed red cells revealed no significant relationships. Donor exposure in the reconstituted-blood group was greater than that in the fresh-whole-blood group (4.0 donors vs. 3.5 donors, $P=0.05$). This difference is accounted for by the obligate use of two donors for blood reconstitution, as opposed to a single donor when fresh whole blood is used. Finally, there were no significant differences between the groups in the rate of death from all causes; in the frequency of a severe postoperative clinical course, of delayed sternal closure, or of the need for extracorporeal membrane oxygenation; or in the overall number of postoperative complications (Table 2).

LABORATORY MEASUREMENTS

All the patients had normal levels of C3a, cardiac troponin I, interleukin-6, interleukin-8, and lipopolysaccharide-binding protein during the preoperative period. Postoperatively, elevations in C3a, cardiac troponin I, interleukin-6, interleukin-8, tumor necrosis factor α , and lipopolysaccharide-binding protein occurred in both groups (Fig. 3). No statistically significant differences were discerned with the exception of a difference in the level of lipopolysaccharide-binding protein. At 48 and 72 hours, the levels of this protein in the fresh-whole-blood group became significantly greater than those in the reconstituted-blood group (18.1 μg per milliliter vs. 15.2 μg per milliliter, $P=0.04$, at 48 hours; and 20.9 μg per milliliter vs. 13.8 μg per milliliter, $P=0.007$, at 72 hours).

DISCUSSION

The notion has long been accepted that the use of fresh whole blood for circuit priming is critical for optimal outcomes after surgery for congenital heart disease. The appeal of this concept most likely stems from the fact that whole-blood priming guarantees the provision of all cellular and non-cellular blood components. Moreover, it seems intuitive that a manipulated or reconstituted product should be less desirable than a natural, unmanipulated product. Such beliefs have been support-

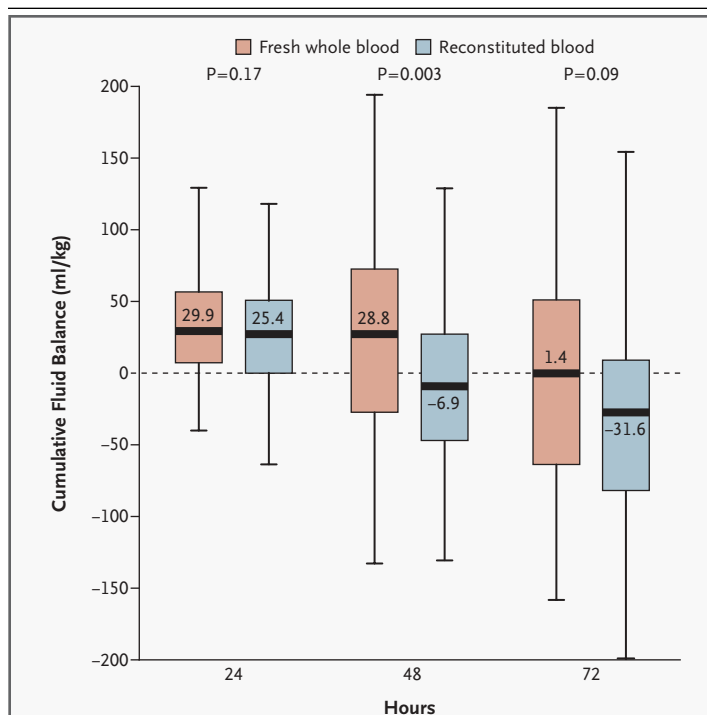


Figure 2. Cumulative Fluid Balance during the First 72 Hours after Cardiopulmonary Bypass in Infants Who Received Either Fresh Whole Blood or Reconstituted Blood for Priming of the Cardiopulmonary Bypass Circuit.

The lower and upper limits of the boxes indicate the 25th and 75th percentiles, and the horizontal lines and values within the boxes the medians. Throughout the 72-hour study period there was a trend toward greater cumulative fluid balance in the group that received fresh whole blood than in the group that received reconstituted blood; the difference was statistically significant at the 48-hour point.

ed over time by potentially biased anecdotal clinical observations (e.g., reduced postoperative bleeding and edema formation in children receiving fresh whole blood for circuit priming) and various theoretical explanations (e.g., reduced inflammatory activation with fresh whole blood), which have remained untested.

In this prospective, randomized, double-blind study, we demonstrated that the use of fresh whole blood for cardiopulmonary-bypass circuit priming in neonates and infants does not confer a significant clinical or biochemical advantage over priming with a combination of packed red cells and fresh-frozen plasma. Perhaps more important, circuit priming with fresh whole blood was associated with a significantly lengthier stay in the intensive care unit, greater perioperative fluid overload, and

Figure 3. Markers of Systemic Inflammation and Myocardial Injury before and after Cardiopulmonary Bypass in Infants Who Received Either Fresh Whole Blood or Reconstituted Blood for Priming of the Cardiopulmonary Bypass Circuit.

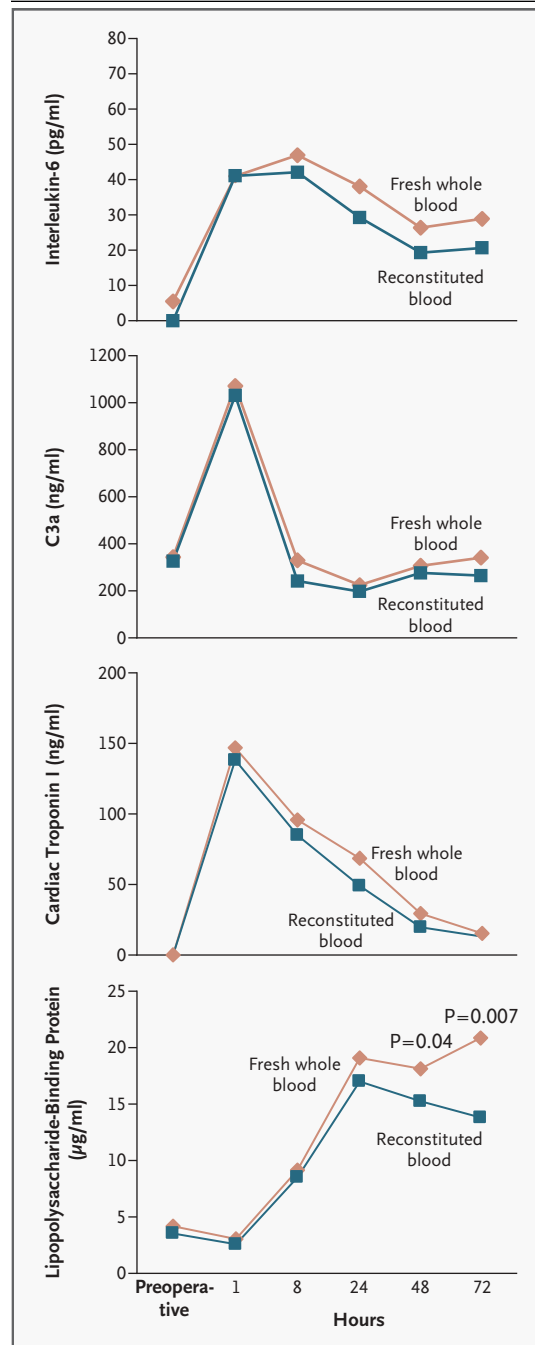
Data are presented as median values. For interleukin-6, the normal range is 0 to 5.5 pg per milliliter; for C3a, 0 to 358 ng per milliliter; for cardiac troponin I, 0 to 2.0 ng per milliliter; and for lipopolysaccharide-binding protein, 2.0 to 15.2 μ g per milliliter. All laboratory values were elevated postoperatively in both groups. Only the level of lipopolysaccharide-binding protein was statistically different between the groups, reaching significantly lower levels in the reconstituted-blood group 48 and 72 hours after surgery.

a trend toward an increased duration of mechanical ventilation. These variables may be related to one another mechanistically. Fluid retention with the persistence of pulmonary edema in patients who receive fresh whole blood could delay postoperative improvement in chest-wall and lung compliance and thereby prolong the requirement for mechanical ventilation. This prolongation, in turn, could increase the length of stay in the intensive care unit.

The biologic explanation for these observed differences in outcome is unknown. Randomization of the patients resulted in study groups that differed substantively only in the type of blood prime used for cardiopulmonary bypass. Furthermore, the preoperative and postoperative inflammatory profiles were not substantially different between groups. However, the possibility that inflammatory mediators not evaluated in this study significantly influenced group outcomes cannot be dismissed.

In contrast to fresh whole blood, all packed red cells were preserved in the blood center by the addition of solutions that contain sodium chloride, adenine, dextrose, and mannitol. Although the clinical effects of these substances at the concentrations used are uncertain, it is known that mannitol is an antioxidant capable of scavenging oxygen free radicals, the levels of which increase with ischemia-reperfusion during cardiopulmonary bypass.¹⁸ This property could diminish injury from peroxidation of structural lipids in cell membranes throughout the body.

The use of fresh whole blood for cardiopulmonary bypass circuit priming did reduce donor exposure during the perioperative period. The mag-



nitude of this decrease is explained by the use of two donors for blood reconstitution and a single donor for fresh whole blood. Aside from this initial advantage, there was no significant difference in the number of subsequent donor exposures between the groups, an observation consistent with the finding that the reconstituted-blood group did

not have greater postoperative bleeding than the fresh-whole-blood group. More stringent donor-eligibility criteria and more sensitive serologic and nucleic acid assays for viral detection have minimized the risk associated with additional donor exposure (transmission of HCV and HIV both occur in less than 1 transfusion in 1 million¹⁹). Moreover, this risk could be eliminated completely by the reconstitution of blood from a single donor. In contrast, the risks associated with an additional day of mechanical ventilation and an additional day in the intensive care unit are significantly greater. The rate of infections in patients undergoing cardiac surgery is 23 per 1000 days, a rate 50 percent greater than that in the general population of patients in the pediatric intensive care unit.²⁰ In addition, the mortality attributable to nosocomial infection in children has been estimated at 11 percent.²¹ Among infants, increased time spent in the intensive care unit after surgery for congenital heart disease has also been associated with worsened cognitive function.²²

Consideration of the relative costs of using reconstituted blood as compared with fresh whole blood is also instructive. If charges are used as a surrogate for actual costs, on the basis of data from our hospital system, there is an additional blood-center charge of \$110 for reconstituted-blood therapy; however, the extended stay in the intensive care unit associated with the use of fresh-whole-blood priming would result in additional charges of \$5,750. This amount does not include ancillary charges for medications and other therapies associated with prolonged intensive care. Since approximately 19,000 operations for congenital heart disease are performed annually in the United States,²³ with the majority requiring cardiopul-

monary bypass, the aggregate cost savings from the use of reconstituted blood for bypass circuit priming could be substantial. Furthermore, from the perspective of blood centers already grappling with the need to maintain a blood-product supply that remains just ahead of demand,²⁴ providing fresh whole blood reduces inventory control and revenue because many units of platelets and fresh-frozen plasma are not obtained.

In conclusion, the use of fresh whole blood for cardiopulmonary bypass circuit priming in neonates and infants does not confer a significant clinical or biochemical advantage over priming with a combination of packed red cells and fresh-frozen plasma. On the contrary, the use of fresh whole blood is associated with a prolonged stay in the intensive care unit, increased perioperative fluid overload, and an increased duration of mechanical ventilation. In our opinion, these clinical hazards outweigh the risk of the additional donor exposure associated with reconstituted-blood priming. The use of component blood products from a single donor could completely eliminate this drawback. Moreover, the negative effect of cardiopulmonary-bypass circuit priming with fresh whole blood on blood-center operations further undermines the justification for and adherence to this long-standing practice.

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