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Transfusion-Free Cardiopulmonary Bypass in Jehovah's Witness Patients Weighing Less Than 5 kg

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Abstract: Performing cardiac surgery on pediatric Jehovah's Witness patients is a great challenge for the surgical team and especially for the perfusionist. Jehovah's Witnesses reject blood transfusions on the grounds of their literal interpretation of passages of the Bible. In accordance with this belief, Jehovah's Witnesses feel that it is also forbidden to retransfuse autologous blood that has been separated from their own circulatory system. We report the use of cardiopulmonary bypass (CPB) during open-heart surgery in three infants with a body weight of 4.5 kg, 3.5 kg, and 3.1 kg, respectively, without transfusion of blood components. A small-volume CPB circuit with a priming volume of 200 mL, including the arterial line filter, was designed to decrease the degree of hemodilution. A dedicated pediatric heart lung machine console with remote pump heads and intensive blood conservation efforts allowed the operation without the use of donor blood. The CPB circuits were primed with crystalloid solution only. The procedures were performed in normothermia or in moderate hypothermia. Pre-CPB hemoglobin levels were 10.8 g/dL, 10.6 g/dL, and 8.5 g/dL. The hemoglobin concentrations measured during CPB ranged from 5.9 to 6.5 g/dL, 6.4 to 6.8 g/dL, and 5.5 to 5.9 g/dL, respectively. The patients did not receive any blood or blood products during their entire hospital stay. **Keywords:** cardiopulmonary bypass, blood transfusion, Jehovah's Witnesses, newborn, infant. *JECT. 2005;37:282–285*

Jehovah's Witnesses reject blood transfusions based on their interpretation of passages of the Bible, such as: "Only flesh with its soul—its blood—you must not eat" (Genesis 9:3–4); "[You must] pour its blood out and cover it with dust" (Leviticus 17:13–14); and "Abstain from . . . fornication and from what is strangled and from blood" (Acts 15:19–21) (1). They refuse both homologous blood transfusion and the retransfusion of autologous blood that has been separated from their circulatory system. Most Jehovah's Witnesses, however, feel that the nonblood-primed external tubing of a cardiopulmonary bypass (CPB) circuit or dialysis is to be viewed as an extension of their own circulatory system, as long as a continuous, uninterrupted circuit is maintained.

Cardiovascular surgery with the associated risk of blood loss represents a considerable challenge in Jehovah's Witness patients because the transfusion of stored blood or blood products does not represent an option. Retransfusion of the patient's own blood also is rejected if there is no continuous contact between the circulation and the autologous blood. Traditionally, cardiac surgery has been associated with the risk of a high frequency of blood transfusions resulting from the characteristics of the operative procedure, especially with the use of heart–lung machines, which require anticoagulation and hemodilution and therefore cause impaired postoperative hemostasis. An even greater challenge is cardiac surgery in infants and neonates. Whereas in adults the priming volume of the CPB circuit corresponds to approximately one third of the patient's blood volume, this relationship is unfavorably altered in neonates and infants, in the past resulting in a bypass circuit priming volume sometimes two to three times greater than the patient's circulating blood volume (2). We report CPB procedures during cardiovascular surgery in three Jehovah's Witness patients weighing less than 5 kg without any transfusion of blood or blood derivatives during their entire hospital stay.

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CASE REPORTS

Case 1

A 6-month-old infant weighing 4.5 kg and measuring 61 cm was operated on for closure of a perimembranous ventricular septal defect (VSD). The VSD was closed with a patch; an additional persistent foramen ovale (PFO) was sutured directly. CPB time was 58 minutes with an aortic cross clamping period of 32 minutes. Twenty milliliters of "Kirsch" solution, a crystalloid cardioplegic solution containing magnesium aspartate and procaine (Cardioplegin, Koehler Chemie, Alsbach, Germany), and 40 mL of crystalloid cardioplegia based on 6% hetastarch (Cardioplegische Perfusionslösung, Fresenius, Bad Homburg, Germany) were administered into the aortic root. Systemic cooling was not performed. The hemoglobin concentration before CPB was 10.8 g/dL (Hct 32%). Because of initial hemodilution, the lowest value during CPB was 5.9 g/dL (Hct 18%). After termination of CPB, a hemoglobin concentration of 6.5 g/dL (Hct 20%) was measured; immediately after the operation, the value increased to 9.4 g/dL (Hct 28%). The patient could be extubated the same evening. The hemoglobin concentration at hospital discharge was 7.9 g/dL (Hct 24%).

Case 2

A 7-day-old neonate with a body weight of 3.55 kg and a length of 55 cm was operated on for correction of tetralogy of Fallot with absent pulmonary valve syndrome. The subaortic VSD was closed by insertion of a patch; the PFO was closed directly. After resection of the hypertrophic muscle in the right ventricular outflow tract, a 12-mm Contegra valved conduit (VenPro, Irvine, CA) was implanted in the right ventricular to pulmonary artery position. CPB time was 103 minutes, aortic cross clamp time 50 minutes, and reperfusion time 45 minutes. The initial hemoglobin concentration immediately before CPB was 10.6 g/dL (Hct 32%). After initiation of CPB, hemodilution caused by the priming volume led to a decrease to 6.7 g/dL (Hct 20%); the lowest value during CPB and the entire hospital stay was 6.4 g/dL (Hct 19%). Cardioplegic arrest was induced by the injection of 20 ml "Kirsch" followed by the infusion of 20 mL of crystalloid cardioplegia (Fresenius). The procedure was performed in moderate hypothermia of 32°C. At the end of the operation, the hemoglobin concentration was 8.0 g/dL (Hct 24%). The patient was discharged from our institution with a hemoglobin concentration of 10.0 g/dL (Hct 30%).

Case 3

An 18-day-old neonate with a body weight of 3.1 kg and a length 52 cm was referred from another hospital in the evening and underwent an emergency operation on the same day for correction of a truncus arteriosus communis in combination with persistent foramen ovale and VSD. After isolation of both pulmonary arteries from the truncus and repair of the aorta, both the atrial septal defect (ASD) and the VSD were closed and a 12 mm Contegra pulmonary valved conduit (Medtronic, MN; formerly VenPro) was implanted in the right ventricular to pulmonary artery position. Immediately before CPB, the anemic hemoglobin concentration was only 8.5 g/dL (Hct 26%). After the initiation of CPB, this value decreased to 5.5 g/dL (Hct 17%). Following the administration of 30 mL of "Kirsch" and 30 mL of crystalloid cardioplegia, the lowest level was 5.4 g/dL on bypass (Hct 16%). CPB was conducted in moderate hypothermia (28°C) and lasted 126 minutes; aortic cross clamp time was 90 minutes. By the end of CPB, the hemoglobin concentration increased to 5.9 g/dL (Hct 18%). The patient could be transferred to the intensive care unit in stable condition. Thereafter, the drawing of blood samples was limited to one daily venous sample for blood gas analysis. A hematopoietic therapy with iron and erythropoietin substitution led to a gradual rise in hemoglobin level to 6.5 g/dL (Hct 20%) on postoperative day 7, when the patient was weaned from the respirator and discharged back to the referring hospital.

PERFORMANCE OF CARDIOPULMONARY BYPASS

CPB Console

In patients with a body weight of less than 7 kg, we are currently using a Stöckert S3 Mast-Mounted Pump Console (Stöckert, Munich, Germany) at our institution. This console allows almost unrestricted positioning of two double roller pump heads around the oxygenator and the venous reservoir (Figure 1). The arterial pump head can be placed very close to the venous reservoir outlet and the heat exchanger/oxygenator inlet, whereas the two pump heads for the cardiotomy suckers can be situated very close to the cardiotomy reservoir inlet. In this way, tubing lengths can be reduced drastically. Shortening of suction lines also reduces the dynamic priming volume of the circuit. Because the whole unit can be placed very near the operating table, a further reduction of tubing length is facilitated.

The bubble sensor is placed between the oxygenator outlet and the arterial line filter to avoid obstruction of the arterial line when the table is tilted. Because of the short tubing, the unsterile bubble sensor would also compromise the sterility of the operative field if it was placed downstream of the arterial line filter (3).

Extracorporeal System

A prerequisite for successful transfusion-free CPB in children with a body weight of less than 5 kg is the use of a dedicated circuit with a low priming volume. Our entire

Figure 1. The neonatal CPB console with mast-mounted double-header roller pumps. Note the arterial pump in the right foreground in proximity to the heat exchanger/oxygenator inlet. The cardiotomy sucker pumps on the left side of the picture are placed close to the reservoir inlet ports. The bubble detector is positioned between the oxygenator outlet and the arterial line filter.

circuit consists of 3/16-inch I.D. PVC tubing. Only the raceway tubing segment of the arterial roller pump was quarter-inch I.D. silicon tubing. The Safe Micro oxygenator used in this cohort of patients has a priming volume of 52 mL (Polystan, Vaerlose, Denmark). The minimum operating blood level in the venous hard shell reservoir according to the manufacturer's specification is 25 mL. A 40-μm arterial line filter (D736, Dideco, Mirandola, Italy) was incorporated in all three cases, although its priming volume of 40 mL added considerably to the circuit's priming volume of approximately 200 mL (Table 1). The circuit was primed with a balanced electrolyte solution (Thomaejonin, Delta Pharma, Pfullingen, Germany), 5.000 IU Heparin and 4×10^5 KIU Aprotinin (Trasylol, Bayer, Frankfurt, Germany).

Vacuum-Assisted Venous Drainage

Vacuum-assisted venous drainage (VAVD) improves the venous return by applying a regulated vacuum to the venous reservoir. A higher bypass flow and better cardiac decompression may be accomplished. The use of a dedicated and approved vacuum controller (Polystan, Vaerlose, Denmark) in combination with a venous reservoir approved for this technique made a reduction of the venous line to 3/16-inch internal diameter possible. Negative pressure was generated in the range of –20 to –30 mmHg. With this equipment, an adequate venous return could be achieved that made the desired CPB flow of more than 3 L/min/m^2 possible. However, we are well aware of the potential risks associated with this technique, in particular air embolism (4–6).

Table 1. Priming volumes.

Polystan Safe Micro oxygenator	52 mL
Arterial line filter Dideco Newborn 736	40 mL
Tubing system 3/16-inch I.D.	65 mL
Reservoir level	25 mL
Dynamic volume	20 mL
Approx. total	200 mL

Anticoagulation Management

Heparin management was performed according to the result of the Hepcon HMS Plus™ (Medtronic, Minneapolis, MN). In line with our hospital protocol for neonates and small children < 10 kg the target heparin level was defined at 6 IU/mL. Aprotinin was administered according to a high-dose protocol with a bolus of 4×10^5 KIU for the patient, 4×10^5 KIU in the priming volume of the extracorporeal circuit, and a continuous infusion of 1×10^5 KIU during CPB.

DISCUSSION

During the past few decades, CPB in Jehovah's Witness patients has triggered reflections on the amount of priming volumes and the introduction of blood-saving techniques (7). With increasing experience gained in the correction of congenital heart defects in Jehovah's Witness patients we were able to operate on still smaller infants with improved techniques (8). The series reported in this article consists of the smallest Jehovah's Witness patients operated on in our hospital using a transfusion-free CPB technique so far. To achieve these results, close cooperation between the cardiac surgeon (operating without blood loss), anesthesiologist (controlling postoperative hemostasis) and perfusionist (optimizing the cardiopulmonary bypass circuit) is mandatory.

The resulting hemoglobin concentration in these tiny patients on CPB is a function of the hemoglobin concentration of the patient and the size of the patient's blood volume immediately before CPB in relation to the priming volume of the extracorporeal circuit. An expected circulating blood volume in our patients of approximately 85 mL/kg and a priming volume of less than 200 mL corresponded well with the resulting hemodilution measured during CPB (Figure 2).

Unfortunately, all three patients were already anemic before bypass. The initial hemoglobin concentration of our third patient with the body weight of only 3.1 kg was very low. However, the lowest hemoglobin values of these patients during CPB corresponds with the data reported by other groups operating on Jehovah's Witness patients with the use of extracorporeal circulation (9–11). More recently, some studies have shown that a criterion-driven transfusion strategy allowing a hematocrit of as low as 15% during CPB may be effective in preventing allogeneic blood transfusion (12,13).

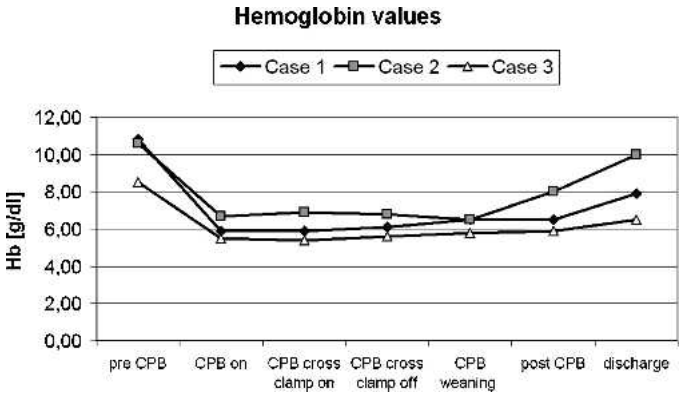

Figure 2. Hemoglobin values.

Neonates and infants undergoing corrective surgery for cyanotic heart defects often show higher hemoglobin levels and may be operated on without donor blood prime when the operation is not only palliative and the cyanotic status will be terminated with correction of the defect (14). However, weaning from CPB of patients with cyanotic heart defects who undergo palliative procedures with postoperative persistent cyanosis in association with a low hemoglobin concentration may not be possible (15).

In a non-Jehovah's witness patient with a body weight of only 2.2 kg and a much higher hematocrit than the three patients presented here, we performed correction of total anomalous pulmonary venous connection without any perioperative blood transfusion. With an initial hemoglobin level of 16.7 g/dL (Hct 50%) transfusion-free CPB was realized. During the 80 minutes of CPB, the lowest hemoglobin level was 8.0 g/dL (Hct 24%) (16). This case represents the smallest patient operated on with CPB at the Deutsches Herzzentrum Berlin without any blood transfusion during the perioperative course.

CONCLUSION

We conclude that it is possible to perform transfusion-free CPB in neonates and infants weighing less than 5 kg in selected cases when transfusion of blood components is not desirable. With appropriate hematocrit values prior to CBP, transfusion-free cardiac operations may be an option, not only for Jehovah's Witness patients.

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