JECT. 2013;45:251–253
The Journal of ExtraCorporeal Technology

Bloodless Surgery in a Pediatric Jehovah's Witness

Jerry Allen, CCP; Lindsay Berrios, CCP; Mike Solimine, CCP; Christopher J. Knott-Craig, MD, FACS

Department of Pediatric Cardiac Surgery, Le Bonheur Children's Hospital, Memphis, Tennessee

Abstract: Pediatric cardiac surgery in Jehovah's Witness patients who refuse the use of blood products remains a challenge because of the extreme hemodilution caused by priming the circuit and subsequent cardiopulmonary bypass. We report our successful strategy for reducing the prime volume for a 2-year-old Jehovah's Witness patient who required open heart surgery. We modified our conventional bypass circuit requirements for this size child by incorporating a lower prime oxygenator and reducing the size of the venous line and circuit, which decreased the circuit prime volume. We managed to reduce our initial sanguineous prime volume from 315 to 210 mL. The prime was further reduced to 160 mL by minimizing circuit length at the field and with venous prime sequestration prebypass. The postbypass hematocrit was 31%. Bloodless pediatric cardiac surgery in Jehovah's Witness patients can be performed safely. Incorporating a lower prime oxygenator into a revised circuit alleviated the need for blood transfusion and allowed us to achieve our calculated flow rate of 2.6 L/min/m^2 while maintaining a hematocrit of 31%. **Keywords:** cardiopulmonary bypass (CPB), congenital heart disease (CHD). *JECT. 2013;45:251–253*

OVERVIEW

Cardiac surgery involving cardiopulmonary bypass without the use of blood or blood products (bloodless surgery) poses unique challenges for the perfusionist, especially in the pediatric population (1) and those adhering to the Jehovah's Witness faith (2,3). The goal of eliminating both homologous blood transfusion and the need for blood products or clotting factors during pediatric cardiac surgery may be difficult to achieve because of the extreme hemodilution, which is usual in the pediatric patient (2,3). The hemodilution is caused by the large prime volume of the cardiopulmonary bypass circuit relative to the small circulating volume in children and any blood loss during the procedure.

In this case study, we report our strategy for reducing the prime volume for a 2-year-old Jehovah's Witness patient who required open heart surgery for correction of a congenital heart defect, specifically, partial atrioventricular canall.

DESCRIPTION

A 2-year-old girl with Jehovah's Witness parents was operated on in December of 2012 at Le Bonheur Children's Hospital for a partial arteriovenous canal. The patient weighed 18.7 kg, was 109 cm tall, and her calculated body surface area measured .75 m^2. Her parents requested that no blood or blood products be administered during or after her surgery but were comfortable with cell-saver use in a continuous circuit during surgery. According to our protocol, the bypass flow rate required would be 1.9 LPM at a calculated cardiac index of 2.6 L/min/m^2 and with a minimum calculated hematocrit (Hct) on bypass of 30%. The minimum threshold of 30% Hct on bypass was the surgeon's preference based on protocols at our institution. The patient's estimated blood volume was 1496 mL. Her preoperative hemoglobin was 11.6 g/dL and the preoperative Hct was 35%.

Our conventional circuit that should have been used for a child weighing more than 15 kg would have required a priming volume of 315 mL (Table 1) and the postdilutional Hct would have been 28% once mixing had occurred on cardiopulmonary bypass (CPB). We understood that to keep the postdilutional Hct above 30%, the circuit needed to be modified. Normally, we would have used 3/8-inch tubing for the venous line and ¼-inch tubing for the arterial line. Instead, we downsized to a ¼-inch venous line. Considering the fact that the venous line was ¼-inch tubing, vacuum-assisted venous drainage (–5 mmHg) was used to improve blood return, as previously reported (4). The modification of the CPB circuit decreased the prime volume from 315 to 210 mL (Table 1).

The Affinity Pixie oxygenator (Medtronic Inc., Minneapolis, MN) that was used in this case has a static

Received for publication March 1, 2013; accepted October 1, 2013.
Address correspondence to: Jerry Allen, CCP, Department of Pediatric Cardiac Surgery, Le Bonheur Children's Hospital, 50 North Dunlap, Memphis, TN 38103. E-mail: Jerry.Allen@LeBonheur.org
The senior author has stated that the authors have reported no material, financial, or other relationship with any healthcare-related business or other entity whose products or services are discussed in this paper.

Table 1. Differences between the conventional and modified circuits.

Disposables	Conventional	Modified
Oxygenator	Dideco D101 (87 mL)	Medtronic Affinity Pixie (48 mL)
Arterial filter	Dideco D 131 (28 mL)	None
Arteriovenous loop	1/4–3/8 inch	1/4–1/4 inch
Arterial roller pump	1/4 inch	1/4 inch
Total prime volume	315 mL	210 mL

priming volume of 48 mL and accommodates flows up to 2.0 LPM. It replaced our conventional Dideco 101 oxygenator (Sorin Group, Milan, Italy), which has a static priming volume of 87 mL. Plasma-Lyte A (Baxter Healthcare Corporation, Deerfield, IL) was used as the crystalloid priming solution with 1100 units heparin and 6 mEq sodium bicarbonate. Mannitol, at 2.2 g, was administered after initiating bypass. Albumin was avoided both in the prime and as a volume expander postoperatively because of its reported association with acute kidney injury and bleeding (5).

Arterial cannulation was performed with a 12-French DLP aortic cannula (Medtronic Inc., Minneapolis, MN) and bicaval venous cannulation was conducted with 16-French and 18-French Terumo right-angled cannulae (Terumo Cardiovascular, Ann Arbor, MI). The heart–lung machine is a Terumo System 1 (Terumo Cardiovascular) with remote pump heads. Although a large roller pump and correlating raceway is routinely used for this size patient with our conventional circuit, a smaller roller pump and raceway, which sits on a platform closer to ground level, was used for this case. In our efforts to reduce prime volume, the raceway line that connects from the outlet of the reservoir to the inlet of the oxygenator measured 26 inches long compared with the usual 33 inches if it had gone through the larger pump head. The pumps for the suckers and vent were also small roller heads. They were mounted on the back of the heart–lung machine allowing the pumps to be positioned closer to the table and shortening the length of our suction lines. We used ¼-inch tubing for all the suckers with the exception of the aortic vent line where we used 1/8-inch to prevent excessive volume loss from the bypass circuit because volume hold-up in the vent line would require an increased circulating volume. We considered using 3/16-inch tubing for the suckers, but increased use could be a major cause of hemolysis. An arterial line filter (ALF) was deleted from the circuit for this procedure in an additional effort to conserve priming volume (28 mL). The surgeon assured us that the parents were aware that several modifications needed to be made to the circuit for their child to receive bloodless surgery. As well, our institution has an established protocol that allows us to secure a rapid court order for the administration of blood products in an emergent situation (2).

We made certain that the surgeon divided the arteriovenous (AV) loop to the shortest possible length and managed to decrease the prime volume by 33 mL. We also removed 23 mL of clear fluid from the venous line before going on bypass by chasing it into a syringe once the surgeon removed the venous clamp. Shortening the AV loop at the field and removing clear fluid from the venous line further decreased the prime volume from 210 to 160 mL. As stated, the patient's baseline Hct was 35%. During the 55 minutes on CPB, the lowest Hct was 25%, which occurred after administering Custodial Bretschneider HTK cardioplegia (Essentials Pharm, Newtown, PA). The highest Hct was 30%. An HPH 400 hemoconcentrator (Minntech Mini, Minneapolis, MN) was used to remove excess fluid during CPB and is not primed until we are on CPB. The postprotamine arterial blood gas sample indicated a Hct of 31%. After terminating CPB, we collected the venous line blood volume and transfused all the blood back into the patient by chasing the circuit with Plasma Lyte A (Baxter Healthcare Corporation).

The patient was transferred to the intensive care unit with a Hct of 31% and was extubated within 4 hours of surgery. There was no hematuria observed intraoperatively or postoperatively. The postoperative blood gas analysis was normal with no metabolic acidosis. The serum lactate postoperatively was 1.4 mmol/L, and the serum creatinine was .7 mg/dL. Total chest tube output was 76 mL. No blood products were administered during the perioperative period and the patient was discharged from the hospital on postoperative day 3 with a Hct of 30%.

COMMENT

By reducing the hemodilutional effect of the circuit, we have determined that we can safely perform bloodless surgery on patients in this weight range who are Jehovah's Witnesses and who prefer not to have any blood products used. At Le Bonheur Children's Hospital, the prime volume of the circuit for a child weighing 2–14 kg ranges from 170 to 205 mL. For patients over 15 kg, a larger circuit must be used, which adds over 105 mL to the prime volume. With a lower prime oxygenator, positioning of the heart–lung machine close to the surgical field and using smaller venous lines, the prime volume can be reduced, which decreases the dilutional effect on the patient. It also allows us to maintain more blood in the reservoir for hemoconcentration during the case, thus coming off bypass with a higher Hct. These combined measures avoided the use of blood products, saved money for the hospital, and most

importantly allowed the child to leave the operating room with a Hct high enough to avoid needing any blood products postoperatively.

Using the 1/8-inch line to vent the heart was a key factor in maintaining a increased circulating volume. Using continuous ultrafiltration was beneficial in removing additional fluid. Incorporating modified ultrafiltration on circuits that have small prime volumes presents a challenge because there is limited volume at the cessation of CPB. Our ultimate goal is to perform as many bloodless surgeries as possible in our pediatric population. Subsequent to this case, we have used similar strategies, but with an ALF on other patients who weigh more than 15 kg, and currently we do 60% of these surgeries bloodless, even on patients who have had multiple prior sternotomies.

REFERENCES

1. Miyaji KA, Kohira SA, Miyamoto TA, et al. Pediatric cardiac surgery without homologous blood transfusion, using a miniaturized bypass system in infants with lower body weight. J Thorac Surg. 2007;134:284–9.
2. Forest RJ, Groom RC, Quinn R, Donnelly J, Clark C. Repair of hypoplastic left heart syndrome in a 4.25 kg Jehovah's Witness. Perfusion. 2002;17:221–5.
3. Karimi MO, Florentino-Pineda IV, Weatherred TE, et al. Blood conservation operations in pediatric cardiac patients: A paradigm shift of blood use. Ann Thorac Surg. 2013;95:962–7.
4. Nakanishi K, Shichijo T, Shinkawa Y, et al. Usefulness of vacuum-assisted cardiopulmonary bypass circuit for pediatric open-heart surgery in reducing homologous blood transfusion. Eur J Cardiothorac Surg. 2001;20:233–8.
5. Utley JR, Stephens DB, Wachtel C, et al. Effect of albumin and mannitol on organ blood flow, oxygen delivery, water content and renal function during hypothermic hemodilution cardiopulmonary bypass. Ann Thorac Surg. 1982;33:250–7.