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Strategic and operational aspects of a transfusion-free neonatal arterial switch operation

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Abstract

Blood transfusion-free complex congenital cardiac surgery in a neonate remains a challenge for multidisciplinary cardiac teams. At our institution, a 3.5 kg neonate, born to a family of Jehovah's Witnesses and postnatally diagnosed with dextro-transposition of the great arteries (d-TGA) and a small muscular ventricular septal defect, underwent a successful arterial switch operation without blood or platelet transfusion. Key points that contributed to success were optimal preoperative haematopoetic conditioning using erythropoietin and iron, a miniaturized cardiopulmonary bypass circuit including a low prime volume oxygenator and crystalloid cardioplegia, and a well-coordinated multidisciplinary team. We report an overview of the literature regarding blood transfusion-free complex congenital cardiac surgery.

Keywords: Congenital cardiac surgery • Arterial switch operation • Jehovah's Witness • Blood transfusion-free

INTRODUCTION

The evolution of blood transfusion-sparing medicine is not only being driven by medical and economic factors, but also by groups with specific religious beliefs, such as Jehovah's Witnesses. In addition to the inevitable intraoperative fall of haemoglobin due to blood loss, the haemodilution due to the priming volume needed to fill the cardiopulmonary bypass (CPB) circuit has a particular impact on the intraoperative drop in haemoglobin. The high priming volume of the CPB circuit is the most important factor leading to haemodilution, particularly in neonates. We describe the joint effort of surgeons, perfusionists, anaesthetists and intensive-care doctors resulting in a modified CPB circuit with the goal of minimizing intraoperative haemodilution, thus allowing blood transfusion-free neonatal repair of congenital heart defects.

CASE REPORT

A male newborn was transferred to our institution after a postnatal diagnosis of dextro-transposition of the great arteries (d-TGA) with a small muscular ventricular septal defect (VSD) of 3–3.5 mm. After initial treatment, the operation was planned. In accordance with the parental wishes to avoid a blood transfusion if at all possible, the patient's intrinsic red cell production was optimized for surgery with iron (2.1 mg/kg/day) and erythropoietin (150 IU/kg every third day) supplementation starting 7 days before the operation (haemoglobin level before erythropoietin treatment 148 g/l). The parents were informed that all efforts would be made to avoid blood transfusion, but that in the event of a life-threatening situation, the child would be given blood. Surgery was performed on the ninth day of life at a body weight of 3.53 kg, with a haemoglobin level of 157 g/l. Near-infrared spectroscopy (NIRS) was used intra- and postoperatively to measure cerebral oxygenation. A median sternotomy was performed, followed by routine cannulation for CPB and cooling to a body temperature of 28°C. The CPB circuit (including the arterial line filter) used for this patient was optimized to reduce the total priming volume to 95 ml (Multibic Hämofiltrationslösung, Fresenius Medical Care, Oberdorf, Switzerland). The length and diameter of the non-heparin bonded tubing of the CPB circuit were reduced, and the oxygenator and CPB machine were placed as close as possible to the operating table. All the tubing was 3/16-inch in internal diameter, except for the arterial line, which was 1/8-inch in diameter. Cardioplegic arrest of the heart was achieved with an aortic root injection of 20 ml of crystalloid Kirsch cardioplegia solution (Mg-Aspartat Procain, Köhler-Chemie, Alsbach, Germany) followed by 20 ml of hydroxyl ethyl starch (Fresenius AG, Bad Homburg, Germany). d-TGA was corrected using the standard arterial switch procedure, and the VSD was closed using a direct suture. Antifibrinolysis was achieved by infusing tranexamic acid. At the end of the CPB, all the remaining blood was returned to the patient with the Cell-Saver system (100 ml washed blood). During CPB and postoperatively in the intensive care unit (ICU), blood sampling was reduced to a minimum. The lowest intraoperative haemoglobin was 72 g/l, the lowest haematocrit was 22.5%, the NIRS remained between 50 and 70%, and the lactate was 1.6–3.9 mmol/l. There was no evidence of inadequate

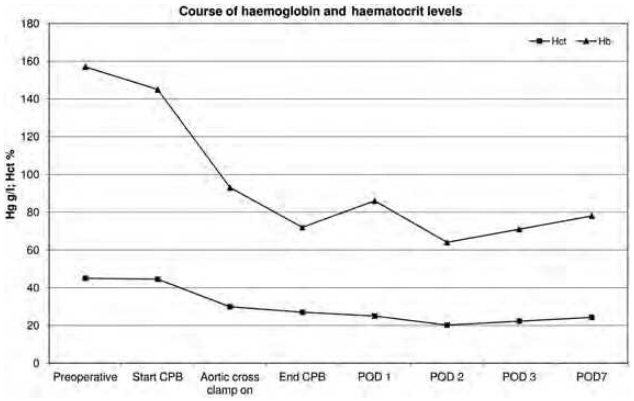

Figure 1: Course of haemoglobin (Hb) and haematocrit (Hct) levels; CPB: cardiopulmonary bypass; POD: postoperative day.

systemic oxygen delivery either during the operation or during the postoperative period despite a postoperative haemoglobin value of 72 g/l on return to the ICU. Postoperative management involved the use of colloid as volume replacement (albumin 4%) to optimize intravascular colloid osmotic pressure and avoid blood transfusion; milrinone, adrenaline and noradrenaline infusion were used to optimize the cardiac output. Preoperative treatment using iron and erythropoietin was continued postoperatively for another 4 weeks. No red blood cell or platelet transfusion was given during the patient's treatment. The haemoglobin and haematocrit values were as depicted graphically in Fig. 1.

DISCUSSION

While there is a consensus that innovations that help reduce the use of blood and blood products be pursued in order to reduce the risks associated with homologous blood, ensuring the safety of the procedure with regard to early as well as late outcome is of paramount importance. While it is true that liberal postoperative transfusion protocols have shown no advantages compared with a more restrictive transfusion protocol and that blood transfusions have been associated with higher complication rates [1], the limits to which blood-sparing infant congenital cardiac surgery can be pursued are ill-defined. There are some reports which show that infants undergoing cardiac surgery with a haematocrit of 25% and greater have better perioperative and developmental outcomes [2, 3]. The religious beliefs of Jehovah's Witnesses requiring them to avoid transfusion of any component of blood, pose a challenge to safe neonatal cardiac surgery using CPB.

Using the case of a neonatal blood and blood product-free arterial switch operation in a neonate born to Jehovah's Witness parents, we intend to highlight the strategic and operational measures that can be adopted to reduce the perioperative need for blood.

First, optimizing the patient for surgery is of utmost importance. Preoperative anaemia is an additive risk factor for adverse outcome after cardiac surgery, even when subsequently corrected with red blood cell transfusion. Consequently, the perioperative use of iron and erythropoiesis-stimulating agents has been recommended. It has been reported that even the administration of a single dose of erythropoietin 7 days prior to surgery has an effect by increasing the haematocrit levels [4].

Further, one of the key elements to avoid excessive haemodilution is the reduction in the priming volume of the CPB circuit, which should be aimed for regardless of religious beliefs. Miniaturized CPB circuits using a priming volume ranging from 130 to 550 ml have previously been reported. The use of a CPB circuit in this case with a priming volume of 95 ml is a significant improvement compared with other reports.

While saving on blood, safe oxygen delivery to the tissues during CPB needs to be ensured. Cerebral monitoring by NIRS provides a good measure of the adequacy of the oxygen supply to the tissues. To avoid poor outcome, intraoperative thresholds for blood transfusion have been reported as a haematocrit <20% on CBP, a brain oxygenation (measured by NIRS) <50%, a lactate level >4 mmol/l and central venous oxygen saturation of <70% [5].

We believe that a low priming volume circuit and short-term use of erythropoiten and iron may offer the possibility of blood transfusion-free neonatal cardiac surgery, but a careful assessment of each patient's unique clinical situation and a well-trained interdisciplinary team approach are mandatory. The need to consent to a rescue blood transfusion in a life-threatening scenario, as well as the unknowns about the risks to neurodevelopmental outcomes have to be explained to parents.

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