



First Hemoadsorption during Cardiopulmonary Bypass in Neonate with Complex Cardiac Malformation

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Abstract

Cardiac surgery with Cardiopulmonary Bypass (CPB) is a trigger of significant Systemic Inflammatory Response Syndrome (SIRS) with an accompanying cytokine release. Additional factors increasing the risk of post-operative SIRS include surgery itself, long CPB duration, and mechanical hemolysis and ischemia-reperfusion injuries. Cytosorb® is a hemoadsorption device that removes many cytokines from the blood. Pediatric patients with exaggerated pre-operative SIRS might be good candidates for an assessment of Cytosorb's® usefulness. We present the case of a full-term newborn with a hypoplastic left heart syndrome. Five days after birth, the patient underwent a Norwood stage I palliation under CPB with adjunction of Cytosorb®. Post-operative course was uneventful, hemodynamic adaptation was good, with rapid weaning off all amine infusions.

Keywords: Cardiopulmonary bypass; Hemodynamics; Blood management; Pediatric anesthesia; Cardiac surgery

Introduction

Cardiac surgery with Cardiopulmonary Bypass (CPB) is a trigger of significant Systemic Inflammatory Response Syndrome (SIRS) with an accompanying cytokine release. Additional factors increasing the risk of post-operative SIRS include surgery itself, long CPB duration, and mechanical hemolysis and ischemia-reperfusion injuries [1]. Potential consequences of post-operative SIRS are delayed weaning off mechanical ventilation, delayed recovery of organ functions and a longer Intensive Care Unit (ICU) stay [1,2].

Cytosorb® (Cytosorbents, NJ, USA) is a hemoadsorption device that removes many cytokines from the blood [3,4]. Neonatal and pediatric patients in hyperinflammatory states have shown clear reductions in IL-6 and IL-10 concentration in plasma during hemoadsorption treatment, independent of eventual survival. In hyper inflammatory states, high plasma levels were reduced more efficiently than low plasma levels, in line with the known concentration-dependent clearance properties of the CytoSorb adsorber. From a safety perspective, the lack of significant cytokine removal at physiologically necessary concentrations is important, as the body is dependent on a certain concentration of cytokines to maintain an adequate immune response. Pediatric patients with exaggerated pre-operative SIRS might be good candidates for an assessment of Cytosorb's® usefulness.

Case Presentation

We present the case of a full-term newborn with a hypoplastic left heart syndrome, involving an absent mitral valve and exceedingly small aortic annulus, ascending aorta and aortic arch. Perfusion of the aortic arch was retrograde through a persistent patent ductus arteriosus. Right ventricular systolic function was normal. Shortly after birth, the neonate required continuous positive airway pressure and then invasive ventilation with permissive hypercapnia. He received levosimendan 12 h before surgery, and maintenance with a prostaglandin E1 infusion. Five days after birth, the patient underwent a Norwood stage I palliation with interatrial septum resection, aortic arch reconstruction and the creation of a Blalock-Taussig shunt. The cardioplegic solution used was Custodiol® HTK. CPB duration was 227 min (median CPB time [MT] of 230 min, [226.25-256.5]*), and aortic cross-clamping duration was 180 min (MT 119.5 min, [101.5-132.75]). Selective cerebral perfusion was 27 min at a central core temperature of 27.8° Celsius.

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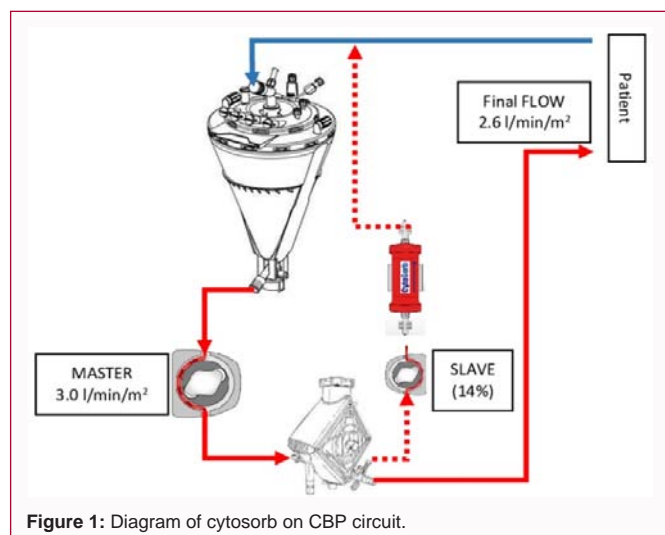


Figure 1: Diagram of cytosorb on CPB circuit.

The Cytosorb[®] cartridge was inserted between the oxygenator outlet (QUADROX-i neonatal HMO 11000[®] MAQUET) and the venous line, assisted by a roller pump slave to the blood pump. The minimum flow rate through the cartridge was 100 ml/min, as per the manufacturer's data. The servo control was 14% of the patient's theoretical flow, indexed to 3.0 l/min/m² to compensate for the drop induced by the Cytosorb[®] and to ensure a flow rate of 2.4 l/min/m² to the patient. Priming was performed using "ventilated reconstituted whole blood" to ensure homeostatic conditions at CPB initiation (Figure 1).

Surgery was uneventful, and correction was adequate, with unobstructed flow through the interatrial communication and inside the aortic arch, and with good ventricular function. The patient returned to the ICU intubated with infusions of norepinephrine, dopamine and milrinone.

Post-operative course was uneventful, without renal, digestive, or infectious complications. Hemodynamic adaptation was good, with rapid weaning off all amine infusions and definitive weaning off norepinephrine on post-operative day 5. The patient was extubated on post-operative day 6 (MT is 11.5 days [9.5–18]), left the ICU on day 22 (MT 39.5 days [29–80.5]), and was discharged home on day 45.

Discussion

The rapid post-operative recovery with early extubation and weaning off catecholamine infusions was remarkable. ICU and

hospital stays were shortened due to an absence of complications. In our experience, similar cases have needed much longer ventilation support and ICU stay. Our case's surgical, anesthetic, and medical care were comparable with similar cases in our institution. The only difference was the Cytosorb[®] cartridge's incorporation into the CPB circuit. Although cytokine levels were not assessed, removing them using the Cytosorb[®] is a plausible explanation for our patient's improved outcome.

To the best of our knowledge, this is the first description of Cytosorb's[®] use during pediatric CPB. Priming of the CPB circuit in a newborn requires homologous blood. Our case required 385 ml of blood, of which 120 ml were used for priming the Cytosorb[®]. We believe the expected benefits to anti-inflammatory processes are worth the greater homologous blood use. A literature review indicated isolated pediatric reports of hemadsorption using the Cytosorb[®] adsorber, including one in a pediatric case 72 h after CBP [5].

Conclusion

The present case represented a complex congenital cardiopathy with a patent ductus arteriosus and a long CPB duration for surgical palliation, which likely contributed to the pre-operative and intra-operative inflammatory process. By reducing cytokine levels, the Cytosorb[®] may have significantly reduced catecholamine infusion time, intubation time, and ICU stay. Future studies should evaluate Cytosorb's[®] effectiveness in selected pediatric cases.

References values with median and interquartile range [Q1–Q3].

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