Case report

Myocardial recovery through ECMO after repair of total anomalous pulmonary venous connection: the importance of left heart unloading

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Abstract

A 7-day-old boy who had been placed on extracorporeal membrane oxygenation on his second day of life developed biventricular failure after undergoing surgical repair of a supracardiac variant of total anomalous pulmonary venous connection. Extracorporeal membrane oxygenation was again necessary for postoperative cardiopulmonary support. However, severe left ventricular failure made it imperative to leave the vertical vein open during support in order to decrease pressure on the left ventricle. The patient was successfully weaned from extracorporeal membrane oxygenation on day 8 after surgery and discharged from the hospital on day 23. © 1997 Elsevier Science B.V.

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1. Introduction

Over the last decade extracorporeal membrane oxygenation (ECMO) has become a widely accepted means for cardiac rescue in children after congenital heart surgery. Theoretically, venoarterial ECMO can provide biventricular assistance, but the efficacy of ECMO in supporting the left ventricle has been questioned [1,4]. Another concern has been the need for venting the left ventricle during ECMO. Although experimental studies have indicated that additional decompression of the left ventricle promotes myocardial recovery [2], its necessity in a clinical setting is controversial [3,9,10].

We recently treated a critically ill neonate who was supported with ECMO before and after repair of a total anomalous pulmonary venous connection (TAPVC). Left ventricular unloading was achieved by leaving the vertical vein open during postoperative ECMO, thus leading to myocardial recovery.

2. Case report

A full-term newborn (body weight 3.5 kg) developed severe cardiorespiratory distress and was intubated and ventilated 9 h after birth. Since cardiorespiratory distress persisted, the treating facility instituted ECMO between the right common carotid artery and the internal jugular vein beginning 48 h after birth and subsequently transferred the patient to our hospital with the suspicion of TAPVC at the age of 7 days. Upon admission systolic arterial pressure was 68 mmHg and PaO₂ 69 mmHg at an ECMO flow of 240 ml/min. A preoperative echocardiographic examination showed poor ventricular function without clear visualization of the pulmonary veins. Transvenous angiography, performed to obtain a more exact diagnosis, revealed a supracardiac type of TAPVC draining to the left innominate vein with an obstructive atrial septal defect. The patient was immediately prepared for surgery.
After median sternotomy cardiopulmonary bypass was established by right atrial-aortic cannulation and the patent ductus arteriosus divided. The cervical perfusion cannulas were left in place. After 15 min of cooling to a rectal temperature of 18°C, the aorta was cross-clamped and cold crystalloid cardioplegic solution infused. Subsequently the vertical vein was ligated and intracardiac repair performed under circulatory arrest. The common venous channel was anastomosed transatrially to the posterior aspect of the left atrium and the atrial septum closed with a small patch of the pericardium. The aortic cross-clamp time was 45 min. A pulmonary artery catheter was inserted during the 59 min of rewarming. The first attempt to discontinue bypass resulted in a drop in systolic arterial pressure to 25 mmHg and an increase in left atrial pressure, measured with a needle catheter, to 20 mmHg. Subsequent attempts to wean the patient were also unsuccessful although the mean pulmonary arterial pressure remained almost normal throughout. After considering the patient’s critical pre-operative status, it was decided to place the baby on ECMO again. Thus, cardiopulmonary bypass was replaced by a newly-assembled ECMO circuit connected to the cervical cannulas. Shortly thereafter, however, the left ventricle obviously distended; left atrial pressure was 20 mmHg and mean pulmonary arterial pressure was 22 mmHg. To provide left atrial decompression and relieve left heart distension, the vertical vein was then opened. The skin was closed with a silastic membrane over the open sternum and the patient transferred to the intensive care unit. The activated clotting time was kept between 180–220 s by continuous heparin infusion. During full ECMO flow, the ventilation settings were at a minimum with a rate of 10 cycle/min and a positive end-expiratory pressure of 4 cm H₂O.

Postoperatively echocardiographic examination revealed slow progressive improvement in left ventricular function beginning on the third postoperative day (POD) (Fig. 1). This improvement in cardiac performance was also recognizable by an increase in arterial pulse pressure. The mean pulmonary artery pressure remained stable at 15 to 25 mmHg during the postoperative period, thus indicating that the pulmonary vascular crisis was not responsible for cardiac failure. The central venous pressure, which also represented left atrial pressure in the absence of the vertical vein stenosis and/or pulmonary vein anastomosis stenosis, was strictly controlled to keep it below 10 mmHg in order to prevent overloading the left heart. Two days later echocardiography showed biventricular function to be satisfactory and weaning from ECMO was initiated; the flow was reduced by 50 ml every 12 h while ventilatory settings were readjusted accordingly. Although arterial oxygen tension declined parallel to the ECMO flow, the oxygen saturation was above 90%. ECMO was discontinued successfully on the eighth POD and the patient finally disconnected from ECMO after 12 days. The vertical vein was then ligated and the chest wound covered again in the same manner as before. Four days later the sternum was closed without complications and the patient subsequently discharged from the hospital on the 23rd POD.

3. Discussion

This case demonstrates that although ECMO represents a life-saving perioperative method for supporting moribund neonates, several days of mechanical support may be required to achieve myocardial recovery after repair of TAPVC. Considering the pathophysiology of this cardiac anomaly, any therapeutic modality which would reduce pulmonary blood flow and allow systemic oxygenation would be beneficial for subsequent surgical repair. However, the effect of ECMO on cardiac function in unrepaired TAPVC is unknown. Preoperative left ventricular volume in TAPVC is at or below the lower limit of normal, presumably due to inadequate filling pressure through a restricted interatrial shunt, whilst ejection fraction and output usually are decreased [5,6]. It can thus be assumed that a further
reduction in left ventricular filling through venoarterial bypass may impair myocardial distensibility for several days. We suppose that ischemic damage in addition to reduced myocardial compliance could be the cause of post-repair severe left ventricular failure in this patient.

Although ECMO can be used to provide biventricular support, decompression of the left ventricle was imperative in this case. In some cases it is true that ECMO with low central venous pressure and high flow rate [10] may possibly prevent overloading of the left heart, yet we believe that left ventricular decompression is important. If left ventricular function is extremely poor and can not overcome the afterload, reducing the preload may be of great importance in promoting myocardial recovery by decreasing myocardial oxygen consumption [7] and preserving the coronary blood flow by maintaining a pressure gradient between the aortic root and the left ventricular cavity. Furthermore, a persistent elevation in left atrial pressure may cause pulmonary venous congestion, thus leading to irreversible lung damage. Therefore, after surgery we routinely vent the left atrium during ECMO in children without an intracardiac shunt.

By taking advantage of the characteristic anatomy of TAPVC and because of possible technical problems (delicate left atrial-pulmonary-confluence anastomosis, small left atrium), it was more logical to vent the left atrium via the vertical vein without placing an additional catheter. This unique method, whereby the vertical vein is left open after repair of TAPVC, has been used to relieve left heart failure [8] and is quite beneficial for the small left atrium associated with this anomaly. Additionally, the extracardiac shunt allows easy control of left ventricular preload through central venous pressure during ECMO. We believe this venting route can also be recommended in patients who undergo ECMO after surgery for TAPVC.

References


