

ECMO After Prolonged Cardiopulmonary Resuscitation as a Successful Bridge to Immediate Cardiac Retransplant in a 6-Year-Old Girl

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Abstract

Heart failure, life-threatening arrhythmias, and sudden cardiac death are common complications in patients with advanced chronic cardiac allograft rejection—the major limiting factor of long-term survival after heart transplant. In patients with sustained cardiorespiratory arrest refractory to cardiopulmonary resuscitation extracorporeal membrane oxygenation therapy is a therapeutic option.

We report the case of a 6-year-old girl with severe chronic allograft vasculopathy who was successfully bridged to cardiac retransplant through extracorporeal membrane oxygenation therapy after prolonged cardiopulmonary resuscitation. Our case demonstrates extracorporeal membrane oxygenation as a rescuing therapeutic option in high-risk, bridge-to-transplant patients, with cardiac arrest. Even after prolonged cardiopulmonary resuscitation, there were no neurologic events, and our patient recovered without any neurologic damage.

Key words: Pediatric heart transplant, Cardiac transplant, Retransplant, Extracorporeal membrane oxygenation, ECMO

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Introduction

Heart transplant is a treatment option for pediatric patients with end-stage heart failure owing to congenital defects or cardiomyopathies.¹ During past decades, medium-term survival of children undergoing heart transplant has markedly improved owing to advances in surgical techniques, more-effective immunosuppressive strategies, and increasing clinical experience in the management of perioperative and postoperative complications.² Nevertheless, owing to cardiac allograft vasculopathy, long-term outcome after heart transplant is still limited, and in advanced stages of cardiac allograft vasculopathy, cardiac retransplant remains the only therapeutic option.

On the waiting list, these patients frequently develop typical clinical manifestations of cardiac allograft vasculopathy such as progressive heart failure, life-threatening arrhythmias, and sudden cardiac death (requiring cardiopulmonary resuscitation).³ Unfortunately, cardiac arrest in children is associated with a high mortality rate and significant subsequent neurologic complications.⁴ Therefore, mechanical circulatory support via extracorporeal membrane oxygenation (ECMO) might be an ultimate treatment option.⁵ However, the upper limit of cardiopulmonary resuscitation duration before ECMO therapy resulting in a favorable neurologic outcome is not known, and the prognosis of patients after resuscitative ECMO therapy remains uncertain. Furthermore, criteria for ECMO therapy are not precisely defined, and predictors of survival are still controversial. We report the survival of a 6-year-old girl who was successfully bridged to cardiac retransplant by venoarterial ECMO therapy after cardiac arrest and prolonged cardiopulmonary resuscitation.

Case Report

The girl was prenatally diagnosed with double outlet right ventricle and hypoplastic left heart syndrome in 2000. She was palliated through the Damus-Kay-Stansel procedure in 2001, but developed ventricular dysfunction during follow-up. Owing to worsening health and severe ventricular dysfunction, she was listed for heart transplant and successfully transplanted in 2002.

During follow-up, 6 biopsy-proven acute rejection episodes were documented (5 times by the International Society for Heart and Lung Transplantation for Ib and once for IIIb). In December 2006, the 6-year-old girl was admitted to our center because of progressive worsening of health (weight, 17.5 kg; height, 116 cm). A coronary angiography revealed accelerated cardiac allograft vasculopathy with no option for surgical or interventional revascularization (left ventricular end-diastolic pressure, 22 mm Hg; pulmonary artery pressure, 31/19 mm Hg; mean pulmonary artery pressure, 25 mm Hg; right ventricular end-diastolic pressure, 12 mm Hg). An electrocardiography showed a pathologic Q wave in lead V5 and was considered a sign of sustained myocardial infarction. An echocardiography revealed severe mitral insufficiency with concomitant enlargement of the left atrium (LA/Ao-ratio = 1.51). Left and right ventricular end-diastolic diameters were 39 mm and 18.4 mm. Furthermore, mild tricuspid insufficiency, suggestive of moderate postcapillary pulmonary hypertension, was present (deltaPmax, 24 mm Hg + central venous pressure). The clinical course was further complicated by oliguria and escalation of inotropic support. Episodes of bradycardia, and 1 asystolic episode of 4 seconds necessitated frequent intravenous administrations of atropine. Intermittent laboratory examinations showed increased levels of troponin as a sign of chronic myocardial ischemia. Consequently, the child was listed for high-urgency retransplant.

One month later, the child had hemodynamically compromising ventricular arrhythmias and had to be resuscitated twice. At the same time, a suitable donor organ became available. The option of ECMO implantation was discussed, but was abandoned owing to prompt hemodynamic stabilization and the potential disadvantages of reoperation. After the first resuscitation, echocardiography showed normal RV

contractility and no further worsening of the left ventricular function. Only a few hours later, the child had severe continuous ventricular arrhythmias refractory to conventional cardiopulmonary resuscitation and advanced life support. She developed severe cardiogenic shock, despite maximal dosages of inotropic and antiarrhythmic medication. The decision was made to implant resuscitative ECMO immediately as a bridge-to-retransplant.

The child was transferred to the operating suite under high-dose catecholamine therapy and external chest compression. Her hemodynamics were continuously monitored by invasive arterial blood pressure measurements. Ice was placed around the child's head to avoid potential hypoxic encephalopathy. The femoral vessels were used for cannulation, using the Seldinger technique under external chest compression. Venoarterial ECMO therapy was started 82 minutes after the start of external chest compression. Table 1 shows the patient's clinical characteristics. After a mean arterial pressure of 50 mm Hg was established, the child's cardiorespiratory condition stabilized. Echocardiography showed a severe decrease of left ventricular function with an ejection fraction less than 10%. Simultaneously, preparation of the recipient's chest was started, and our patient underwent retransplant successfully. Furthermore, the perioperative and postoperative courses were complicated by reversible renal failure. Postoperatively, computer tomography revealed neither intracerebral bleeding nor hypoxic brain injury. Neurologic examinations showed no detectable neurologic deficits. The girl was discharged 1 month after the heart transplant.

Table 1. Patient's clinical characteristics.

Age	6.7 y
Weight	17.5 kg
Height	116 cm
Body surface area	0.75 m ²
Duration of cardiopulmonary resuscitation	82 min
Lowest pH	7.171
Highest lactate	13.08 mmol/L
Highest creatinine value	132 mmol/L (1.5 mg/dL)

Discussion

Cardiac arrest in children is still associated with high morbidity and mortality rates, especially when

considering the neurologic outcome. A systematic literature review done by Young and Seidel demonstrated that only 13% of 2349 children with sustained in or out-of hospital cardiac arrest survived to hospital discharge.⁴ Similarly, a multi-institutional analysis conducted by Slonim and associates reported 13.7% survival to hospital discharge for pediatric patients with cardiac arrest in the intensive care unit. Survival after prolonged cardiopulmonary resuscitation longer than 30 minutes was only 5.6% in the same patient population.⁶

Some reports indicate the use of extracorporeal life support can reduce mortality in patients after cardiopulmonary arrest in which conventional resuscitation has failed. According to the extracorporeal life support organization (ELSO) registry data, age-related survival of patients ranged from 21% to 39% in children resuscitated after cardiac arrest through ECMO therapy.⁷ Extracorporeal membrane oxygenation therapy also has been successfully used as bridge-to-heart transplant in children with differing survival rates.^{8,9} del Nido and associates reported a survival to hospital discharge of 35% in their subset of patients.¹⁰ In accordance with the data of the International Society for Heart and Lung Transplantation and the United Network for Organ Sharing registry, cardiac arrest before ECMO therapy was identified as an independent risk factor for mortality.^{2, 11} Bae and associates reported that survival is significantly reduced by 8% in bridge-to-transplant patients with cardiac arrest before ECMO therapy.¹²

As reported in the 13th official International Society for Heart and Lung Transplantation report, cardiac retransplant remains a significant independent risk factor for early mortality.¹³ The coincidence of cardiac arrest with prolonged cardiopulmonary resuscitation before ECMO therapy during cardiac retransplant reflects that our patient was at the highest risk for early death. From the beginning, we were not only concerned about the survival, but also, severe neurologic complications. Neurologic damage is a common complication after prolonged cardiac arrest, and a major and probably the most-important complication associated with extracorporeal life support.¹⁴ Its incidence increases with the duration of support.

Kelly and associates reported the survival of a 4-year-old boy after cardiopulmonary resuscitation duration of 176 minutes before ECMO support

without neurologic complications.¹⁵ Kane and colleagues reported that cardiopulmonary resuscitation duration was not associated with mortality in a retrospective analysis of 172 patients undergoing ECMO therapy to aid cardiopulmonary resuscitation.¹⁶ Morris and associates reported that children with cardiopulmonary resuscitation longer than 60 minutes could survive without significant neurologic complications.¹⁷ However, a useful approach in an attempt to reduce the probability of neurologic damage is application of mild hypothermia.¹⁸ Similarly, Duncan and associates reported that they placed ice around the patient's head during resuscitative ECMO support to reduce or prevent ischemic brain injury.¹⁹ We think that ECMO therapy should be considered as early as possible as a rescue therapy in pediatric patients after ineffective cardiopulmonary resuscitation. Rigorous, continuous monitoring of adequate blood pressure and the patient's neurostatus is mandatory to minimize potential brain damage.

Conclusions

Our report shows that ECMO implantation can (1) establish stable hemodynamics until a donor organ is available and (2), heart transplant can be performed successfully in high-risk patients. This case adds further evidence to the fact that ECMO therapy is a useful treatment option in pediatric patients with cardiac arrest giving a good neurologic outcome even if used during prolonged cardiopulmonary resuscitation. Effective conventional cardiopulmonary resuscitation and neuroprotection might be crucial for a favorable outcome. Further studies are needed to identify predictors of outcome and more accurately defined criteria for ECMO therapy during cardiopulmonary resuscitation to further improve outcome of these high-risk patients.

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