

# Extracorporeal Membrane Oxygenation as a Resuscitation Measure in the Pediatric Emergency Department

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**ABSTRACT:** **Background:** Extracorporeal membrane oxygenation (ECMO) may serve as a bridge to regain cardiac function in refractory resuscitation. However, its use has so far been limited owing to low availability, especially in emergency departments. **Objectives:** To describe two children with acute myocarditis successfully treated with ECMO in the emergency department of a tertiary pediatric medical center. **Description:** The children presented with vomiting, followed by rapid deterioration to cardiogenic shock that failed to respond to conservative treatment. Given the urgency of their condition and its presumably reversible (viral) etiology, treatment with ECMO was initiated in the department's resuscitation room. **Results:** Outcome was excellent, and cardiac function remained normal throughout 6 and 10 months follow-up. **Conclusions:** Extracorporeal life support has enormous potential in the emergency department and warrants further assessment.

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**KEY WORDS:** extracorporeal membrane oxygenation (ECMO), myocarditis, refractory cardiogenic shock

Extracorporeal membrane oxygenation (ECMO) is widely used for artificial cardiopulmonary support after cardiac surgery and in selected cases of cardiac and respiratory failure in neonatal, pediatric, and adult intensive care units. Previous reports have described its use as a bridge to regaining cardiac function in refractory resuscitation [1-5], to provide temporary perfusion and oxygenation of tissues when these are not effectively provided by the cardiopulmonary system.

Guidelines for this type of extracorporeal cardiopulmonary resuscitation (E-CPR) have been published by the American Heart Association and the Extracorporeal Life Support Organization [1,2]. Specifically, the technique is suggested in cases of acute reversible cardiac or respiratory failure due to hypothermia, drug toxicity, myocarditis, and in-hospital cardiac arrest [1,2].

However, ECMO is currently available only in a limited number of centers, and its availability particularly in emergency departments (EDs), where most patients with these

conditions often undergo resuscitation, is even scarcer. Therefore, the literature contains only a few, mostly isolated, reports on the use of ECMO in the ED [3,4], and one recent larger study in eight adult patients [5].

The aim of the present report is to describe two children who were successfully connected to an ECMO circuit in the ED of a pediatric tertiary care facility as part of an end-stage measure for refractory resuscitation. The rationale, indications, complications and limitations of this technique are discussed.

## PATIENT DESCRIPTIONS

### PATIENT 1

A previously healthy 3 year old girl presented to the pediatric ED with a 1 day history of recurrent non-bilious vomiting without fever or diarrhea. Vital signs were: temperature 37.7°C, pulse rate 200/min, blood pressure 88/42 mmHg, and oxygen saturation level 99%. Findings on physical examination were unremarkable. A peripheral venous line was inserted, blood was drawn for complete blood count and chemistry, and intravenous fluids were initiated.

A few hours later, while the child was still in the ED, her general condition deteriorated. Respiratory distress was noted, with an increase in pulse rate to 225/min. She was transferred to the resuscitation room, and while receiving oxygen by mask was connected to an electrocardiograph monitor which demonstrated a wide complex tachycardia. Initially, blood pressure and peripheral perfusion were maintained, and trials of adenosine followed by amiodarone were administered. However, there was no change in pulse rate or rhythm, and hypotensive cardiogenic shock evolved. Repeated synchronized shocks with increasing energy were unsuccessful. Bedside echocardiography demonstrated poor cardiac contractility with no anatomic abnormalities, suggesting acute myocarditis.

Given the good prognosis of previously healthy children with acute myocarditis who survive the acute phase, and considering current accepted guidelines, a multidisciplinary team suggested the option of using ECMO as a bridge to recovery. After approval was obtained, the vessels were promptly cannulated and the patient was connected to an

ECMO machine. Subsequently she was transferred to the cardiac intensive care unit (CICU). In addition, she received supportive care with fluids, vasoactive drugs (milrinone and nitroprusside), cardiac pressors (dopamine and adrenaline), and an anti-arrhythmic agent (amiodarone).

Cardiac rhythm returned to sinus on day 4. Contractility gradually improved, and the patient was disconnected from the ECMO machine on day 8. Ten days later she was discharged home from the hospital, neurologically intact, on oral amiodarone treatment. After 6 months of follow-up without adverse events, the drug was discontinued. Cardiac function remained normal.

#### PATIENT 2

A previously healthy 17 year old boy presented to the ED with fever, malaise, myalgia, and vomiting of 3 days duration. Vital signs were as follows: temperature 37°C, pulse rate 164/min, blood pressure 105/26 mmHg, and oxygen saturation level 83%. The patient appeared pale, and peripheral perfusion was abnormal. He was immediately assigned to an ED room for further assessment and treatment while receiving 100% oxygen by mask. A few minutes later, he experienced sudden cardiorespiratory collapse and was transferred to the resuscitation room, where the electrocardiograph monitor showed ventricular fibrillation. Cardiopulmonary resuscitation was immediately instituted, including basic life support with defibrillation, and infusion of adrenaline and amiodarone.

With these measures, organized rhythm returned in the form of wide complex tachycardia with a weak pulse. Despite additional electrical therapy and lidocaine infusion, cardiac rhythm did not return to sinus. Due to respiratory failure with a clinical picture of pulmonary edema, the patient was intubated and ventilated with high oxygen and pressure levels. However, he remained hypoxic and hypotensive and did not improve adequately with further mechanical ventilation and continuous infusion of adrenaline and dopamine. The clinical and echocardiographic signs were consistent with acute myocarditis.

The patient was in a state of respiratory failure combined with cardiogenic hypotensive refractory shock, presumably of reversible etiology. Therefore, treatment with ECMO was considered. Since the patient's condition precluded his transfer even within the hospital, the ECMO personnel and equipment were promptly brought to the ED. Vessel cannulation was performed, and the patient was connected to the machine in the ED resuscitation room. After his condition stabilized he was transferred to the CICU for further care.

On day 4 of hospitalization, under treatment with lidocaine, sinus rhythm was regained. Cardiac function gradually improved, and the patient was disconnected from the ECMO machine on day 7. On day 31 he was discharged home from the hospital neurologically intact, on oral carvedilol treatment. Ten months later, cardiac function remained normal.

## DISCUSSION

In general, ECMO support is considered when a patient remains in hypotensive shock despite maximal treatment and the clinical condition is believed to be potentially reversible. Acute myocarditis in children meets these criteria. While the immune system manages the infection, the ECMO compensates for the inflamed heart, reducing its burden of work until the infection is controlled [6,7]. The natural history of acute fulminant myocarditis necessitates mechanical ventilation and cardiopulmonary resuscitation in many cases, as described before [8]. In 9% of the cases described, the outcome was poor despite all efforts when ECMO was not used.

We describe two patients who presented to our pediatric ED with rapidly deteriorating and refractory cardiogenic shock due to acute myocarditis, probably of viral etiology. Given their extreme condition, the speculated outcome was poor. Both successfully underwent ECMO initiated in the ED. We believe their excellent outcome was largely attributable to our timely use of ECMO support.

These cases highlight the importance of accessibility to ECMO in the ED. At present, ECMO is unavailable in many hospitals, and even where it exists it is not available at all times. Besides high cost and need for a special facility, the main reason for the scarcity of ECMO machines is the need for specially trained, on-call personnel. To overcome this barrier, one possibility that was suggested is transferring patients to centers capable of providing ECMO support, or adopting a "reaching out" program whereby the patient is retrieved from the referring institution to the ECMO-available center using a mobile ECMO system.

In a recent paper in the adult emergency medicine literature, Bellezzo and colleagues [5] suggest that ED physicians undergo training to connect and operate the ECMO machine. They also developed a decision-rule algorithm for applying this procedure.

The potential uses of extracorporeal life support as a rescue treatment for severely ill or injured patients in the ED, and particularly the pediatric ED, are manifold. Where available, clinicians should weigh its potential benefit in the best interests of their patients. Owing to the enormous resources required, clearer indications for its use are needed, together with further assessment of its potential risks and cost-effectiveness.

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