

# Extracorporeal life support for cardiac arrest in a paediatric emergency department

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**ABSTRACT** The initiation of extracorporeal membrane oxygenation (ECMO) in the emergency department (ED) is a rare event. Herein, we report a case of acute fulminant myocarditis in a nine-year-old girl who was successfully resuscitated by early initiation of ECMO support in the paediatric ED of KK Women's and Children's Hospital, Singapore. The patient had rapidly progressed into a witnessed pulseless ventricular tachycardia on presentation, and ECMO was started in the ED following the failure of standard resuscitation measures to establish spontaneous circulation. ECMO was continued for nine days. The patient recovered well with normal neurocognitive function. The initiation of ECMO in the ED is potentially life-saving in the resuscitation of children with witnessed in-hospital cardiac arrest due to a reversible cause.

*Keywords:* emergency department, extracorporeal membrane oxygenation, fulminant myocarditis

## INTRODUCTION

The severity of myocarditis in children varies from a relatively mild disease to a fulminant course with rapid circulatory collapse and a high mortality rate. Maximum medical therapy is not effective in many cases of acute fulminant myocarditis. However, in some cases, the deterioration of cardiac function can be reversed with the timely institution of extracorporeal membrane oxygenation (ECMO), which may substantially improve the prognosis.<sup>(1)</sup> To date, the initiation of ECMO for children in the emergency department (ED) setting is rare. Herein, we present the first case of a nine-year-old girl with fulminant myocarditis who survived following the initiation of ECMO in an ED in Singapore.

## CASE REPORT

A previously healthy nine-year-old girl presented to the ED of KK Women's and Children's Hospital, Singapore, with vomiting that had persisted for three days. The mother noted the child had been lethargic and pale on the day of presentation. At the ED resuscitation room, the patient was found to have ventricular tachycardia (VT) with a heart rate of 160 bpm and a thready pulse. The emergency code team, comprising an intensivist, anaesthetist and senior paediatric ED physicians, and a cardiologist, was immediately activated. The patient was intubated and synchronised cardioversion was administered, but she went into a witnessed pulseless VT. Chest compressions and defibrillations were administered multiple times according to the paediatric advanced life support guidelines from Singapore's National Resuscitation Council.<sup>(2)</sup> The patient also received

multiple doses of intravenous adrenaline and amiodarone. Emergency echocardiography performed demonstrated a poorly contracting heart.

A decision was made for emergency ECMO in the ED. Chest compressions were continued until placement of the right femoral arterial and venous cannulae using the cut-down (venoarterial) method by the cardiothoracic surgical team. ECMO was commenced. As the ECMO flow could not be brought above 1.1 L/min due to the small calibre of the patient's right femoral artery, she was brought to the operating theatre (OT) for neck cannulation. The total duration of cardiopulmonary resuscitation (CPR) in the ED was 110 mins.

The patient required ECMO for nine days. Her stay in the intensive care unit (ICU) was complicated by bilateral pneumonia, pleural effusions and hepatitis. She required chest tube insertions and an additional five days of supportive mechanical ventilation after decannulation. Her cardiac enzymes and transaminase levels gradually normalised, and serial echocardiography demonstrated gradual improvement in cardiac contractility. Eight days post decannulation, she was moved to the cardiac step-down unit for cardiac rehabilitation. She received physiotherapy for right foot drop, which was due to neuropraxia secondary to complications from the femoral cannulation.

Nearly four weeks after her admission, the patient was discharged from the hospital. At discharge, she had normal cognitive function, with a cerebral performance category score of 1. At follow-up 20 months post-ECMO, the patient's cardiac fractional shortening had improved to 32%. Her right foot drop

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had completely resolved except for mild atrophy of her right lower limb. She was able to participate in normal physical activities in school.

## DISCUSSION

ECMO is used in cases of cardiopulmonary failure to re-establish cardiac output and organ perfusion such that permanent end-organ injury while awaiting reversal of cardiac and other organ disease processes is prevented. An overall survival rate of 51% was seen in children who were supported with rapid-response ECMO after suffering from in-hospital cardiac arrest that did not respond to conventional CPR.<sup>(3)</sup>

ECMO support for children with fulminant myocarditis has been available in our institution since 2002; the initiation of ECMO is done mainly in the OT or ICU. The present case is the first case of ECMO initiation in the ED of our institution. Posner et al reported their first experience with ECMO in the ED of a children's hospital in the year 2000; in that report, the ECMO was initiated for two children who presented with cardiac arrests.<sup>(4)</sup> The first child who had undiagnosed long QT syndrome survived without any detectable neurologic sequelae. However, the other child who had an underlying complex congenital heart disease suffered brain death and support was thus withdrawn. In 2007, Yamamoto and Young<sup>(1)</sup> reported the institution of ECMO in their institution's ED for two children with fulminant myocarditis. Both of their patients survived and were discharged with normal cognitive function. The reports by Posner et al,<sup>(4)</sup> and Yamamoto and Young<sup>(1)</sup> were both from the United States. In Taiwan, Huang et al described a cohort of 27 paediatric patients who were put on extracorporeal cardiopulmonary resuscitation (ECPR) for in-hospital cardiac arrest.<sup>(5)</sup> ECPR is defined as ECMO instituted during active CPR with chest compressions.<sup>(3)</sup> All of the 27 patients had cardiac arrests in the ICU, except for one patient who had sustained a cardiac arrest in the ED.<sup>(5)</sup> This patient had fulminant myocarditis and ECMO was initiated in the ED. However, the patient did not survive.

The low numbers of successful ECPR initiated in the ED, as compared to those initiated in the ICU or OT, may be due to a few reasons. One reason is that there is difficulty in identifying a suitable candidate for the initiation of ECMO at the ED level. It has been shown that patients who sustained cardiac arrest due to respiratory causes have poor results on ECMO, whereas those with isolated cardiac diseases such as acute fulminant myocarditis have better outcomes with ECMO.<sup>(6-8)</sup> In addition, the majority of cardiac arrest patients presenting to the ED are out-of-hospital cardiac arrests that have a poorer prognosis than inpatient cardiac arrests. Moreover, the use of ECMO is resource-intensive. The ECMO team in our hospital consists of a paediatric cardiothoracic surgeon, perfusionists and OT nursing staff. An ECMO pump, vascular cannulae, and surgical instrument set and blood to prime the ECMO pump is needed for ECMO. It would be a waste of resources to deploy a full team of staff to initiate ECMO in a patient that may not benefit

from the intervention. In the present case, we correctly identified the child as a suitable candidate for ECPR in the ED, and were able to mobilise the ECMO team early.

In a case series involving 80 children, Alsoufi et al found that acceptable survival and neurologic outcomes can be achieved with ECPR in children who have had a prolonged cardiac arrest (up to 95 mins) refractory to conventional resuscitation measures.<sup>(6)</sup> In the present case, our patient received CPR for a total of 110 mins (from onset of cardiac arrest till successful cannulation and initiation of ECMO) prior to the initiation of ECMO. She is the first patient in our institution with fulminant myocarditis to survive a cardiac arrest prior to ECMO initiation. A recent case series of eight children who underwent ECMO in our hospital for fulminant myocarditis reported a 62.5% survival to hospital discharge rate.<sup>(9)</sup> In that case series, the two children who had a cardiac arrest before the initiation of ECMO died.<sup>(9)</sup>

Our first experience of ECPR in the ED with the reported patient who had acute fulminant myocarditis resulted in survival with good neurological outcome. This demonstrates that the timely institution of ECPR in the ED can improve the survival of children with in-hospital cardiac arrest that is due to a reversible cause (e.g. fulminant myocarditis) and is unresponsive to conventional CPR.

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