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CASE REPORT

A case of pediatric out-of-hospital cardiac arrest due to fulminant myocarditis requiring extracorporeal cardiopulmonary resuscitation

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Abstract

A 7-year-old girl presented with a 2-day history of fever and chest pain that led her to collapse, prompting her father to call the emergency medical services (EMS). Both an EMS ambulance and a physician-staffed ambulance were dispatched to the scene. Upon arrival, the EMS crew discovered that the patient was in cardiac arrest, with ventricular fibrillation (VF) as the initial heart rhythm. Due to the patient's refractory VF, the physician requested the receiving hospital to prepare for extracorporeal cardiopulmonary resuscitation (ECPR), which was successfully initiated 105 minutes after the patient's collapse. The patient was admitted to the intensive care unit, where her cardiac function gradually improved. On the eighth day, she was successfully weaned off extracorporeal membrane oxygenation and discharged from the hospital on the thirty-third day without any neurological complications. The presumed cause of the cardiac arrest was fulminant myocarditis, based on the patient's clinical history and findings from cardiac magnetic resonance imaging. Overall, early mechanical cardiopulmonary support is crucial for patients with fulminant myocarditis. However, cases resulting in out-of-hospital cardiac arrest generally have poor outcomes, even with ECPR. This particular case demonstrated that optimal resuscitation, spanning from the prehospital phase to the intensive care unit, utilizing ECPR, played a vital role in achieving a favorable neurological outcome.

Keywords

Cardiac arrest; Extracorporeal membrane oxygenation; Myocarditis; Pediatric; Prehospital care

1. Introduction

Fulminant myocarditis is a severe condition associated with high mortality rates, often resulting in circulatory failure and cardiac arrest. In such cases, extracorporeal cardiopulmonary resuscitation (ECPR) may be employed as a final measure for resuscitation [1, 2]. However, even with ECPR, the outcomes of in-hospital cardiac arrest cases tend to be unfavorable [3]. Additionally, there is currently insufficient data to support the use of ECPR for pediatric out-of-hospital cardiac arrest (OHCA) [4].

In this report, we present a case of pediatric OHCA caused by fulminant myocarditis. Remarkably, the patient was successfully resuscitated despite a prolonged cardiac arrest duration of 105 minutes prior to initiating ECPR.

2. Case report

A 7-year-old girl (height: 125 cm; weight: 20 kg, body surface area: 0.825 m^2) without any specific medical conditions was prescribed antibiotics and antipyretics by her pediatrician due to intermittent mid-chest pain and fever for 2 days. At 5:00 AM, she suddenly called out for her mother, immediately developed convulsions and collapsed, prompting her father to call the emergency medical service (EMS) and was guided by the EMS dispatcher to provide chest compressions.

Upon receiving the emergency call, both an EMS ambulance and a physician-staffed ambulance were dispatched. The EMS ambulance reached the scene within 11 minutes after the call, where the EMS crew confirmed that the patient was experiencing cardiac arrest with ventricular fibrillation (VF) and promptly administered a shock, which unfortunately did not successfully defibrillate the patient. The physician-staffed ambulance arrived 22 minutes after the EMS ambulance, following which the physician performed endotracheal intubation and administered 0.2 mg of epinephrine and 150 mg of amiodarone *via* intraosseous infusion, and determined that the patient was suffering from refractory VF. The physician confirmed signs of life, as the patient exhibited grimace during manual chest compression and her pupils were not dilated. The receiving tertiary hospital was then immediately contacted to inform emergency physicians, cardiovascular surgeons on call and medical engineers to prepare for ECPR. The patient was transported to the hospital and arrived approximately 50 minutes after her collapse.

Upon arrival at the hospital, the patient was still in cardiac arrest with sustained VF. Her pupils were dilated and had lost reflex to light. Arterial blood gas analysis on arrival revealed an elevated serum lactate level (18 mmol/L), indicating that the patient was in a low-flow status. The emergency physicians and cardiovascular surgeons performed catheter insertions while continuing chest compressions. However, as there was no catheter available in the recommended size for a 20-kg child, percutaneous cannulation was performed on the femoral vein and artery using a NextGen™ 12 Fr and a NextGen™ 10-Fr (Bio-Medicus, Tokyo, Japan), respectively. A left superficial femoral artery graft with a distal perfusion cannula was used to ensure adequate perfusion of the left leg, as well as a circuit of 6.0-mm diameter (BIOCUBE 2000™; Nipro, Osaka, Japan). Approximately fifty-five minutes after the patient's arrival, ECPR was initiated using the MERA Centrifugal Blood Pump System HCS-CFP (SENKO MEDICAL INSTRUMENT, Mfg. Co., Ltd., Japan). Until this point, the patient had received a total of 13 doses of 0.2 mg epinephrine since her collapse. Initially, the ECPR settings were adjusted to 2830 revolutions per minute (RPM) and a flow rate of 1.2 L/min based on the circuit diameter, which is generally inadequate for a 20-kg pediatric patient with complete loss of cardiac output. Then, she was admitted to the intensive care unit (ICU) and subjected to targeted temperature management at a body core temperature of 34 °C for 72 hours. Her biochemical parameters are shown in Table 1.

On the second day, continuous renal replacement therapy (CRRT) was provided due to decreased urine output. However, the patient's serum lactate level, which had initially returned to normal, rose to 5.7 mmol/L, indicating a need to improve the patient's circulatory status (Fig. 1). To achieve this, the catheters were replaced with those arranged the day before (a 14-Fr cannula in the right internal jugular vein and a 12-Fr cannula in the left femoral artery). To further enhance the patient's circulatory status, an adult-sized oxygenator (SOLAS 23H-CSP, Senko Medical, Tokyo, Japan) was used along with blood transfusions. As a result of these interventions, the flow rate increased to 2.0 L/min, the lactate level returned to normal, and the patient's circulatory status improved.

Additionally, the electrocardiogram (ECG) continued to indicate VF on the second day. Despite the continuous administration of amiodarone, the arrhythmia persisted, leading to continuous infusion of landiolol at a rate of 4.8 µg/kg/min. Subsequently, the patient successfully returned to a normal sinus rhythm on day 3. Her renal function also improved, and she was weaned from CRRT on day 7. The cardiac function gradually improved, with a left ventricular ejection fraction reaching 65%, and she was successfully weaned off from extracorporeal membrane oxygenation on day 8. By day 10, the patient's condition had improved to the extent that extubation was possible, and on day 11, she was transferred from the ICU. Cardiac magnetic resonance imaging (MRI) performed on day 31 revealed edema and inflammatory changes in the basal to postero-inferior myocardium (Fig. 2), confirming a diagnosis of fulminant myocarditis as the cause of the cardiac arrest. Notably, the patient was discharged from the hospital on day 33 without any neurological complications. Follow-up echocardiography conducted on the day before discharge demonstrated an ejection fraction of 60%, which further improved to 70% one year later.

3. Discussion

In this case, ECPR was used to treat a pediatric OHCA resulting from fulminant myocarditis. Remarkably, the patient not only survived but also experienced no neurological complications. The implementation of optimal resuscitation strategies, starting from the prehospital phase and continuing throughout the ICU management, played a crucial role in the successful resuscitation of this pediatric patient.

Pediatric OHCA can be triggered by various factors, with VF being a less common cause than in adults [5]. Unexpected pediatric cardiogenic cardiac arrest with VF often stems from catecholaminergic polymorphic ventricular tachycardia and commotio cordis. However, myocarditis was the suspected cause in this particular case based on preceding symptoms and MRI findings. Although fulminant myocarditis is a condition with high mortality and can lead to pediatric cardiogenic cardiac arrest, it only contributes to a small percentage of pediatric cardiac arrest cases [6].

A recent study has shown the benefit of early ECPR introduction in promoting early organ perfusion among adult victims [7]. While there is currently insufficient evidence to recommend ECPR as a general treatment for pediatric OHCA [4], it might still prove beneficial in certain individual pediatric cases where the decision is made on a case-by-case basis.

To effectively administer ECPR to pediatric patients experiencing cardiac arrest, certain conditions must be met, including the availability of a range of catheter sizes suitable for any pediatric body size. In this case, the recommended size of catheters was unavailable at the time of arrival. It should be noted that even a 2-Fr difference in catheter diameter can significantly change the pre-pump negative pressures in pediatric patients with cardiac arrest, resulting in poor drainage [8]. In this particular case, the circulation was optimally supported by upsizing the cannula. Therefore, while it would be ideal to have a wide range of catheter sizes, this may not always be feasible due to hospital policies and a lack of legal arrangements.

Another crucial consideration for ECPR is the time to initiate the procedure. It has been shown that a longer cardiopulmonary resuscitation (CPR) duration before ECPR is associated with a lower chance of survival [3]. In this case, ECPR was implemented more than 100 minutes after the initial cardiac arrest and the epinephrine doses were increased over time during CPR. While the optimal frequency of epinephrine administration has not been thoroughly studied [9], frequent administration could worsen the prognosis by increasing myocardial oxygen consumption or causing arrhythmias.

Several factors may have contributed to this patient's positive neurological outcome despite the 105 minutes of CPR.

TABLE 1. Biochemical parameters from days 1 to 8.

Variables	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7	Day 8
AST (U/L)	185	386	596	392	417	342	262	153
ALT (U/L)	82	94	175	139	194	169	149	98
T-bil (mg/dL)	0.2	1.2	1.4	0.9	0.6	0.6	0.6	0.5
CK (U/L)	916	10,228	12,084	8415	6099	3646	1992	804
BUN (mg/dL)	20	26	31	35	27	20	17	29
Cre (mg/dL)	0.82	0.75	1.01	1.25	1.46	1.50	1.35	2.09

AST: Aspartate aminotransferase; ALT: Alanine aminotransferase; T-bil: Total bilirubin; CK: Creatine kinase; BUN: Blood urea nitrogen; Cre: Creatinine.

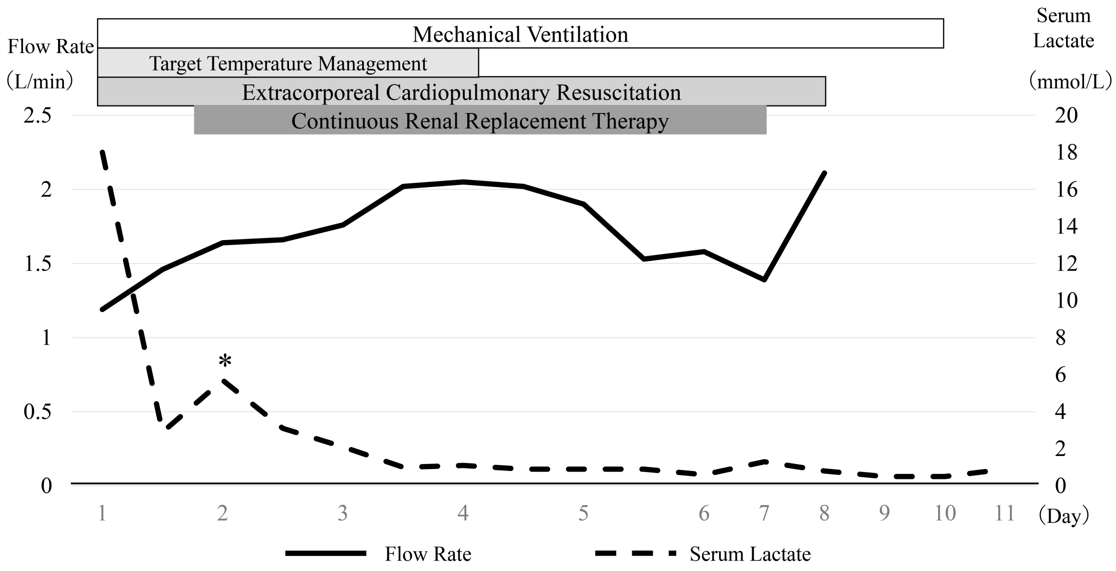

FIGURE 1. Clinical course. The patient was admitted to an intensive care unit after extracorporeal cardiopulmonary resuscitation (ECPR) implementation. On day 2, her serum lactate level increased to 5.7 mmol/L (*) and was reduced after catheter revision. The patient's cardiac function gradually improved, and ECPR was discontinued on day 8.

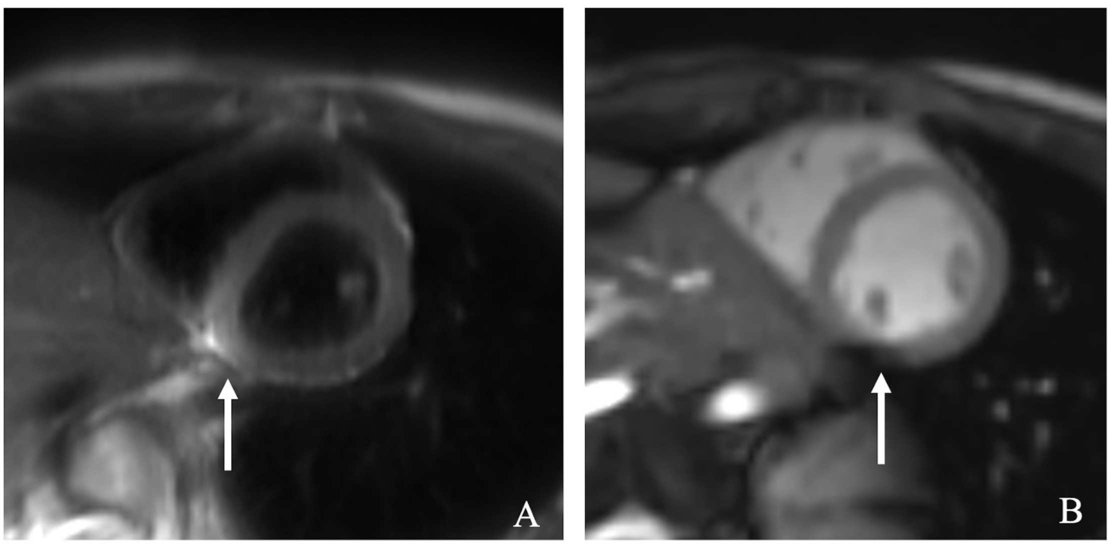

FIGURE 2. Cardiac magnetic resonance imaging of the case. The cardiac magnetic resonance imaging (CMRI) on day 31 reveals a left ventricular ejection fraction of 61% and a normal left ventricular volume, with hypokinesis in the basal and mid-posterolateral segments. These segments display a high-intensity area on the T2 weighted image (A, arrow) and delayed gadolinium enhancement in the T1 weighted image (B, arrow), indicating myocardial edema or fibrosis. Based on these findings, the diagnosis of fulminant myocarditis was established.

It is well known that factors such as witness status, bystander CPR and shockable initial rhythm are associated with better outcomes [5]. Although there were no measurements regarding the quality of CPR, the patient's signs of life during CPR suggest that high-quality manual chest compressions were administered, which helped maintain the patient's low-flow status until the initiation of ECPR. High-quality CPR is one of the key determinants for the successful implementation of ECPR [10]. Additionally, the hospital where the patient was treated is experienced in performing ECPR on adults and has established systems for providing organ support during post-resuscitation care, such as target temperature management and CRRT. Collectively, these factors might have contributed to the patient's favorable neurological outcome despite the extended duration of CPR.

4. Conclusions

This study reports the case of a pediatric OHCA triggered by fulminant myocarditis in which the patient successfully survived after ECPR implementation.

This case demonstrates the potential for ECPR to yield positive outcomes even in scenarios of prolonged resuscitation. However, the specific factors that contribute to these positive outcomes, and the circumstances under which ECPR may not result in favorable outcomes, remain to be fully understood.

ABBREVIATIONS

CRRT, continuous renal replacement therapy; CPR, cardiopulmonary resuscitation; EMS, emergency medical service; MRI, magnetic resonance imaging; OHCA, out-of-hospital cardiac arrest; ECPR, extracorporeal cardiopulmonary resuscitation; VF, ventricular fibrillation.

AVAILABILITY OF DATA AND MATERIALS

Due to patient confidentiality and privacy concerns, the data and materials related to this case report may not be made publicly available. However, requests for any additional information regarding this case report can be directed to the corresponding author, who can provide a de-identified summary of the data upon request.

AUTHOR CONTRIBUTIONS

KM, KT and HF—designed this study. AK, SH, KM, SY, NT, TK and AS—collected the data. KM and KT—wrote the original draft. HF—reviewed and finalized the manuscript. All authors approved the final version of this manuscript.

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

Informed consent for the publication of this report was obtained from the patient's parents. The Ethical Review Committee of Nara Medical University waived the need to approve this study because of its nature as a case report.

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CONFLICT OF INTEREST

The authors declare no conflict of interest.

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