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CASE REPORT

Extracorporeal Cardiopulmonary Resuscitation as a Bridge to Cardiac Transplantation in Refractory Cardiac Arrest Due to Fulminant Myocarditis: A Case Report

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Abstract: Extracorporeal cardiopulmonary resuscitation (ECPR) is increasingly used for refractory cardiac arrest, although evidence for a survival benefit remains heterogeneous and appears highly dependent on patient selection and systems of care. We report the case of a previously healthy 36-year-old woman who presented with acute fulminant myocarditis and cardiogenic shock. Following an in-hospital cardiac arrest unresponsive to conventional cardiopulmonary resuscitation, bedside ECPR was initiated using peripheral veno-arterial extracorporeal membrane oxygenation (VA-ECMO) as a bridge to longer-term mechanical circulatory support with a biventricular assist device (BiVAD). After conversion to central BiVAD support, the patient was listed super-urgently and subsequently underwent successful donation-after-circulatory-death heart transplantation. She was discharged home neurologically intact and remains well five months after discharge. This case demonstrates that when deterioration is imminent and standard therapies have failed, ECPR may provide life-saving support while preparing for definitive mechanical circulatory support, even when most members of the clinical team lack ECPR experience. Timely leadership and coordinated multidisciplinary expertise were the key to achieving a successful outcome in this case.

Keywords: ECPR, ECMO, VA-ECMO, ECLS, extracorporeal cardiopulmonary resuscitation, MCS

Introduction

Extracorporeal cardiopulmonary resuscitation (ECPR) is increasingly used to manage refractory cardiac arrest.[1,2] It typically involves percutaneous or surgical cut-down cannulation of the femoral artery and vein to initiate peripheral veno-arterial extracorporeal membrane oxygenation (VA-ECMO), aiming to restore organ perfusion and tissue oxygenation.[2,3] Established ECPR programmes now operate in many centres worldwide, providing support for both in-hospital and out-of-hospital cardiac arrest.[1,2] However, evidence of its clinical benefit remains limited,[1,2] although some studies report improved survival and neurological outcomes.[4]

Fulminant myocarditis is a potentially reversible cause of cardiogenic shock, and temporary extracorporeal life support (ECLS) may provide a bridge to myocardial recovery or, when recovery does not occur, to further mechanical circulatory support or transplantation.[5,6] We present a case of ECPR in fulminant myocarditis, used as a bridge to biventricular assist device (BiVAD) implantation and subsequent cardiac transplantation.

Case Report

A previously fit and well 36-year-old female (60 kg, 1.6 m, BMI 23.4 kg/m^2) presented to a district general hospital with a brief history of fever, abdominal pain, and hypotension. Her transthoracic echocardiogram revealed severe biventricular

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failure, and she had bilateral consolidation on chest computed tomography. She was admitted to her local intensive care unit with cardiogenic shock and pulmonary oedema, presumed to be secondary to acute myocarditis. She was subsequently referred to and accepted by the heart failure team at our tertiary institution for advanced heart failure management, either conservatively or with consideration of mechanical circulatory support (MCS). She was considered a suitable candidate for MCS, as either a bridge to recovery or a potential bridge to heart transplantation. She was sedated, intubated and ventilated to facilitate safe transfer by land ambulance.

On her arrival at our institution, she underwent a transoesophageal echocardiogram (TOE), which revealed a dilated left ventricle with severe biventricular failure and an ejection fraction of 10%. The critical care team initially stabilised her on intravenous cardiovascular support with milrinone (0.32 micrograms/kg/min), dopamine (5.55 micrograms/kg/min), and noradrenaline (0.06 micrograms/kg/min). Her vasoactive-inotropic score was 15.1.

The following day, she developed a broad complex tachycardia and lost cardiac output. Conventional cardiopulmonary resuscitation was initiated with manual chest compressions and later using the LUCAS-2 Chest Compression System (Physio-Control/Jolife AB, Lund, Sweden). Invasive arterial pressure monitoring confirmed the presence of pulsatile flow during this time. She initially regained spontaneous circulation following external defibrillation and administration of 300 mg of intravenous amiodarone. However, she subsequently developed ventricular tachycardia and fibrillation, leading to a refractory cardiac arrest. The team decided to perform bedside ECPR to restore perfusion and allow time for decision-making, then ultimately to transfer to the operating theatre for BiVAD initiation, which was delayed by around 30 minutes because the cardiac theatre team was off-site at the weekend.

Whilst still receiving mechanical compressions with the LUCAS-2, she was administered 9000 units of heparin and percutaneously cannulated under ultrasound and TOE guidance with a 21Fr 55cm lighthouse-tip return cannula (Medtronic, Minneapolis, MN, USA) in the right femoral vein, normally used as a return cannula in our practice, inadvertently used for venous drainage, and a 19Fr 15cm Maquet HLS arterial return cannula (Getinge, Rastatt, Germany) in the left femoral artery. She was established on peripheral VA-ECMO with a pre-primed emergency ECMO circuit [ECMO console: CentriMag (Abbott, Pleasanton, CA, USA); oxygenator: Chalice Paragon Adult Maxi PMP (Chalice Medical, Nottinghamshire, UK)]. Initial drainage was slow, but after fluid administration, a flow of 3.3 litres per minute was established. After the theatre team and surgeon arrived, the heart was reassessed and showed ventricular standstill and persistent aortic valve closure, with the left ventricle continuing to dilate. She was therefore transferred to the operating theatre, where she underwent conversion of peripheral VA-ECMO to central BiVAD, plus repair of the left femoral artery. The purpose of peripheral VA-ECMO was to immediately restore systemic perfusion during refractory cardiac arrest, but because severe biventricular failure was already established and ventricular unloading was inadequate after VA-ECMO initiation, the multidisciplinary team decided to proceed to central BiVAD rather than add an intermediate LV-unloading device. The BiVAD provided biventricular decompression and ongoing circulatory support, as described in other reports.[7,8] During these procedures, her lactate peaked at 19 mmol/L. In theatre, her initial core temperature was 33°C, which had transiently drifted down following ECMO initiation. The team initially rewarmed the patient to 35°C, then fully rewarmed her to 37°C before leaving theatre. Cerebral near-infrared spectroscopy (NIRS) monitoring (INVOS, Medtronic, Minneapolis, MN, USA) was continued for several days postoperatively. Approximately 68 minutes elapsed from the initial loss of cardiac output to the initiation of VA-ECMO flow. This interval included decision-making and cannulation. This was not a period of uninterrupted CPR, as spontaneous circulation transiently returned after defibrillation and amiodarone, before recurrent ventricular tachycardia and ventricular fibrillation ultimately led to refractory cardiac arrest. A further 162 minutes elapsed on peripheral VA-ECMO before BiVAD support was established in theatre. [LVAD console: CentriMag (Abbott, Pleasanton, CA, USA); oxygenator: Chalice Paragon Adult Maxi PMP (Chalice Medical, Nottinghamshire, UK); RVAD console: CentriMag (Abbott, Pleasanton, CA, USA)]. Following BiVAD initiation, she required volume resuscitation of around five litres of crystalloid, 5% human albumin solution and red blood cells to maintain LVAD flows.

The patient required prolonged critical care support until she became eligible for super-urgent transplant listing 23 days later. Myocardial biopsy confirmed severe lymphocytic myocarditis, and serial echocardiography failed to show any myocardial recovery. Sixteen days after listing, she underwent a successful heart transplant from a DCD (donation-after-circulatory-death) heart donor. Postoperatively, her sternum was initially left open, with the skin closed, due to cardiac

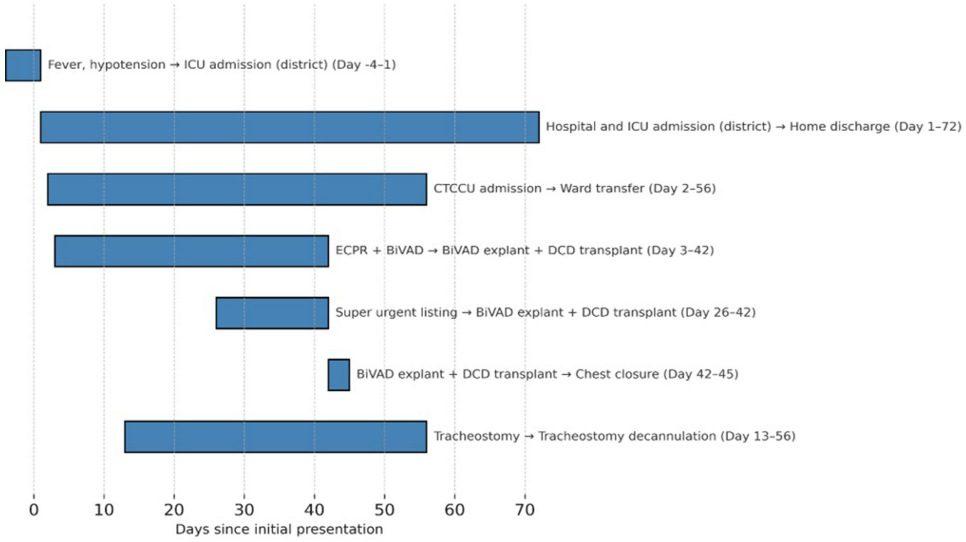

Figure 1 Clinical timeline.
Abbreviations: ICU, intensive care unit; CTCCU, cardiothoracic critical care unit; ECPR, extracorporeal cardiopulmonary resuscitation; BiVAD, biventricular assist device; DCD, donation after circulatory death.

size mismatch, tissue oedema, and bleeding, and then definitively closed three days later. The tracheostomy tube was removed on day 56, and she remained in the hospital for a total of 72 days before being discharged home neurologically intact. At five months post-discharge, she continues to do well physically and neurologically, under regular follow-up with the transplant team.

Figure 1 shows the patient's clinical timeline.

Discussion

Myocarditis often has meaningful recovery potential so that temporary MCS can be a bridge to recovery; yet this patient's biopsy-proven severe lymphocytic myocarditis failed to recover, necessitating transplantation.[9]

Although this case ultimately succeeded, the ad hoc decision regarding ECPR was distinctive and concealed several potential pitfalls and limitations. Our hospital's ECPR service was suspended in 2020 due to COVID-19-related capacity constraints, meaning that whilst ECLS is a documented rescue strategy for refractory ventricular arrhythmias and cardiogenic shock,[10] bedside emergency ECPR is not common practice in our department. However, a primed ECMO circuit is available in cardiothoracic critical care at all times. Additionally, aside from the decision-maker consultant intensivist, who had previous ECPR experience, the critical care staff involved lacked ECPR experience, and the perfusionist was initially off-site because it was the weekend, arriving just in time to initiate VA-ECMO.

Due to the critical nature of the situation and the limited ECPR experience of the team, the lighthouse-tip return cannula was inadvertently handed to the cannulating consultant instead of the usual multistage drainage cannula and was used for venous drainage. Although this was not our usual drainage cannula, no drainage issues occurred during VA-ECMO.

The neurological outcomes following the prolonged low-flow state remained uncertain; however, as the heart was distending on VA ECMO, and considering the patient's young age and previous good health, the surgical team decided to proceed with BiVAD insertion without waiting for a formal neurological assessment, to provide biventricular decompression and ongoing circulatory support, as described in other reports.[7,8] Her young age and transient return of spontaneous circulation were favourable characteristics described in ECPR populations,[1] while a shockable rhythm has also been associated with survival following ECPR.[11] However, the excellent neurological outcome cannot be attributed to any single factor. Our decisive action, whilst ethically and clinically complex, allowed definitive circulatory support to proceed despite uncertainty regarding neurological prognosis.

ECPR outcomes strongly depend on systems and preparation,[12] yet this patient survived an exceptional ad hoc ECPR performed after the formal programme had been suspended. This case demonstrates the feasibility of successful ad hoc

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ECPR in exceptional circumstances, despite the absence of an active ECPR programme, where established ECMO/MCS infrastructure, immediately available equipment, experienced clinical leadership, and multidisciplinary expertise are present.

VA-ECMO as a bridge to cardiac transplantation is well documented,[13,14] and ECPR as a bridge to heart transplantation has also been reported in adult and pediatric populations.[15,16] Adachi et al reported VA-ECMO subsequently converted to biventricular assist-device support as a bridge to myocardial recovery in fulminant myocarditis.[8] The distinctive feature of the present case was the ad hoc ECPR undertaken in our intensive care unit after the formal institutional ECPR service was suspended, with most of the clinical team lacking prior ECPR experience, followed by early BiVAD support without formal neurological assessment and subsequent heart transplantation; the distinctive aspect therefore lies in the circumstances and sequential rescue pathway rather than in ECPR as a bridge to transplantation by itself. We are not aware of any guidelines addressing this situation.

A strength of this report is the detailed description of an unusual ad hoc ECPR pathway and subsequent transition to definitive mechanical circulatory support and transplant. However, as a single case from a specialist centre with established ECMO, MCS, and transplantation expertise, the findings may not be generalisable, and no causal relationship between individual interventions and the favourable outcome can be established.

Conclusion

When no further conventional therapeutic options are available, and deterioration is inevitable in a time-critical arrest situation, ECPR may be a viable option to restore vital organ perfusion whilst preparations are made for BiVAD implantation, even when most members of the clinical team lack ECPR experience. This case illustrates the potential feasibility of ad hoc ECPR in exceptional circumstances, when a formal ECPR service is inactive but appropriate ECMO/MCS infrastructure and experienced clinical leadership remain available.

Data Sharing Statement

The data supporting this case report are not publicly available to protect patient privacy, but they may be shared in anonymised form upon reasonable request from the corresponding author, subject to appropriate discussion with the authors, hospital authorities, ethical review and approval.

Ethical Approval and Informed Consent Statements

Written informed consent for publication of this case and any accompanying images was obtained from the patient. Ethical approval was not required for this case report in accordance with institutional and national guidelines.

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Author Contributions

All authors approved the final manuscript. All authors made a significant contribution to the work reported, whether that is in the conception, study design, execution, acquisition of data, analysis and interpretation, or in all these areas; took part in drafting, revising or critically reviewing the article; gave final approval of the version to be published; have agreed on the journal to which the article has been submitted; and agree to be accountable for all aspects of the work.

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