Extracorporeal Cardiopulmonary Resuscitation for Out-of-Hospital Cardiac Arrest

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What is ECPR?

Extracorporeal cardiopulmonary resuscitation (ECPR) is the use of extracorporeal membrane oxygenation (ECMO) in patients with cardiac arrest. The theory is to bypass the patient's malfunctioning heart, buying time to address the underlying issue that led to the cardiac arrest and then removing the support once the heart has recovered. Towards that end, ECPR specifically uses venous-arterial (VA) ECMO to replace the forward flow of blood.[1] This is in contrast to venous-venous (VV) ECMO, which oxygenates the blood but does not replace the work done by the heart. A recent example of VV ECMO use are the many severely ill COVID patients who ended up on this treatment due to their profound difficulty oxygenating.

VA ECMO relies on a venous catheter to withdraw blood, which is oxygenated by the circuit and then pumped back to the body under pressure through the arterial catheter. ECMO cannulation can be achieved centrally via a sternotomy with catheters in the right atrium and ascending aorta or peripherally through various large vessels, most commonly the femoral vein and artery (Figure 1). For ECPR, peripheral cannulation is preferred due to the emergent nature of the procedure. Systemic anticoagulation is typically applied to prevent clotting of blood in the ECPR circuit.[2]

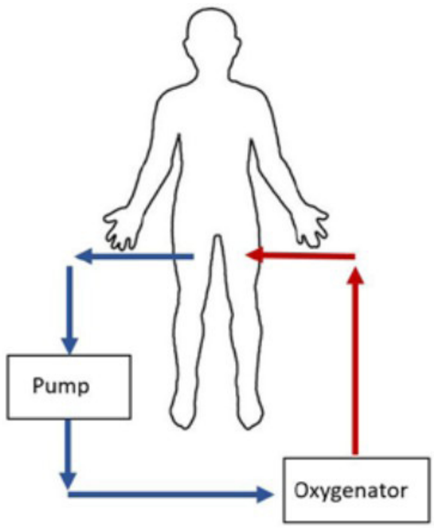

Figure 1: Venous-arterial ECMO circuit diagram (I don't seem to have this one (there is also a figure 2 below) so I reached out to the authors)

Why ECPR for OHCA?

ECPR is an intriguing modality for improving the dismal outcomes of out-of-hospital cardiac arrest (OHCA) with conventional treatment. Approximately 350,000 cases of OHCA occur annually in the United States and rates of survival with a good neurologic outcome barely reach 8%.[3] But when ECPR is used for OHCA, a meta-analysis of more than 3000 patients across 44 studies found 18% survived with good neurologic outcome.[4] Taken at face value, this would suggest a number-needed to-treat (NNT) of 10, which is superior to many treatments in emergency medicine, including aspirin for myocardial infraction, which has a NNT of 42.[5] In addition, a randomized controlled trial of ECPR versus conventional treatment in refractory shockable arrests found a survival to hospital discharge of 43% vs 7% with most of the ECPR patients having good neurologic outcomes.[6] However, these encouraging numbers are likely something of an overstatement, as the study was only a single center study and not all OHCA patients are appropriate ECPR candidates for various reasons, including the need for timely intervention.

What are the challenges of ECPR?

Aspirin administration for myocardial infarction is a much simpler intervention than placing cardiac arrest patients on ECMO. In comparison, implementing ECPR is far more challenging. First of all, ECPR is an extremely time-sensitive intervention, with the time from arrest to cannulation and administration of ECPR being repeatedly demonstrated to be a key predictor of survival.[7,8] Moreover, providing ECPR requires extensive institutional coordination and capacity in order to emergently place a patient on ECMO and manage these patients in specific intensive care units afterward. Furthermore, ECPR is an expensive, resource-intensive, and complex treatment that many community hospitals or health care systems simply cannot provide, and many patients who do receive this intervention will still not survive.[9] ECPR could also be viewed as harmful for patients that survive but have no meaningful recovery, and can unnecessarily prolong the process of dying.[10] Finally, providing ECPR in an emergency medicine setting potentially requires transporting OHCA patients who are still pulseless. Transportation of these patients can compromise the quality of resuscitation due to the challenges of transport and has been associated with decreased survival.[11]

Which patients may benefit from ECPR?

Given the costs and challenges of ECPR, careful patient selection is important.[12] Timeliness to ECPR is one of the most important criteria, as prolonged exposure to the low-flow state of chest compressions worsens outcomes. Another key determinant of patients who might benefit is the presence of a reversible cause of the cardiac arrest. As mentioned above, ECPR serves as a bridge therapy, replacing the work of the heart while the body recovers or interventions are performed to reverse the initial insult, such as cardiac catherization for myocardial infarction. Thus, ECPR has special promise for cases where recovery is expected with time, such as overdoses of certain cardiac toxins.[13] Hypothermic arrests are a unique potential application of ECPR as the cold temperature is neuroprotective and no other means of rewarming is as effective as ECMO.[14] Conversely, ECPR is less appropriate for patients with significant comorbidities (severe lung disease, end-stage renal disease, cirrhosis), severely compromised neurologically, or those with contraindications to anticoagulation such as patients with massive hemorrhage.

Conditions that may benefit from ECPR	Conditions that contraindicate ECPR
Myocardial infarction	Intracranial hemorrhage/other major bleed
Pulmonary embolism	Severe neuro-cognitive impairment
Cardiac toxin overdose	Advanced chronic obstructive lung disease
Primary arrhythmia	End-stage renal disease
Hypothermia	Cirrhosis / Metastatic malignancy

Figure 2: Interaction of ECPR with various conditions

Conclusion

Although ECPR requires significant resources and institutional capacity, it offers promise for improving OHCA outcomes in selected patients. While ECPR has already been implemented in some hospital systems, further technological advancement and a growing evidence base may lead to this treatment expanding its reach.

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