Extracorporeal Cardiopulmonary Resuscitation: From Cannulation to Discharge Home

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Extracorporeal Cardiopulmonary Resuscitation (ECPR) is defined as the implantation of veno-arterial extracorporeal membrane oxygenation (VA-ECMO) in a patient who experienced a sudden and unexpected pulseless condition attributable to cessation of cardiac mechanical activity.[6] The goal of ECPR is to improve cardiac output, as well as to restore oxygenation and perfusion during the low flow phase of cardiopulmonary resuscitation (CPR) in the setting of cardiac arrest (CA).[3] Although it was first implemented in 1976, ECPR has only begun to be more frequently utilized for a variety of resuscitation efforts within the last two decades.[6] It is important for ECPR to be discussed, not only because of the dire situations in which it is utilized, but also due to the advantage it holds over conventional CPR (CCPR), which may only be delivering 30-40% of normal blood flow to the brain.[7] ECPR has demonstrated evidence of higher survival rates to discharge and also at 6-12 months post-discharge from the hospital.[3]

As the technology of ECPR continues to advance and gain attention, there is still much to learn and understand about its relevance to practice. However, it is evident that ECPR is changing and improving how we resuscitate patients who are unresponsive to CCPR suffering from refractory cardiac arrest, both inside and outside of the hospital.[7] When a patient is in CA, the standard cannulation strategy, which can be seen in Figure 1, involves peripheral femoral-femoral cannula placement with the option of adding in a distal limb perfusion cannula based on the program's protocols.[2] If the patient still has an open sternum post-operatively, it is most feasible to cannulate centrally, otherwise peripheral cannulation is preferred considering it can be performed with minimal interruptions in chest compressions, limiting the low/no flow states.[3] Once inserted, the cannulae are connected to an extracorporeal circuit, that contains a mechanical blood pump which sends deoxygenated blood to a gas exchange device and then the oxygenated blood travels to the arterial vessel.[2] Cannulae that are chosen should be able to support 3.5-5L/min of flow in adults and 120-150mL/kg/min in smaller children.[3] There is also an option of placing an additional drainage cannula if flow is insufficient due to inadequate cannula size.[3] Thus, ECPR or extracorporeal membrane oxygenation (ECMO) can be used as a rescue therapy for supporting the patient when suspected etiology of their arrest may be reversible with interventions such as coronary angiography or percutaneous coronary interventions can be performed.[2] While ECPR holds a great capability to save lives, it is important to ultilize ECMO on the right patient and in the right setting to be able to see positive outcomes.

There are still many areas of uncertainty that exist within implementation of ECPR in patient care.[6] When a patient goes into cardiac arrest, whether it be outside of hospital cardiac arrest (OHCA) or inside hospital cardiac arrest (IHCA), and CCPR is initiated, there is one goal, to get a return of spontaneous circulation while minimizing low-flow states and maintaining the integrity of main organ function, especially the brain. Before the decision for ECPR can be initiated, there has to be realistic criteria that needs to be considered, such as the proximity to a hospital that has an ECPR program if an OHCA has occurred, if the cause of the CA is reversible,

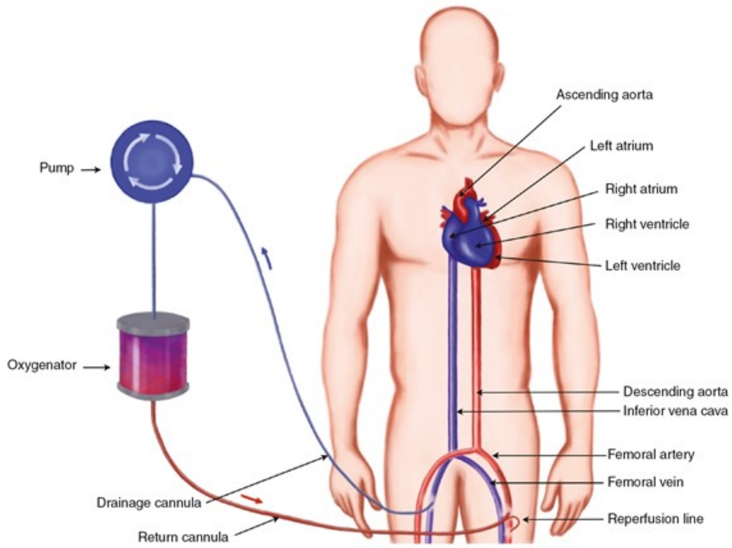

Figure 1[1]

if the patient had a functional status prior to the arrest, and if the patient's brain had undergone any sustained period of irreversible hypoxia.[2] However, although there is no universal ECPR criteria, it is important that hospitals with ECPR programs have predefined guidelines for who or whom not to place on extracorporeal life support (ECLS), especially with high risk patient populations. Being consistent with these guidelines will help give the patient the best opportunity for a full recovery. In the setting of CA, it is often difficult to make a split-second decision and prolonged discussions may waste valuable time.[4] Research shows that a good functional recovery is more likely if the time from collapse to the start of ECMO flow is less than 60 minutes.[2] Futhermore, patients who undergo prolonged CCPR are more likely to experience widespread organ damage, including but not limited to, brain injury, myocardial dysfunction, and/or systemic inflammatory response.[2] Similarly, much like the lack of universal crtieria for utilization, there are no universal criteria for the contrainidcations for ECLS, aside from the absolute "Do Not Resuscitate" orders. Various contraindications across different programs include severe neurological impairment prior to cardiac arrest, irreversible disease process that is known prior to cardiac arrest, severely immunocompromised patients, severely coagulopathic patients, prolonged arrest "low-flow" time, and lack of access for cannulation due to poor anatomical anomalies.[3] Even though it may be difficult morally to say "no" to placing a patient on ECLS and allowing the patient to expire, it is acceptable especially when there will be no direct benefit to the patient, which prevents any further hardships to the family when death is imminent.[4]

Once ECMO has been established, the multi-disciplinary work on deciphering the cause of the CA begins, recent AHA guidelines state "that ECPR may be considered for selected patients when the suspected etiology of CA is potentially reversible during a limited period of mechanical cardiorespiratory support" and this limited period is when the intensive care team decides what, and if any, interventions may need to be taken to fix any abnormalities.[6] At this point, ECMO is now being used as a "bridge" to some sort of destination. This bridge can be to "recovery/stabilization", where the platform provides time for the appropriate diagnostic procedures and/or interventions to be performed. It could also be a "bridge to bridge", where the patient will next get some type of implantable device. Lastly, either ECMO or an alternative long-term device can be used as a "bridge to transplantation" awaiting a heart transplant or organ preservation/donation or "bridge to decision/destination", where the patient lives their life and let's the pathology of the disease run it's course.[4] The decision on the purpose that the platform is serving is made based on the health status of the patient as well as the wishes and desires of the patient and/or family.

The application of ECLS is gaining popularity across the world as new technological advances are appearing year after year in both adult and pediatric ECLS. The specialization of a perfusionist's role in ECLS makes it an exciting and powerful time to be a perfusionist.[5] Surgeons and perfusionists can collaborate with which cannulas should be used and obtain the appropriate supplies for the application of ECLS. With established programs, once the patient is in the ICU, adequately trained nurses have the abilities to monitor the ECMO circuit and patient, however a perfusionist is required to be in-house at all times as a resource for care of the patient and for troubleshooting equipment and clinical difficulties, especially pertaining to the evolving cardiac function of the patient. Perfusionists can help collaborate with the intensive care team as they monitor the hemodynamic state of the heart. Special attention should also be paid to the status of the left heart which can develop myocardial dysfunction and lead to severe complications such as irreversible cardiac function and/or pulmonary edema.[3] Left ventricular distention can arise from many variables, and as the specialist, the perfusionist should pay close attention to exclude any mechanical issues with the ECMO circuit and be sure the pump is functioning at an optimal set flow rate for the specific patient. Other aspects that the perfusionist can address with the ICU team are cannula position, volume status (overloaded versus underfilled), and pharmacological interventions (inotropes for improved contractility or vasodilators to decrease afterload). Lastly, if medical management does not resolve the problem of distention and the patient is still hemodynamically compromised, the perfusionist can recommend intervening with a left ventricular vent option to decompress the left ventricle while optimizing cardiac output and perfusion for the patient.[3] However, complications can arise from various organ systems that necessitate intervention, not just the heart. Neurologic status of patients must be determined as soon as safely possible post-arrest and needs to be closely monitored, as it could be a huge determinant in decision-making going forward. Near-infrared spectroscopy (NIRS) monitors are frequently used to monitor cerebral oxygenation and serve as an indicator of neurological activity and overall perfusion in the patient.[3] Patients on ECLS also commonly see acute kidney injuries that may or may not require temporary renal replacement therapy while the kidneys recover.[3] Perfusionists bring a wealth of knowledge in such a specialized field that they are constructed to become such an integral part of a new era in ECLS.[5]

It is evident that extracorporeal cardiopulmonary resuscitation holds many advantages in resuscitating a patient in refractory cardiac arrest who is not responding to conventional cardiopulmonary resuscitation. The field of ECPR is still relatively new to perfusion practice. However despite its novelty, it is being used more frequently to help augment cardiac output, improve oxygenation, and restore perfusion to vital organs due to cardiac arrest. Perfusionists have such a specialized skill set and wide array of knowledge in the field of cardiopulmonary diseases and mechanical support, that their position is invaluable and irreplaceable in the world of ECPR.

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