Extracorporeal Cardiopulmonary Resuscitation in Cardiac Arrest

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KEYWORDS

- Extracorporeal cardiopulmonary resuscitation (ECPR)
- Veno-arterial extracorporeal cardiopulmonary oxygenation (VA-ECMO)
- Out-of-hospital cardiac arrest (OHCA) • In-hospital cardiac arrest (IHCA)

KEY POINTS

- Regardless of mechanics, stakeholders, or cannulation logistics, extracorporeal cardiopulmonary resuscitation (ECPR) is resource-intensive and requires careful patient selection, ongoing quality improvement, and team training.
- Flexibility to refine criteria as evidence evolves is essential to ensure extracorporeal membrane oxygenation care reflects contemporary best practices.
- Infrastructure for ECPR includes prehospital, in-hospital, and postdischarge care.
- For program development, ongoing multidisciplinary collaboration and adherence to evolving guidelines is essential.
- There is an unmet need for ongoing research to refine patient selection and optimize protocols to maintain equity and cost-effectiveness.

INTRODUCTION

Cardiac arrest is a leading cause of morbidity and mortality worldwide, with particularly dismal survival rates in cases of out-of-hospital cardiac arrest (OHCA). Despite advancements in cardiopulmonary resuscitation (CPR) and postarrest care, outcomes remain poor for patients who do not achieve return of spontaneous circulation (ROSC) with conventional measures. In this context, extracorporeal cardiopulmonary resuscitation (ECPR)—the deployment of veno-arterial extracorporeal membrane oxygenation (VA-ECMO) during ongoing resuscitation—has emerged as a promising therapeutic strategy for select patients with refractory cardiac arrest. By providing circulatory and oxygenation support while addressing the underlying cause of arrest, ECPR offers the potential for neurologically intact survival in a population historically associated with near-zero survival.

This article reviews the clinical significance, indications, operational requirements, challenges, and future directions of ECPR for both OHCA and in-hospital cardiac arrest (IHCA), integrating the latest recommendations and data.

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Abbreviations	
AHA	American Heart Association
CI	confidence interval
CPCs	Cerebral Performance Categories
CPR	cardiopulmonary resuscitation
CS	cardiogenic shock
CT	computed tomography
ECPR	extracorporeal cardiopulmonary resuscitation
ER	emergency room
IABPs	intra-aortic balloon pumps
IHCA	in-hospital cardiac arrest
MCS	mechanical support
OHCA	out-of-hospital cardiac arrest
PaO_2	oxygen partial pressure
PEA	pulseless electrical activity
ROSC	return of spontaneous circulation
SCAI	Society for Cardiovascular Angiography and Intervention
SDRC	San Diego Resuscitation Consortium
TEE	transesophageal echocardiography
tMCS	temporary mechanical support
TTE	transthoracic echocardiography
TTM	targeted temperature management
VA-ECMO	veno-arterial extracorporeal membrane oxygenation

PATIENT SELECTION AND INDICATIONS

ECPR should not be routinely used but may be considered in select patients when high-quality CPR has been delivered and the patient is either within or in close proximity to an ECMO capable center. Studies have shown that patients with shockable rhythm have the most favorable outcomes.[1,2] Alenazi and colleagues[3] performed a systemic review analyzing patient eligibility criteria and found marked heterogeneity in acceptable parameters used across systems for ECPR eligibility, underscoring the need for further research to improve identification of optimal criteria.[2] Among the most variable parameters included age cutoffs, which varied from 50 to 80 years, with the most common cutoff being 75 years of age and most systems limiting ECPR to shockable rhythms.

Patient selection for ECPR requires nuanced consideration beyond standard inclusion criteria. Functional baseline and comorbid burden play a pivotal role. The availability of ECMO resources and the readiness of the multidisciplinary team are equally important, as time-to-cannulation is highly dependent on institutional infrastructure and geography. In some settings, mobile ECMO teams have been developed to mitigate these delays. Ethical and psychosocial factors must also be weighed carefully, with early involvement of family members and palliative care teams essential for aligning care with patient values, particularly in borderline cases.

The most widely accepted indications for ECPR are grounded in the principles of early intervention, reversible pathology, and preserved end-organ viability. Sample inclusion criteria are summarized in Box 1. While not an exhaustive list, this summarizes some key inclusion criteria cited in the literature; however, there is wide variability in practice as to what constitutes an appropriate ECPR candidate.

While some institutions employ looser inclusion criteria for ECPR with the goal of increasing center volume and experience and increasing the absolute number of survivors, the drawbacks to this approach are that it can severely strain the resources of a system, inevitably leads to lower survivorship rates, and can decrease the morale of medical staff when they are not regularly affirmed by clinical success given the arduous nature of ECPR.[4] Therefore, each institution must go through regular evaluation and refinement of inclusion criteria to identify the "Goldilocks" between resource allocation and ECPR survivorship to meet the center-specific definition of what constitutes a successful program.

TIMING OF TRANSPORT AND INITIATION OF EXTRACORPOREAL CARDIOPULMONARY RESUSCITATION

Outcomes in ECPR are strongly time-dependent.[5–7] The recommendations supporting early ECPR are currently largely supported by expert consensus, observational data, and protocols followed by high-volume centers demonstrating time to ECMO clearly correlates with neurologic outcome.[8–10] The general framework is that there should be a short no-flow time until initiation of CPR less than 5 minutes.[3] ECPR should

Box 1
Sample criteria for extracorporeal cardiopulmonary resuscitation candidacy proposed in the literature

Age less than 65 to 70 years: While not an absolute cutoff, younger patients tend to have better physiologic reserve and recovery potential. Some programs consider physiologic age or functional status when weighing borderline cases.[3,18,40]

Witnessed arrest: Strongly predictive of improved outcomes, particularly when paired with rapid initiation of CPR.[3,18]

Short no-flow interval: Arrest-to-CPR time less than 5 minutes is a critical threshold. Prolonged no-flow time increases the risk of irreversible hypoxic-ischemic brain injury.[3,18,40]

Initial shockable rhythm ventricular fibrillation/pulseless ventricular tachycardia (VF/pVT): These rhythms are associated with higher ROSC and survival rates. PEA is considered intermediate; asystole portends the worst prognosis.[2,3,40]

Arrest-to-ECMO (low-flow) time less than 60 minutes: Delays in cannulation reduce survival likelihood. Ideal candidates are those with ongoing high-quality CPR and cannulation within this time window.[1–3,8]

Signs of life during CPR: Movement, pupillary response, or agonal respirations suggest residual cerebral perfusion and correlate with better neurologic outcomes.[1,3]

Intermittent ROSC or transition from asystole/PEA to VT/VF: Indicates potentially salvageable myocardial substrate.[1,2,40]

Reversible or treatable underlying pathology: Examples include acute myocardial infarction, pulmonary embolism, hypothermia, or drug overdose.[2,3,20,21]

$ETCO_2$ greater than 10 mm Hg during CPR: A surrogate for cardiac output during compressions; levels less than 10 mm Hg is associated with poor outcomes.[2,3,40]

be considered after 10 to 15 minutes of failed conventional CPR so long as the patient remains in refractory cardiac arrest despite high-quality advanced cardiac life support (ACLS) and the patient meets ECPR inclusion criteria (ie, age, comorbidities, shockable rhythm or reversible cause, and so forth).[8–11] A maximum arrest duration after which ECPR becomes futile has not been well delineated, and therefore, the current Extracorporeal Life Support Organization recommendation is to establish adequate ECMO flow within 60 minutes of onset of cardiac arrest.[8] In a retrospective study comparing an ECPR resuscitation protocol versus standard CPR protocol, ECPR was associated with significantly higher neurologically improved survival at all CPR durations less than 60 minutes despite severe progressive metabolic derangement; however, longer CPR duration was associated with a decline in survival in both groups.[1]

Three main randomized controlled trials can be leveraged to glean acceptable duration of low-flow and outcomes in ECPR. The ARREST trial was a single-center, open-label trial in which patients with OHCA were randomized to early ECMO-facilitated resuscitation or standard ACLS treatment on hospital arrival.[12] The trial was terminated early due to superior survival to hospital discharge in the ECPR strategy (risk difference 36.2%; 95% confidence interval [CI]: 3.7% to 59.2%).[12] Importantly, the median time to ECMO flow was 59 minutes.[12] In contrast the Prague OHCA trial, resulted in a significantly higher rate of neurologically favorable survival at 30 days (30.6% vs 18.2%, $P = .02$), though the difference at 180 days did not reach statistical significance, likely because the trial was underpowered but was ultimately terminated early due to futility.[12] In this study, patients were evaluated for ECPR candidacy after 5 minutes of failed resuscitation with median time to ECMO flow of 61 minutes (interquartile range [IQR] 55–70) in the early invasive group.[13] The INCEPTION trial was also a negative randomized control trial; however, it had a median low-flow time of 74 minutes (IQR 63–87), which was longer than what was seen in the ARREST and Prague OHCA trials. There are likely many factors leading to heterogeneous outcomes seen in these studies and the effect size may depend on system experience, patient selection, prehospital times, low-flow times, and cannulator experience making comparisons difficult.

The relationship between time-to-ROSC is also an important metric and was evaluated in a prospective registry of patients with OHCA.[14] The study showed that the yield of survivors per minute of resuscitation increased from initiation and started to decline in the eighth minute.[3] Importantly, 50% and 90% of survivors achieved ROSC by 8 and 24 minutes, respectively, at which times the probability for survival for those with initial shockable rhythms was 31% and 10%, respectively, and for nonshockable rhythms was 5.2% and 1.6%, respectively.[14] Therefore, it has been proposed that transport to an ECPR-capable center should be considered at 16 minutes (ie, between 8 and 24 minutes) of on-scene resuscitation to allow for adequate time for achieving ROSC in the prehospital setting while balancing the risks and benefits of earlier and later transport.[14] In a Dutch trial, the highest survival rate was seen in patients transported within 20 minutes with survival significantly declining as time on scene increased.[15] It is for this reason that county-wide initiatives with a prehospital ECPR program such as the San Diego Resuscitation Consortium (SDRC) endorse benchmarks such as "get off scene in 15" to prioritize rapid transport.[16] The timing of ECPR initiation, as outlined in Fig. 1, highlights key considerations in patient selection and workflow optimization.[12–14,16]

SYSTEMS OF CARE REQUIRED TO IMPLEMENT AN EXTRACORPOREAL CARDIOPULMONARY RESUSCITATION AT THE LOCAL AND REGIONAL LEVEL

Successful implementation of an ECPR program requires close coordination among a multidisciplinary team as well as the implementation of robust systems of care supporting this intervention. This typically involves coordinating cardiogenic shock care across regional networks in a "hub and spoke" model, which helps to facilitate patient transfer from community health care facilities ("spokes") to higher level of care at tertiary or quaternary centers ("hubs") with multidisciplinary teams.[17]

County-wide initiatives, such as the SDRC, have demonstrated the feasibility of regionalizing ECPR by integrating prehospital EMS teams with ECPR-capable institutions to rapidly identify candidates, expedite transport, and achieve timely cannulation for out-of-hospital or emergency department cardiac arrests. In this system, EMS activation of an "ECPR Alert" allows bypass of non-ECPR facilities and direct transfer to designated centers, where eligibility is assessed using predefined criteria. Reported median time from EMS dispatch to initiation of ECMO flow was 61 minutes, with a neurologic survival rate of 32% among ECPR patients compared with 0% in excluded patients. Notably, continuation of the program after its initiation did not require additional funding, underscoring the sustainability of this regionalized approach.[18]

In both IHCA and OHCA, a successful ECPR program is defined by 24/7 availability and strong multidisciplinary support as well as an on-site coronary angiography laboratory.[7,19] While the stakeholders at each institution will vary the multidisciplinary model typically includes emergency medicine, procedural, perfusion, and intensive care teams working together and alongside trained bedside nurses, respiratory therapists and ECMO coordinators to ensure timely and effective delivery of care. Regular simulation training, protocol development, and quality review processes are essential to maintain team readiness and optimize outcomes.[20,21]

Additionally, institutional experience influences outcomes, with high-volume ECMO centers demonstrating better proficiency and lower complication rates.[22,23]

Out-of-hospital Cardiac Arrest

In OHCA, the process typically begins with the identification of a potential ECPR candidate by a 911 dispatcher or EMS provider. Once recognized, a prehospital notification system alerts the hospital team to prepare for possible ECMO cannulation. In most institutions, this activates a paging system that mobilizes the full ECPR response team.

For OHCA arriving to the emergency room (ER), several key elements are critical to support tightly orchestrated choreography for ECPR. (1)

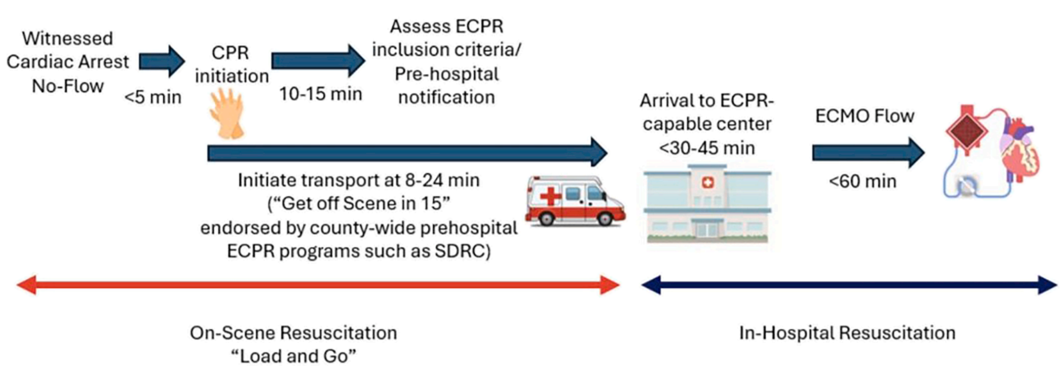

Fig. 1. General framework for out-of-hospital arrest time benchmarks for ECPR. Times as suggested by cited literature. SDRC, San Diego Resuscitation Consortium.

ER ECMO activation requires expedited transfer and prearrival notification and communication. (2) Protocols must be in place to include clear inclusion and exclusion criteria, rapid triage, and streamlined handoffs between prehospital and in-hospital teams. (2) Upon arrival, mechanical CPR is continued while preparation is underway for femoral cannulation.[13,21,24] (3) At least 2 emergency nurses to prepare the ECPR equipment and instruments, routine patient care and monitoring.[25] (4) Delegation of tasks, for example, by having a dedicated nurse to run ACLS, a nurse to keep track of time and to chart review comorbidities and relevant patient history and communicate this back to the team while the physician leads perform procedural aspects related to resuscitation.[13]

Ultimately outcomes, including neurologic recovery and overall survival, are largely driven by center experience and established protocols in high-performing systems, as supported by the American Heart Association (AHA) and recent randomized trials.[13,21,] Higher case volumes are linked to improved survival through multidisciplinary expertise, faster cannulation, optimized patient selection, and fewer complications, while less-experienced teams face delays and suboptimal outcomes.[22,23] Neurologic recovery is best assessed using Cerebral Performance Categories (CPCs), with CPC 1 or 2 considered optimal, noting that many CPC 2 patients improve to CPC 1 over time. Mature ECPR programs consistently achieve markedly better outcomes than conventional CPR.[26]

Proceduralists within the ER can vary from one institution to the next and can include trained emergency physicians, interventional cardiologists, or cardiothoracic surgeons. Alternatively, some institutions prefer to rapidly transport out-of-hospital arrest patients directly to the catheterization laboratory for cannulation. Ultimately practices vary, and there are no robust data to support one practice over another and are largely determined by institutional culture and comfort.

An emergency medicine physician cannulation approach may aid in rapid deployment and successful end-organ perfusion but will require additional team members to provide postcannulation procedural care including the placement of a limb antegrade reperfusion catheter and left ventricle (LV) venting device if needed, typically by interventional cardiology or cardiothoracic surgery. Having clear delegation of tasks and consistent algorithm is ultimately crucial for the success of any program. In an emergency physician cannulation model, institutions that are typically successful employ a system of 24 hour emergency duty. San Diego County is unique in using emergency physicians as ECPR initiators and cannulators.[18] The success of this model has entailed staffing at least 2 emergency physicians trained in ECMO cannulation on duty at any given time performing the cannulation procedure and delegating to 1 physician verifying eligibility.[26] The physicians are responsible for overseeing high-quality resuscitation measures, communicating with family, and the final handoff to the catheterization laboratory or intensive care unit.[25] In this model, the time from cardiac arrest to initiation of ECMO was 61 minutes (IQR 50–69 minutes) and neurologically intact survivorship was 32% as compared to historical data showing 8% chance of neurologically intact survivorship after 20 minutes of CPR.[27]

Beyond the hospital-based model, several innovative programs have emerged to expand access to ECPR for OHCA. The Minnesota Mobile Extracorporeal Cardiopulmonary Resuscitation program represents a notable example of delivering on-site ECMO cannulation at the location of cardiac arrest.[28] In Europe, certain centers have adopted models in which ECMO cannulation specialists deploy directly to referring hospitals to perform cannulation prior to patient transfer, thereby minimizing the risks associated with transporting unstable patients.[29] Additionally, private cardiovascular travel teams have been developed to provide specialized ECMO cannulation support across different care settings.

In-hospital Cardiac Arrest

IHCA has a lower mortality than OHCA.[30] In the context of IHCA, the concept of a “shock team”—a dedicated, highly trained and rapidly deployable group—has emerged as a best practice for coordinating complex interventions, ensuring rapid decision-making and escalation of care, and minimizing delays to temporary mechanical support (tMCS) deployment.[31] This team-based model of care for cardiogenic shock (CS) is now endorsed by the AHA and has been successfully implemented at many high-volume centers as it helps to bring together important stakeholders into a formalized way, streamlining the delivery of care and minimizing heterogeneity.[31–35] A model in which all relevant providers are notified about a patient through a one-call system for activation helps to expedite decision-making given the time-sensitive nature of CS care rather than individual dyssynchronous consultation.[31] Additionally, patients presenting with cardiac arrest may require bridging from tMCS to heart transplant or durable mechanical support (MCS) devices, underscoring the importance of multidisciplinary team involvement.[31]

In the Critical Care Cardiology Trials Network, a multicenter network of cardiac intensive care units in North America, centers with shock teams used more pulmonary artery catheters, use more advanced types of tMCS targeted to the hemodynamics of the patient rather than intra-aortic balloon pumps (IABPs).[36] Furthermore, centers with shock teams had lower risk-adjusted mortality (23% vs 29%; adjusted OR 0.72; 95% CI: 0.55–0.94; $P = .016$), suggesting a standardized multidisciplinary shock team approach can improve outcomes in CS.[36]

The IHCA patient population requiring ECPR is classified as the highest severity of CS according to the Society for Cardiovascular Angiography and Intervention (SCAI) staging system (ie, SCAI stage E) and tends to have the highest consumption of intensive care unit-based therapies including dialysis, blood transfusion, ventilation management, and so forth.[31–37] Therefore, multidisciplinary expertise is essential in mitigating the strain and resource utilization on the system by having clearly aligned strategies and protocols in place.

DEVICES AND EQUIPMENT AIDING IN THE DELIVERY OF EXTRACORPOREAL CARDIOPULMONARY RESUSCITATION

Mechanical CPR devices, such as the Lund University Cardiopulmonary Assist System, are often used during cardiac arrest to deliver consistent chest compressions and usually frees up geographic space around the patient and improves human allocation of resources by freeing up personnel to other tasks needed for ECPR. Additionally, mechanical CPR has been shown to be safe and noninferior to human chest compressions.[38] In the LUCAS in cardiac arrest (LINC) trial, among adults with out-of-hospital arrest, there was no significant difference in 4 hour survival between patients treated with mechanical CPR as opposed to those treated with manual CPR.[39]

Transesophageal echocardiography (TEE) can also be a valuable adjunct during resuscitative efforts by providing real-time imaging in a patient population, which routinely has a protected airway with an endotracheal tube to assess cardiac activity, guide chest compression quality and aortic valve opening, and identify reversible causes of arrest such as pericardial tamponade, aortic dissection, or massive pulmonary embolism.[40] Importantly, this can help to minimize compression interference as in the case of transthoracic echocardiography (TTE), resulting in shorter pulse checks. TEE can also provide important prognostic information, such as detecting left ventricular outflow tract obstruction during chest compressions, identifying ventricular fibrillation, or demonstrating myocardial standstill with greater fidelity than TTE, which is often technically challenging in this patient population. Furthermore, in the context of ECPR preparation, TEE may reveal critical contraindications to veno-arterial ECMO support, such as aortic dissection. Importantly, during pulseless electrical activity (PEA) arrest, TEE can help differentiate true PEA from fine ventricular fibrillation, thereby directly influencing resuscitation strategy. It has been proposed that the use of focused point-of-care TEE with a 5 view protocol (midesophageal 4 chamber, midesophageal long axis, transgastric short axis, bicaval, and descending thoracic aorta long axis) has the potential to guide and improve outcomes in resuscitation.[40] TEE is additionally useful for procedural guidance in confirming ECMO cannula placement.[40–42] Multiple groups have reported on the use of workshops and simulation sessions as well as in vivo training to be effective learning tools for expanding the use of focused TEE beyond cardiology into critical care, emergency, anesthesiology and other specialties that may have a stake in the role of caring for the arresting patient.[40,43,44]

POSTCANNULATION MANAGEMENT

The sequence of postcannulation management varies between institutions. Following initiation of ECPR, some centers prioritize immediate transport to the cardiac catheterization laboratory for coronary angiography and possible intervention, while others obtain a head and/or full-body computed tomography (CT) scan to identify additional injuries or etiologies precipitating the arrest.[21] Each approach carries distinct advantages and limitations that must be weighed carefully. In the catheterization laboratory, patients are evaluated for coronary artery disease and additional interventions, when necessary, such as pericardiocentesis, addressing limb perfusion issues, placement of additional lines and pulmonary artery catheter (Swan-Ganz), implantation of left ventricular venting device, and so forth. The approach of transporting to the catheterization laboratory first, however, may lead to additional interventions and utilization of resources in an otherwise futile scenario such as catastrophic neurologic injury that could have been discovered at the outset with a CT scan-first approach. However, obtaining a CT scan initially may add additional logistical complexities with regards to transport and may have limited prognostic role in the early postarrest phase. Importantly, neuroprognostication should be avoided in the absence of a catastrophic complication or injury until at least 72 hours after initiation of ECMO flow or rewarming if a targeted temperature management (TTM) strategy is used.[45]

Postcannulation care by experienced ECMO teams is as critical as the initial resuscitation and cannulation steps for the overall success of the ECPR patient.[21] Basic "ECMO hygiene" in the immediate (0–6 hours), early (6–12 hours), and late (>12 hours) postcannulation period includes the following elements summarized in **Box 2**.[45] Importantly, a right upper extremity arterial line should be placed as soon as possible to facilitate frequent arterial blood gases to assess cerebral oxygenation and carbon dioxide management. Care should be taken to avoid rapid correction of hypercapnia with the ECMO circuit sweep gas flow, as aggressive and rapid shifts in arterial CO_2 ($PaCO_2$; >20 mm Hg in the first 24 hours) can lead to neurologic injury.[46] Avoidance of hyperoxia is also critical by targeting right radial oxygen saturation 94% to 98% and oxygen partial pressure (PaO_2) 60 to 150 mm Hg, with avoidance of PaO_2 greater than 150 mm Hg due to the association of adverse outcomes, with the highest incremental risk seen when PaO_2 greater than 300 mm Hg.[47–49] A left ventricular venting or unloading strategy such as a microaxial tMCS device or IABP should be considered in appropriate cases to mitigate the increased afterload effects of VA ECMO.[50–52]

While universally accepted standard protocols are lacking, additional postcannulation elements include a TTM strategy according to institutional protocols, performing an initial neurologic examination and titrating sedation and analgesia accordingly, airway and ventilation management, and anticoagulation management. Early involvement of the palliative care team is widely recommended to support both patients and their families, promote comfort-focused care, and facilitate informed decision-making.[53] Social work consultation is also strongly encouraged, given the complex psychosocial challenges that frequently arise in the postcardiac arrest setting.[52]

Box 2
Basic "ECMO Hygiene" postcannulation checklist

Immediate (0–6 hours):

- Initiate and stabilize ECMO support with flows and pressors titrated to achieve mean arterial pressure (MAP) 65 to 80 to ensure adequate end-organ perfusion and minimize circuit/cardiac afterload
- Confirm cannula location and depth (drainage cannula at junction of inferior vena cava and right atrium and return cannula at the lower aorta) and confirm securement of cannulas and evaluate insertion sites for bleeding and dress using sterile precautions
- Confirm circuit integrity by obtaining premembrane and postmembrane blood gas to ensure differential gas exchange with a target postmembrane PaO_2 of 150 mm Hg
- Initiate TTM particularly for OHCA
- Place right upper extremity arterial line and titrate sweep/fraction of inspired oxygen (FiO_2) and/or ventilator FiO_2 to target PaO_2 60 to 150 mm Hg and avoid large, abrupt decreases in partial pressure of arterial carbon dioxide ($PaCO_2$) (>20 mm Hg in 24 hours)
- Initiate anticoagulation per protocol
- Optimize sedation and analgesia
- Obtain baseline echocardiogram evaluating for aortic valve opening
- Place pulmonary artery catheter for invasive hemodynamic monitoring and to guide eventual weaning
- Place distal antegrade arterial reperfusion catheter to ensure optimal perfusion to the lower extremity
- Assess the need for a left ventricular venting strategy such as a microaxial tMCS device or IABP to mitigate the increase afterload of VA ECMO
- Baseline and serial organ function assessment with lactate levels

Early (6–12 hours)

- Ongoing hemodynamic and oxygenation optimization
- Maintain lung-protective ventilation
- Continue to optimize sedation and analgesia
- Continue to evaluate organ function and serial lactate and monitor for complications (bleeding, thrombosis, hemolysis, infection, and so forth)
- Frequent assessment of limb perfusion using clinical assessment, Doppler ultrasound,

near-infrared spectroscopy to monitor regional tissue oxygen saturation, and laboratory assessment

Late (12+ hours):

- Engage additional stakeholders including social work and palliative care
- Daily goals of care checklists formulated on rounds and with broad multidisciplinary input and involve family early keeping in mind long-term goals (ie, bridge to recovery vs bridge to advanced therapies vs palliative care)
- Consider initiation of enteral nutrition and evaluate need for insulin for target glucose 140 to 180 mg/dL, as well as stress ulcer prophylaxis
- Use best-practice care bundles to prevent common hospital-acquired infections
- Closely monitor all lines and catheters and promptly remove if unnecessary
- Ongoing assessment of ability to wean from ECMO utilizing hemodynamics and echocardiographic data including the assessment for alternate modes of tMCS (eg, axillary device support) if needed
- Begin rewarming if TTM strategy was used after 24 to 48 hours from initiation
- Daily spontaneous breathing and awakening trials as early as possible and after rewarming if TTM strategy was used
- Begin formal neuroprognostication 72 hours after initiation of ECMO or after rewarming has been achieved if TTM strategy was used

DETERMINANTS OF SUCCESSFUL NEUROLOGIC OUTCOMES

Younger age, shockable rhythm, witnessed arrest, bystander CPR, ROSC, and shorter time to cannulation have been associated with favorable neurologic outcomes in ECPR.[20,54] The potential complications of cardiac arrest that specifically impact neurologic recovery include hypoxic-ischemic brain injury, ischemic stroke, intracerebral hemorrhage, seizures, and brain death. Hypoxic-ischemic brain injury is the most common, occurring in approximately one-quarter of patients, and is a direct consequence of prolonged low-flow or no-flow states prior to and during cannulation.[26] Ischemic stroke and intracerebral hemorrhage are less frequent but are significant contributors to poor neurologic outcomes, often related to vascular injury, embolic events, or anticoagulation required for ECMO support. Seizures and brain death are also observed and are associated with severe global cerebral injury and poor prognosis.[55]

Early and successful cannulation may mitigate some of these risks by restoring cerebral perfusion, but the procedure itself carries risks of vascular injury, bleeding, and embolic events, all of which can worsen neurologic recovery.[22,55,56] Meta-analyses confirm that while ECPR can improve the odds of favorable neurologic outcome in select patients, the overall rate of acute brain injury remains high, and complications related to the cannulation process and subsequent ECMO support are important determinants of neurologic prognosis.[55,57–59]

Emerging physiologic markers such as end-tidal CO_2 and serum lactate levels during CPR are also being explored as prognostic markers in the ECPR patient.[55,60] As mentioned earlier, postcannulation management such as avoiding overaggressive correction of hypercapnia and avoidance of hyperoxia also play a critical role in neurologically successful outcomes.

POSTDISCHARGE CARE

Patient trajectories after ECPR typically fall into 3 broad categories. The first group includes patients who experience clinical deterioration and ultimately succumb despite maximal supportive efforts. The second group comprises those who progress to advanced therapies, such as heart transplantation or durable MCS including left ventricular assist device. The third group demonstrates meaningful recovery. It is important to recognize the high prevalence of depression and postintensive care syndrome among survivors of cardiac arrest, underscoring the need for early mental health and support group involvement to address these challenges as well as the need for both physical and cognitive rehabilitation.[61–63] For patients who do not recover, the mindful discontinuation of therapy is paramount, and when approached with focus on dignity and comfort, can be deeply meaningful and gratifying for families.

CHALLENGES

One of the biggest challenges for ECPR is the creation of widespread implementation protocols and sustainability strategies for making this a commonplace and resource-effective treatment. Further research and randomized control trials are necessary to better define patient selection criteria and improve outcomes. However, research in this field is particularly challenging to conduct given the large variability in regional resources and expertise and differences in local practices making cross-institutional comparisons difficult.

With the increase in cross-collaboration across systems, concerns from smaller transferring institutions must also be addressed such as the fear of losing patients and the fear of being perceived as less proficient in shock care must be recognized to ensure durable collaboration and stakeholder retention.[31] In parallel, standardized reporting of outcomes including the CPC classification when assessing neurologic recovery, can help provide consistency and fidelity across programs.

SUMMARY

ECPR represents a transformative approach to managing refractory cardiac arrest, offering potential survival and recovery benefits in carefully selected patients. Multidisciplinary collaboration, adherence to evidence-based selection criteria, and thoughtful postcannulation management are essential components for success. Ongoing innovation in program models—including mobile ECMO teams and specialized cannulation strategies—continues to expand access and improve outcomes. However, significant challenges persist, including determining medical futility, addressing complex psychosocial needs, and securing institutional and community support. Future efforts must focus on refining patient selection, optimizing protocols, and fostering equitable access to ensure that ECPR fulfills its promise as a life-saving intervention.

In summary, patients treated by experienced, high-volume ECPR teams have superior neurologic and survival outcomes compared to those treated by less experienced teams. This underscores the importance of regionalizing ECPR to specialized centers with established protocols and multidisciplinary expertise.[22,23,64]

CLINICS CARE POINTS

- Patient selection is the cornerstone of any successful ECPR program; while general eligibility principles exist, each institution must regularly evaluate and refine its own criteria to balance resource utilization with survivorship in a way that reflects its specific infrastructure, expertise, and patient population.
- Multidisciplinary collaboration — spanning emergency medicine, interventional cardiology, critical care, perfusion, and nursing — is essential for timely ECPR delivery; having clearly defined roles, standardized protocols, and coordinated team activation minimizes critical delays in cannulation, with formalized structures such as shock teams representing one model for achieving this at high-volume centers.
- Successful ECPR programs require 24/7 multidisciplinary availability and robust institutional infrastructure; regionalization to high-volume centers with established protocols and multidisciplinary expertise is associated with superior neurologic and survival outcomes compared to lower-volume programs.

DISCLOSURE

The authors report no relevant conflicts of interest related to this topic.

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