Society for Heart Failure and Transplantation

SOCIETY FOR HEART FAILURE AND TRANSPLANTATION'S

THE REVIVAL

Promoting Academics to Improve Clinical Outcomes.

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EDITOR'S NOTE

Dr Manoj Durairaj

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Dear Readers of the Revival,

Greetings! It gives me great happiness to bring to you "The Revival" with a new look and format. The issue carries the message from our newly installed President, Dr Julius Punnen and Secretary, Dr S Rajan. They have taken over the reins of the SfHFT from March 2023. I thank Dr V Nandakumar and Dr Jabir Abdullakutty, the past President and Secretary for wholeheartedly supporting The Revival Team.

The Guest Author for this issue is Dr. Bikash Sahu. He has done a commendable job in detailing the process of ECMO Cardiopulmonary Resuscitation (ECPR). Conventional CPR provides only 25%-30% of cardiac output, whereas ECPR not only provides adequate tissue perfusion (preventing primary end organ injury), but also protects the organs from secondary reperfusion injury by providing the additional benefit of controlled hypothermia. The modality of ECPR is time sensitive (needs to be initiated within 10-15 min of CPR), capital intensive and needs a dedicated team of highly trained health care providers who can be available at short notice. Adoption of ECPR by hospitals and emergency care services in the field in India combined with a protocol driven approach to managing cardiac arrests can change the outcomes for countless patients.

I hope our dear Readers will enjoy reading this comprehensive article. Happy Reading!

Dr Manoj Durairaj
Editor "The Revival"

SUB EDITOR

Dr Talha Meeran

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Consultant Cardiologist,
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Dear Colleagues,

"The March issue of REVIVAL discusses in great detail the concept of ECPR. There has been great interest in this field over the last 2 years and tremendous gains have been made. Dr Bikash Sahu has provided an excellent review on this topic beginning with ECPR team planning, team composition, patient indications/contraindications and further salient points on practical management of such patients. Of particular note are the various risk prognosticator scores that can help in predicting which patients would benefit from timely ECPR intervention.

Sincerely,
Dr Talha Meeran
Sub Editor "The Revival"

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Special thanks to Dr Bikash Sahu for authoring this month's article.

Designed by Maithili Kulkarni

PRESIDENTIAL MESSAGE

Dr. Julius Punnen

Sr. Consultant Cardiothoracic Surgeon, Narayana Health, Bangalore

Dear Members,

It is an honour and a privilege to address you today as the newly appointed president of this prestigious organization. As we look ahead to the challenges and opportunities that lie ahead, there is one area in particular that I believe deserves our attention and focus: extracorporeal cardiopulmonary resuscitation, or eCPR.

As you know, cardiac arrest remains a major cause of morbidity and mortality in our society, despite advances in medical technology and care. In recent years, however, eCPR has emerged as a promising new approach to treating cardiac arrest, with the potential to dramatically improve outcomes for patients and reduce the burden on healthcare providers and systems.

The benefits of eCPR are clear: by rapidly initiating cardiopulmonary bypass, we can give the heart and lungs a chance to rest and recover, while oxygenated blood is circulated throughout the body. This can improve the chances of survival and recovery for patients with cardiac arrest, especially those who are younger and otherwise healthy, and bridge others with end-stage organ dysfunction to one or the other forms of advanced therapy such as mechanical circulatory support or transplantation.

However, implementing eCPR is not without its challenges. It requires a coordinated effort between prehospital providers, emergency department personnel, cardiac specialists, as well as specialized equipment and training. As members of the Society for Heart Failure and Transplantation, we have a unique opportunity to lead the way in advancing the field of eCPR, through research, education, and advocacy.

SfHFT is committed to promoting the widespread adoption of eCPR across our society, through education, and collaboration with other organizations and stakeholders. By working together, we can make eCPR a standard of care for patients with cardiac arrest, and improve the lives of countless individuals and families.

I look forward to working with all of you in the years ahead, as we continue to advance the field of heart failure and transplantation, and make a difference in the lives of those we serve.

Thank you for your attention, and let us work together to make eCPR a reality for all who need it.

Sincerely,

Dr Julius Punnen

SECRETARY'S NOTE

Dr. S. Rajan

Director - Cardiac Surgery Institute of Cardiovascular Diseases
The Madras Medical Mission.

Dear Members,

I am pleased to extend my greetings to all of you. It is a great privilege and a huge honour for me to take charge as the Secretary to serve our society and this also brings in great responsibilities.

I choose this space to express my sincere gratitude to all the doctors spread around India and abroad for working selflessly for the betterment of health services under the umbrella of SfHFT.

SfHFT has evolved into a very vibrant society and this evolution has also raised the expectations. We have seen that in the active participation in the last few years. This showcases the strength of our society.

Recently concluded SfHFT 2023 was a huge success with good number of registrations. The scientific program was very well laid out and it received appreciation from India and abroad alike. The quality of scientific work showcased in the conference showed our core strength in the transplant scenario.

It is of paramount importance for all of us in practice and training to coalesce – the prestige and influence of our speciality will be considerably enhanced and be a powerful stimulus in realization of our shared vision.

I invite you to contribute to our magazine – The Revival.

Finally, I thank all my predecessors, seniors, colleagues and young junior doctors for trusting and giving me an opportunity to work with you.

Please communicate with us and help build a lively and dynamic organization.

With warm personal regards,

Yours sincerely,

Dr S. Rajan

ABOUT THE AUTHOR

Dr Bikash Sahu

MBBS, MD, DNB, MNAMS, PDCC, FIACTA, DM (AIIMS), FIECMO, AMPH (ISB)

Director, Transplant Services, ECMO & Shock, HOD, Department of Anesthesia, Dean-Academics, Aster Ramesh Hospitals, Andhra Pradesh.

Qualifications:

- MBA in Healthcare (AMPH), Indian School of Business (ISB).
- Trained in ECMO at The Alfred, Melbourne, Australia.
- FIECMO (Fellowship in ECMO) by The Simulation Society.
- DM in Cardiothoracic and Vascular Anaesthesia- AIIMS, New Delhi.
- National Fellowship in Cardiac Anaesthesia (FIACTA).
- PDCC (Post-Doctoral Certificate Course) in Cardiothoracic and Vascular Anaesthesia from Sree Chitra Tirunal Institute of Medical Sciences and Technology (SCTIMST), Trivandrum.
- DNB, Anaesthesiology, National board of Examinations, New Delhi.
- MBBS & MD- Anaesthesiology, Goa Medical College, Goa University.

Areas of Interest/ specialization:

1. ECMO, Shock management
2. Heart Transplantation
3. Academic training

Achievements:

- 18 years of exclusive cardiac anesthesia and critical care experience.
- Managed more than 10,000 cases including Adult, Paediatric and Neonatal Elective and Emergency Cardiothoracic & Vascular Surgical Cases, Robotic Cardiac Surgery, 30 Heart Transplants, VADs and ECMO.
- Set up JCI accredited Multiorgan Transplant Programme at the Aster Ramesh group, the only one in Andhra Pradesh.
- Set up the ECMO and Shock program at Aster Ramesh group.
- Started the Fellowship in Cardiac Anesthesia at Aster Ramesh group.
- Accredited faculty and examiner in cardiac anesthesia
- Set up the Dept of Cardiac Anesthesia & Cardiac Surgical Intensive Care at Ruby Hall clinic, Pune.
- Set up Pune's first Heart Transplant ICU at Ruby Hall Clinic.
- Key member of the core team of five doctors responsible for the setting up of the Department of Cardiothoracic and Vascular Sciences at Goa Medical College, Goa.

Awards & Recognitions:

1. Conferred the Goa Scholar by the Government of Goa.
2. Gold Medal/ University topper at post-graduate examinations.
3. Conferred Degree of MNAMS by the National Board for Academic Achievements.

Introduction:

The survival rates following CCPR although improving both for IHCA and OHCA, are still low. This has led to ongoing efforts to improve outcome of cardiac arrest using various pharmacological and mechanical methods. If the patients continue to remain in cardiac arrest despite CCPR, the cause of death in these patients is multiorgan failure due to cardiogenic shock. If we can prevent multiorgan dysfunction from occurring, we will be able to save these patients. Many times the etiologies of arrest are reversible. If the patient continues to be in refractory arrest, one of the options available is ECPR- procedure that takes over the function of heart and lungs and provides temporary support to maintain organ perfusion and allows time to treat the precipitating cause. The initial positive reports of initiating ECLS in cardiac arrest patients along with recent advances in ECLS technology making the devices transportable, techniques of percutaneous cannulation and attempts to improve survival after refractory cardiac arrest have led to the development of ECPR as an intervention in refractory CA patients.

Definition:

ECPR is the initiation of VA-ECMO in patients with acute and sudden cessation of cardiac mechanical activity when CCPR interventions are unable to achieve a sustained ROSC (Refractory arrest) 1. Sustained ROSC is defined to have occurred when chest compressions are not required for 20 consecutive minutes following cardiac arrest 7. Refractory cardiac arrest definitions vary from 10-30 min and the optimum duration before ECPR should be considered remains unspecified. It is rational however, to define refractory CA as lasting beyond 10 min so as to achieve better survival and neurological outcomes by reducing the No flow time and the Low flow time. If arrests last for more than 15-30 min, outcomes are poorer despite all interventions.

ECPR is a time-sensitive, resource and capital-intensive intervention and needs a well-coordinated, protocol driven team of well-trained healthcare providers. It can be initiated in OHCA and IHCA and should be considered after 10-15 min of unsuccessful CCPR. This article discusses the salient features- clinical and administrative, involved in running an adult ECPR program.

Pathophysiology:

There are 2 mechanisms of brain injury during cardiac arrest 1. The primary injury occurs due to cessation of cerebral blood flow leading to cerebral hypoxia, anaerobic metabolism and cytotoxic edema culminating in cell death. The secondary injury is the reperfusion injury occurring after ROSC from reactive oxygen free radical generation. This is also called as "Post cardiac arrest syndrome". The severity of this syndrome depends on the severity of ischemic insult.

Optimal CPR and rapid ROSC (short duration of low flow time) reduces the severity of post cardiac arrest syndrome. CCPR can provide only 25-30 % of cardiac output. ECPR provides greater perfusion to all organs than CCPR and reduces the low-flow time. The heat exchanger in ECPR allows therapeutic hypothermia to be initiated which helps to limit the secondary injury. Thus ECPR reduces the risk of primary organ injury as well as secondary reperfusion injury. It also allows the heart time to recover, minimizes need for inotropes/ vasopressors and allows time to identify the reversible causes and treat them. ECPR by itself does not provide favorable outcomes but a protocolized approach is imperative.

There are 4 distinct phases when initiating ECPR during resuscitation 2.

- **Phase 1:** start of cardiac arrest to start of CCPR- No Flow time. This time should be limited, ideally less than 1 min for best chances of neurological and other organ function recovery (usually No flow time should be limited to < 5 min). Thus, Witnessed arrest or IHCA offers the best scenario for ECPR. This time may be difficult to assess in OHCA.
- **Phase 2:** start time of CPR to launching the ECPR system- Low flow time.
- **Phase 3:** time of launch of ECPR to achieving return of circulation with adequate flow and perfusion- Low flow time.
- **Phase 4:** time of return of circulation to on-going targeted post cardiac arrest care

Limiting the duration of each of these phases and the steps taken in these intervals play an important role in patient outcome. Hence, patient selection becomes the most important factor determining outcome in ECPR. The centres need to frame institute/ centre specific criteria for ECPR in cases of IHCA and OHCA based on their resource capabilities. Preemptive discussions about ECPR by identifying these high risk patients early aids in lowering the no flow time and low flow time and is pertinent for better outcomes. In OHCA, there has to be clarity in approach by centres to either cannulate on site or retrieve to cannulate in hospital (Scoop and Run approach).

Inclusion and Exclusion Criteria [3,4]:

The routine use of ECPR cannot be recommended in all cases of cardiac arrest due to lack of sufficient evidence. However, if the etiology of the arrest is reversible and ECPR can be initiated rapidly, it can definitely be considered. Some of the reversible causes of arrest may be Acute coronary syndrome, Acute pulmonary embolism, Refractory arrhythmias (VF/VT), Cardiac injury, Myocarditis, Cardiomyopathy, Drug induced myocardial depression or arrhythmias etc 2. ECPR plays different roles in all these scenarios. It may be act as a

- Bridge to recovery by providing time for diagnostic and therapeutic interventions.
- Bridge to organ transplantation
- Bridge to advanced device therapy
- Bridge to decision making

Inclusion Criteria:

- Age < 70 years
- Witnessed arrest
- Arrest to first CPR (No flow time) < 5 minutes
- Initial shockable rhythm
- Initial cardiac rhythm- VF/ pVT/ PEA
- Arrest to ECMO flow (Low flow time) < 60 min. The maximum arrest duration before ECPR has not been well defined but best survivals are seen if ECPR initiated within 60 mins of arrest (low flow time). This duration may be longer in hypothermic arrest patients.
- ETCO2 > 10 mm Hg during CCPR
- Intermittent ROSC or recurrent VF
- Signs of life during CCPR
- Absence of previously known life-limiting comorbidities, organ dysfunction, terminal malignancy
- No Aortic regurgitation

Exclusion Criteria:

- Age > 70 years
- ETCO2 < 10 mm Hg during CCPR
- Femoral cannulation impossible- severe PVD, iliac-femoral occlusion
- Known Aortic Regurgitation > mild
- Aortic dissection suspected
- Known severe irreversible brain damage
- Terminal malignancy
- Traumatic origin with uncontrollable bleeding
- Non cardiac origin- asphyxia, submersion, primary cerebral disorders
- Irreversible organ failure
- Severe sepsis
- Poor level of daily activity of living before cardiac arrest

Procedure [3,4,5]:

The goal of ECPR is to restore cardiac output rapidly through VA-ECMO. It should always be initiated in a familiar, well controlled environment under strict institution-specific, well documented protocols and clinical care pathways. It may be preferable to transport the patient with ongoing CPR to the cannulation location (Scoop and run approach) rather than transport the resources to the patient in OHCA. Early notification to these centres about potential ECPR cases is important and appropriate transport facility should be available to shift these patients from pre-hospital to in-hospital care. The decision making process and the preparedness process needs to be separated. Pre-primed circuits with crystalloids (avoid glucose and blood products for priming circuit) reduces time to initiation and these pre-primed circuits can be used up to 14-30 days.

Optimal timing for initiation is not well defined. However, shorter intervals have correlated to improved survival. The time needed for initiation is dependent on the resource capabilities of the team and the patient factors. It is reasonable to consider ECPR after 10-20 min of failed CCPR as the survival rates beyond 20 minutes is < 5 %.

High quality uninterrupted CPR should be ensured during the transport process. Automated compression devices aid in this by reducing staff fatigue but regular monitoring of these devices during CPR should be practiced to prevent migration on the abdomen leading to ineffectiveness and complications. A detailed handover from the ambulance team to ECPR team leader should include information about time of arrest, Witnessed or unwitnessed, Initial rhythm, duration of bystander CPR and patient's past history.

Ideally the ECPR team should be available 24/7. This may not always be possible in all institutions but at least there should be a protocol to assemble the team and equipment as early as possible. The approaches to cannulation in a given clinical scenario has to be pre-defined to optimize the speed of initiation and reduce complications. The cannulas of various sizes and the cannulation equipment has to be easily available. The size of the cannula depends upon the size of the vessel and the amount of flow needed (target flow of 3-4 l/min). Arterial 15-17 Fr and Venous 19-25 Fr multistage cannula provide adequate flows. Sometimes arterial vasospasm may be seen in cardiac arrest patients after multiple doses of adrenaline which may make cannulation difficult.

The optimal location for initiation of ECPR depends upon resource capabilities of institutions and their teams along with logistic issues. The cannulation and initiation can be done in ER, Cathlab, OT, ICU or pre-hospital setting and it needs to be done by the most skilled and immediately available trained personnel – surgeons, intensivists, cardiologists or ER physicians. In case of OHCA, the data is unclear if initiation of pre-hospital ECPR is better than transporting these patients to the centre. In the absence of evidence it is recommended that suitable patients for ECPR should be transported to the hospital.

The percutaneous cannulation via common femoral artery and femoral vein using modified Seldinger technique under ultrasound guidance is the commonest approach to improve success rates and decrease complications. Alternate sites like femoral-jugular, femoral- subclavian or jugular-subclavian also can be employed based on team's expertise and experience. In cases of pulmonary embolism as the cause of arrest, ultrasound becomes even more important to exclude cannulation of a thrombosed vein. The first cannula inserted needs to be flushed with heparinized saline to prevent clot formation. The time required for initiation is of utmost importance, hence if two operators are available contralateral cannulation is preferred as it is faster. Unilateral cannulation of both femoral vessels can also be done. Venous cannulation on right preferred as its easier to reach RA/ SVC junction. The venous and arterial guide wires needs to be imaged using ultrasound, ECHO or fluoroscopy before insertion of cannula. Surgical cutdown techniques can also be used for cannulation specially in failed percutaneous attempts, the major advantage being direct visualization of the vessels but it increases the risk of bleeding and infection. A central approach (sternotomy) for ECPR initiation may be preferred in OT scenarios. External cardiac massage should be continued throughout the cannulation phase using automated compression device. This provides more space around the patient while minimizing body movements during cannulation. Stop compressions during puncture but for not more than 60 seconds. The cannula position should be confirmed via fluoroscopy or ECHO before fixation.

Standard ACLS protocols should be continued throughout the duration of cannulation. The following parameters guide towards adequacy of CPR during ECPR. Quantitative waveform capnography and intra-arterial pressure are very useful e.g. if ETCO2 is less than 10 mmHg or if diastolic blood pressure is less than 20 mmHg then CPR quality has to be improved. The ACLS team leader should not be engaged in ECMO cannulation and should oversee the whole process of resuscitation. We need to be cautious during defibrillating these patients once guidewires are inserted. Due to the risk of electrocution of the cannulators, one needs to suspend defibrillation at this point till VA ECMO is established. Adrenaline and other drugs needs to be continued as per ACLS protocols. However, adrenaline bonuses should be discontinued just prior to connecting the cannula to the circuit due to the risk of hypertension on ECMO. The distal perfusion canula is not required initially but has to be placed within 4 hours to reduce the risk of limb ischemia. Priority should always be given to diagnostic and therapeutic interventions. The mechanical compressions should be stopped once VA-ECMO flow initiated. Standard VA ECMO initiation protocols are followed with gradual increases in support to target a blood flow of 3-4 l/ minute. Serial measurement of lactates to monitor organ function is used to guide further support.

Post ECPR management [2,7]:

The mechanical ventilation has to be adjusted with PEEP $\geq$10 cm H2O to improve oxygenation of native blood and to reduce pulmonary edema. The position of the endotracheal tube should be confirmed. The fiO2 on the ventilator should be kept to a minimum while the post membrane pO2 should be limited to 100-150 mm Hg to target saturations up to 92-97% to prevent reperfusion injury. The sweep gas rate to be adjusted to prevent hypocarbia. ETCO2 monitoring is used to adjust native ventilatory settings. The pump flow rate and the perfusion pressures will depend upon the age of the patient and the diagnosis. A right-sided arterial line to be inserted to measure the actual MAP perfusing the coronaries and brain. It will also assist in monitoring ABGs to analyze cerebral and myocardial oxygen delivery. Central Venous access to be inserted. The vasopressors need to be titrated to maintain MAP between 60-80 mmHg. Ensure pulsatility in the right arterial line. If pulse pressure < 10 mm Hg, then it indicates LV distension due to poor ejections. A 12-lead ECG and bedside ECHO to be done to monitor cardiac function and rule out LV distension. ABG and other lab investigations need to be performed to assess organ function, coagulation abnormalities, metabolic/ electrolyte disturbances. Xray chest to confirm the position of the cannula and rule out lung abnormalities. If sign of awakening are present, patients need to be sedated and paralysed. Heparin is used as anticoagulation to maintain ACT around 160-180 seconds. Steps to correct coagulopathy using appropriate blood component therapy and blood sugar control need to be initiated. Some of these patients may need Renal replacement therapy on ECPR. Standard VA-ECMO maintenance and monitoring protocols to be followed.

Once the ECMO is stabilized, the focus should be on early diagnostic and therapeutic interventions. Emergency CAG to be performed along with PCI if indicated. CT scan of brain, abdomen and pelvis, pulmonary angiography to be performed to identify the cause of cardiac arrest. Bedside USG may also be used to rule out pneumothorax, hemothorax, hemoperitoneum, major organ injury if CT cannot be performed. Body temperature monitoring to be started and maintain temperature 34-36 ^{0}C for first 48 hours. The distal perfusion cannula has to be placed within 4 hours.

Total circulation equals the native cardiac output plus ECMO blood flow. The myocardium will have electrical activity but not effective ejections, may take beyond 48 hrs to recover effective ejections. During this period one needs to watch out for LV distension using bedside echo and take remedial measures to vent the LV. Efforts to restore perfusing rhythm as early as possible by correcting acidosis, hypoxia, electrolyte imbalances and defibrillation to reduce LV distension, pulmonary edema and LV thrombus formation. If LV distension persists, LV venting is recommended using IABP, LV Vent, Impella or Atrial septostomy. Target MAP between 60- 80 mm to minimizes risk of LV distension.

Although, no consensus about weaning, it should be initiated only after the etiology is addressed and the native heart function returns. Generally, it takes about 3 to 4 days. Hence, prognostication to family to be done after 96 hours (>48 hrs after stopping sedation). Premature weaning may lead to hemodynamic collapse and death while unnecessary prolonged support also leads to significant infection, bleeding and associated morbidity and mortality. Standard VA-ECMO weaning protocols are utilized. Generally, VA-ECMO patients have no survival benefits after 4 weeks and one needs to consider other forms of support if there is no recovery within 2 weeks.

There are financial, legal and ethical dilemmas which complicate ECPR initiation 3. It may not always be possible to wean these patients off ECMO. Sometimes, the patient may recover neurologically but myocardial recovery may be insufficient. The options in this case are temporary LVAD followed by Destination LVAD or Transplantation. Hence, early discussion to a referral centre that provides these services is recommended. If these patients are not candidates for LVAD or transplantation, then we need to consider decannulation, palliation and end of life care. In this case, ECPR ends up as a bridge to nowhere. If the patient is brain dead, then organ donation may be considered based on national/ regional guidelines of brain death declaration and organ donation. Organs like kidney, liver and lungs have been successfully transplanted from brain dead patients following ECPR 3. However, one has to consider the ethical and legal issues involved in such organ donations before initiating it.

Although it is mandatory as per ELSO guidelines to counsel patients about ECMO along with a clear exit strategy and seek consent before initiation, it may not always be possible in ECPR scenario due to time constraints. Also, financial discussions with family members before initiation is difficult in ECPR scenarios. One way to deal with this scenario is to identify these potential patients early and preemptively counsel them about need for ECPR. Otherwise, centre specific guidelines for eligibility criteria and exit strategies should be well documented and immediate meeting with the next of kin after initiation of ECPR should take place to explain these guidelines in detail and obtain the necessary consent. The families should be counselled daily regarding possible outcomes along with current status.

Complications [1,3]:

	Points
Age	
≤20 y	2
Each additional 10 y	+2
Preexisting renal insufficiency	
Yes	+8
Time of day	
3 PM to 10:59 PM	+4
11 PM to 6:59 AM	+13
Illness category	
Medical cardiac	−2
Surgical cardiac	−11
Surgical noncardiac	−6
Presenting rhythm	
PEA	−1
pVT	−5
VF	−8
Palpable pulse initially	−5
Duration of cardiac arrest	
Each 10 min	+2

Table 1: RESCUE-IHCA Score

- Bleeding
  - Cannulation site commonest (8-70%) due to vessel injury
  - Retroperitoneal hematoma
  - Systemic organs- intracerebral, GI, pulmonary etc
- Leg ischemia (3-15%)- distal perfusion cannula within 4 hours to prevent.
- Compartment syndrome esp if unilateral cannulation
- Infection (8-22%)- cannula site or cannula related
- Stroke/ Intracerebral bleed (2-17 %)
- Unsuccessful cannulation (2-51%, higher in ECPR than ECMO)
- Aberrant placement of cannula

Outcomes:

There are no published RCTs comparing CCPR with ECPR outcomes but observational studies have shown survival range of 15-50% and survival to hospital discharge of 29%. ECPR is becoming popular as a rescue intervention in refractory cardiac arrest, both IHCA and OHCA with a 40% survival to discharge in IHCA and 20% survival to discharge in OHCA. The survivors generally fall into CPC 1-2 categories.

ECPR has been shown to provide better survival and neurological outcomes compared with CCPR. There are no RCTs to demonstrate effectiveness of ECPR in IHCA but observational studies have shown 20-40% survival. The variation in outcomes makes it important to select eligible patients carefully given the fact that the intervention is resource intensive. The SAVE score and RESP score can predict survival after ECMO but they are not valid for ECPR scenarios 6. The RESCUE-IHCA score is a simple, real-time bedside score 6. It comprises 6 pre and intra-arrest variables and no laboratory values. The sum of the points for all 6 variables gives the probability of mortality- the greater the points, the higher the probability of death. It can predict with 72 % accuracy, probability of death ranging from 22-99% in adult ECPR patients. The Okada score can also be used but it needs laboratory values (pH) and has not been externally validated 6.

There is no conclusive evidence for and against the use of ECPR in IHCA and OHCA. CHEER trial in 2015 showed a survival of 45% and 60% in OHCA and IHCA respectively following ECPR with reasonable neurological outcomes. It is extremely important to formulate separate guidelines and inclusion criteria for IHCA and OHCA for best utilization of existing resources to ensure best possible outcomes in these patients as the etiology and outcomes vary in both scenarios. It may be reasonable to start ECPR as a bridge to decision making. The factors predicting poor survival in ECPR include lower post ECMO arterial pH, higher lactate and end organ injury not normalizing within 24 hours.

This indicates ineffective CCPR and longer time taken to initiate ECPR. It is imperative therefore, to target ECPR initiation time to < 30 min for better outcomes.

SAVE-J trial studied the effectiveness of ECPR vs CCPR in OHCA with VT/VF as the initial rhythm and concluded that ECPR, therapeutic hypothermia and IABP improved neurological outcomes.

THAPCA trial showed no benefit of hypothermia or Targeted temperature management (TTM) 2. No RCT on TTM, however studies have shown favorable outcomes with 34^{0}C. TTM to 33 to 35 ^{0}C for 24 to 48 hrs is associated with better survival with good neuro-behavioral outcome at 1-year follow up but no clear evidence of TTM in ECPR, may increase the risk of infections.

Although, no clear prognostic markers identified for ECPR however, pupillary diameter upon hospital arrival, GWR (Gray to white matter ratio) on CT-brain within 1 hour after ECPR, BIS, cerebral NIRS, time to initiation of ECPR, higher arterial pH and lower lactates at admission can predict successful neurological outcomes after ECPR1.

ECPR program:

The first step involved in starting an ECPR program involves a serious introspection of the needs assessment, resource capability and feasibility within the organisation to ensure long term sustainability of the program7. The vision, involvement and commitment from the leadership and the multidisciplinary team involving clinicians and administrators along with clarity of their roles is critical. The infrastructure involves a dedicated ICU, ECMO equipment and a multidisciplinary team which includes senior leadership, administrators and clinical team of intensivists, cardiac surgeons, anesthetists, cardiologists, pulmonologists, nephrologists, infectious disease specialists, gastroenterologists, interventional radiologists, psychiatrist, vascular surgeons, perfusionists, dieticians, physiotherapists and nurses. A ECPR trolley with ECPR kit should be kept in readiness always in a well-defined location for ECPR initiation. The role allocation for the various steps involved in ECPR also needs to be pre-defined.

There is a need to develop clear centre-specific guidelines. There are 2 teams needed- one for CCPR and other for ECPR. The roles for various team members have to be clearly assigned during ECPR. The ECPR team takes care of cannulation, ECHO/ USG, equipment readiness and console management. The CCPR team manages chest compressions, airway, defibrillation, drugs and documentation.

The clinical pathway should clearly define whom to call and notify about the size of the patient, suspected etiology and the location of the patient. The ECPR team should be available in-house 24/7 or should assemble as early as possible. The ECPR team should be able to adapt to different clinical and patient scenarios consistently using stringent SOPs. Regular training and simulations need to be done to ensure quick availability, readiness and delivery of safe ECPR practices. The decision to call for ECPR should be made early preferably within 5-10 min of arrest. Generally the team leader or the intensivist makes this call. In OT it has to be the surgeon or the anesthesiologist. The CCPR and ECPR processes need to be monitored regularly using various quality of care matrix. Every case should be reviewed to identify areas for improvement and adherence to protocols. The outcome and complication data should be collected and audited regularly.

A clear collaboration of hospital and prehospital systems through integrated protocols to identify appropriate patients early and providing pre-arrival notification to hospital teams along with timely transport to hospital with continuous high quality CPR is required in OHCA patients7. Coordination with other established ECPR programs for guidance as well as joining registries like ELSO will help to compare and measure outcomes. Regular debriefings after initiation, daily rounds, monthly meetings with structured data will help in reviewing processes and modifying them for better outcomes.

Conclusion:

ECPR as an intervention, can be considered as a rescue intervention in refractory arrest both IHCA and OHCA but only when there is a likelihood of clinical benefit, availability of trained clinical team and institute with expertise and infrastructure to provide post ECPR care.

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Abbreviations:

CCPR	Conventional Cardiopulmonary Resuscitation
ECPR	Extra Corporeal Cardiopulmonary Resuscitation
IHCA	In-hospital Cardiac Arrest
OHCA	Out-of-hospital Cardiac Arrest
ECLS	Extra Corporeal Life Support
CA	Cardiac Arrest
ROSC	Return Of Spontaneous Circulation
VF	Ventricular fibrillation
VT	Ventricular tachycardia
ETCO2	End-tidal Carbon-di-oxide
PVD	Peripheral vascular disease
VA- ECMO	Veno-arterial Extracorporeal Membrane Oxygenation
CPR	Cardiopulmonary resuscitation
ER	Emergency room
ICU	Intensive Care Unit
OT	Operation theatre
RA	Right atrium
SVC	Superior vena cava
ACLS	Advanced Cardiac Life Support
PEEP	Positive end-expiratory pressure
LVAD	Left ventricular assist device
CPC	Cerebral performance category
RCTs	Randomized clinical trials
BIS	Bi-spectral Index
NIRS	Near-infrared spectroscopy

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