GUIDELINE

EXTRA-CORPOREAL MEMBRANE OXYGENATION DURING CARDIOPULMONARY RESUSCITATION (E-CPR)

1. TARGET AUDIENCE

This Guideline is intended for Medical and Nursing staff of the Intensive Care Unit (ICU), the Emergency and Trauma Centre (E&TC) and the Cardiac Catheterisation Laboratory (Cath Lab).

2. PURPOSE

This guideline outlines the procedures to be followed in the use of Extra-Corporeal Membrane Oxygenation during Cardio-Pulmonary Resuscitation (E-CPR) in the E&TC, ICU, Cath Lab and Wards.

3. DEFINITION

E-CPR is defined as the provision of an artificial circulation during cardiopulmonary resuscitation using the pumping of blood from a femoral venous catheter through an oxygenator into a femoral arterial catheter as an alternative to ventilation with oxygen and external cardiac massage.

4. INDICATIONS

Out-Of-Hospital Cardiac Arrest

- Patients who arrive at the E&TC with out-of-hospital cardiac arrest which is refractory to standard advanced cardiac life support treatment and the patient meets all the following criteria:
  - The cardiac arrest is suspected to be due to primary cardiac or respiratory cause
  - For cardiac causes, the initial cardiac rhythm was ventricular fibrillation/tachycardia ("shockable") and the arrest was witnessed by a bystander or paramedic
  - Chest compressions were commenced within 10 minutes
  - The cardiac arrest duration (collapse to arrival at E&TC) is < 60 minutes**
  - The patient is aged between 18-69 years
  - There are no major co-morbidities that would preclude return to independent living

  OR

- The patient is profoundly hypothermic (<32°C) due to accidental exposure

  OR

- The arrest was due to a reversible non-cardiac cause (i.e. asthma, overdose of a vaso-active drug) and the arrest was witnessed by a paramedic ("monitored arrest")

In order to ensure that out-of-hospital cardiac arrest patients arrive within a short time-frame, eligible patients will be transported by ambulance with an Autopulse™ as soon as possible after the initiation of resuscitation.

**Exceptions to the "60 minute rule" may be made in younger patients (<60 years), or when patients are hypothermic on arrival (temperature <35°C) or in any case where the consensus view of the attending ICU Consultants is that there is a reasonable prospect for survival if E-CPR is undertaken.

In-hospital cardiac arrest

Patients with in-hospital cardiac arrest which is refractory to CPR and the cause may be reversible, including:
• The patient who arrests in the hospital with suspected acute coronary syndrome. Note, in such cases, consider use of the LUCAS2™ mechanical CPR machine and cardiac catheterisation with a plan for subsequent ECMO in the Cath Lab if there is not a return of adequate spontaneous circulation (see Guideline for the use of the LUCAS2)

• The patient in the Cath Lab undergoing coronary angiography who suffers a cardiac arrest and who does not immediately respond to standard resuscitation

• The patient with suspected massive pulmonary embolism

• Any other cause where there is likely to be reversibility of the underlying condition if an artificial circulation can be provided

5. EXCLUSIONS

• An initial cardiac rhythm of asystole or pulseless electrical activity unless this rhythm onset was witnessed by paramedics

• Patients in whom cannulation is likely to be impossible (severe peripheral vascular disease)

• Patients who have arrested at another hospital and are still in cardiac arrest

• Unwitnessed cardiac arrest

• Patients with active bleeding

• Where there is no realistic prospect of reversal of the underlying cardiac/ respiratory condition

• Advanced age precludes prolonged intensive care and mechanical support

• Limitation of medical treatment or advanced care plan that precludes further resuscitation

• Patients awaiting lung transplantation

6. E-CPR REQUIREMENTS

In addition to the standard resuscitation, there are three key components of E-CPR, all of which must be provided concurrently:

• External chest compressions using the Autopulse™ or LUCAS2™ machine, and

• Peri-arrest therapeutic hypothermia using a rapid intravenous infusion of large-volume (40mL/kg) ice-cold saline administered as an IV bolus during E-CPR to induce therapeutic hypothermia (32-34°C) for neurological protection, and

• Rapid percutaneous canulation using small cannulae (15F arterial, 19F multi-stage venous) and connection to the pre-primed ECMO machine
7. ECMO-CPR EQUIPMENT

The equipment for E-CPR is held in the ECMO storage area of the ICU (see photo). The key components are:

The “E-CPR trolley”, containing:

- “Cannulator 1” Box: this contains the Defries pack, mask, hat, gown and gloves
- “Cannulator 2” Box: this contains the mask, hat, gown, gloves, Betadine, ultrasound probe sleeve and gel, Pajunk needle, Biomedicus 14F Blue dilators, Avalon dilators, forceps, IL saline and spike, extra guidewire, 10000Units heparin, 60mL catheter tip syringes x 2, sterile scissors, ECMO clamps x 4
- 15F arterial and 19F multiflow venous cannula packs
- The Autopulse™ machine and spare batteries
- “Post Cannulation Box”: masks, hats, gowns, Long Tegaderm x 2, CVC pack and drape, Cook Backflow cannula, Marquet backflow connector, Betadine, skin preps, grip-lok, cable ties, cable tie gun, blue scissors, backflow 3 way connector.

Photo: E-CPR Equipment
8. E-CPR ACTIVATION

For out-of-hospital cardiac arrest patients, the ambulance service will give approximately 15 minutes warning of the arrival of a cardiac arrest patient who will be transported to the E&TC on an ambulance Autopulse.

1. The E&TC nurse answering the ambulance communications telephone will contact the ICU SR on for wards

2. The ICU-SR will then contact the ward ICU Consultant

3. The ward ICU Consultant will then telephone two ICU Consultants who are accredited in ECMO cannulation

4. In the event that one/both of these two ICU Consultants do not answer their phones within 2 minutes, the ward ICU Consultant will then text all ICU Consultants

The nursing staff in E&TC will prepare a Trauma Bay for the reception of the patient.

9. E-CPR ROLES:

There is 10 staff with each having a specific role. Each of the roles will be defined with a laminated card that will be distributed by the Team Leader.

These roles are:

- Team Leader
- Cannulator 1
- Cannulator 2
- Console person
- Sonographer
- Airway doctor
- Airway nurse
- CPR
- Scribe
- Drugs

Each of these roles is outlined on the laminated card. The cards also indicate where the person allocated this role should stand.

“Team Leader”

- Distributes “Role Cards”
- Leads and coordinates the resuscitation
- Ensures that one of the E&TC Trauma rooms is set up and ready
- Contacts Cardiology
- On patient arrival, checks exclusion criteria with Cannulator 1 and 2
- Ensures that Autopulse is running and hand ventilation continues with 100% oxygen
- Ensures garments are removed and groin area is shaved
- After skin prep, ensures no further defibrillations
- Requests adrenaline 1mg IV each 4 minutes after rhythm and pulse check
- Ensures that no CXR/CVC or arterial line are inserted during cannulation
- Requests “CPR” person to stop Autopulse on request from Cannulator 1 during needle insertion
- In the E&TC, will be the E&TC Emergency Physician

“Cannulator 1”:

- Is an Intensive Care Consultant
- Attends the ECMO area in the ICU and adds the cold saline pack (containing 4L cold saline) from the refrigerator to the E-CPR trolley
- Proceeds to the site of the cardiac arrest with the E-CPR trolley
- Opens “Cannulator Pack 1” and lays out the Defries pack on a trolley
- Scrubs, dons sterile gown and gloves
- Prep and drapes patient
- Applies ultrasound sleeve and gel to vascular probe
- Images the femoral area and demonstrates the positions of the femoral artery and vein
- Cannulates the femoral artery and vein
  - Right side for venous access/ left side for arterial return
  - Inserts both guide-wires prior to dilatation
  - Requests pauses in chest compressions during needle and guide-wire insertion

“Cannulator 2”:

- Is an ICU Consultant or experienced ICU Senior Registrar
- Opens “Cannulator 2” box contents
- Pours 1L saline into blue bowl and adds 10000Units heparin
- Opens 15F arterial and 19F multi-stage venous cannulae
- Scrubs, gowns and gloves and assists “Cannulator 1” with draping, cannulation and circuit connection

“Console Person”:

- Proceeds to the site of the arrest with a pre-primed ECMO circuit and spare batteries for the Autopulse™
- Prepares the ECMO circuit for use
  - Turn console on
  - Sets RPM to 0
  - Unscrews yellow cap from oxygenator
  - Unclamps blue and red tubing
  - Run at 2000rpm for 2 minutes and ensure flow into priming bag
  - Reapply yellow cap to oxygenator
  - Clamp circuit
  - RPM set to 0, ECMO safety clamp on
  - Apply white cream to rotary pump
  - Press “Zero” on console
  - Connect oxygen green tubing to flow meter and set on 3L/min
  - Await cannulation, then move to bedside
  - Check with C1 and C2 that there is no air in circuit
- When cannulae are inserted and connected, commences ECMO flow at 3L/min and oxygen flow 3L/min
"Sonographer"

- Prepares ultrasound machine
- Confirms access (venous) guide-wire in IVC
- Confirms return (arterial) guide-wire is in aorta NOT in IVC
- Bolus 40mL/kg IV ice-cold saline for target temperature <34°C

"Airway Doctor"

- Supervises the move from the ambulance stretcher to the E&TC bed with Autopulse™ continuing
- Commences hand ventilation with 100% oxygen using a bag/valve connected to the ETT
- Does NOT connect the patient to a ventilator until ECMO flow commences
- In the E&TC, will be an Emergency Physician or Senior Registrar

"Airway Nurse"

- Assists the Emergency Physician with airway management
- Connects ETCO2 and cardiac monitoring leads
- May need to draw up and administer sedation (midazolam 5mg/5ml) and muscle-relaxant (rocuronium 100mg in 10mL) if the patient is spontaneously moving during Autopulse™ compressions

"CPR"

- Stands by Autopulse, pauses machine on request from team Leader

"Scribe"

- Commences documentation
  - Time of arrival
  - Time of decision for E-CPR
  - Time cannulation commences
  - Time to ECMO support
- Measures and announces time cycle to ensure rhythm check and adrenaline administration each 4 minutes

"Drugs"

- Prepares adrenaline for bolus administration

10. E-CPR ROLES outside the E&TC (ICU, Cardiac Catheter Laboratory, Ward or Operating Theatre):

There are 8 staff who each has a specific role.

- The Team Leader is a senior ICU Consultant or senior registrar
- The “Airway Doctor” will also do the role of the “Airway Nurse”
- The “CPR” person will also do the role of the “Drugs” person and administer the IV adrenaline
11. CARDIAC ARREST MANAGEMENT DURING CANNULATION:

The patient on Autopulse™ must not be connected to a mechanical ventilator but instead be ventilated gently by bag/valve with 100% oxygen.

During cannula insertion, all other procedures and therapies must be delayed, including arterial line placement/CVC placement, defibrillation and chest X-ray.

***DO NOT DEFIBRILLATE DURING ECMO CANNULATION***

The patient may be fitted with a standard C-spine collar to prevent excessive head movement during Autopulse™ compressions. This may be removed when on ECMO, unless there has been a significant head strike.

12. NOTES ON CANNULATION DURING CPR:

Cannula insertion:

- The femoral vessels must be imaged with ultrasound
- The femoral artery and vein will be accessed with a needle and the standard guide-wire inserted
- The venous guide wire must be imaged in the IVC and the arterial guide wire must be ascertained as NOT being in the IVC
- A small skin incision is required to facilitate rapid dilation
- Smaller ECMO cannulae (15F arterial, 19F multi-flow venous) are inserted since smaller cannulae are faster and easier to insert, and relatively low ECMO flows (3L/minute) only are required during therapeutic hypothermia
- No femoral artery back-flow cannula is required initially

Commence ECMO perfusion:

Once the cannulae are inserted, the ECMO circuit will be connected and flow will be commenced. The Autopulse™ will then be switched off.

Adequate therapeutic hypothermia (32-34°C) is imperative for neurological protection during and after prolonged cardiac arrest. If the temperature is still >34°C after the 40mL/kg bolus of cold saline and commencement of ECMO, then the heat exchanger will be filled with ice chips/cold saline, connected to the ECMO oxygenator and the heat-exchanger flow started.

13. MAINTENANCE ON ECMO

Once on ECMO, the subsequent patient management will depend on the clinical setting:

- For patients with presumed cardiac arrest of cardiac cause, transfer to the Cath Lab for coronary angiography and possible angioplasty will be required. The Cardiology Registrar on-call should be paged
- For patients with suspected massive pulmonary embolism, consideration should be given to thrombolysis or pulmonary embolectomy
• Patients who have suffered a significant head strike during their collapse should undergo CT brain and C-Spine scanning as soon as possible after stabilisation

• A 5 lumen antibiotic coated central line should be inserted into the right internal jugular vein once the patient is on ECMO, the Autopulse™ is stopped and the C-spine collar has been removed

• Once ECMO flow is established, commence morphine/midazolam 1-5mg/hr IV. The maximum dose is 5mg/hr of each. Administer a longer acting non-depolarising muscle relaxant (eg rocuronium 50mg IV) for moving/shivering. After admission, this is changed to remifentanil/propofol (see Immediate Management of Out of Hospital Cardiac Arrest at the Alfred-POSTARREST TEAM (PAT))

• A femoral artery backflow cannula will need to be inserted either percutaneously or surgically after admission to the ICU

• Bladder temperature catheter is inserted

• A chest X-ray is performed after a NGT has been inserted

14. TRANSFER TO THE CARDIAC CATHETERISATION LABORATORY

If acute coronary occlusion is suspected, then the patient should be transferred to the cath Lab. The ICU Consultant on-call for “Backfill 1” will generally undertake this task.

The Cardiologist will undertake coronary angiography using a femoral artery (contra-lateral side to ECMO arterial catheter), brachial artery or radial artery approach.

In general, a coronary artery bare-metal stent(s) will be inserted and this will require administration of aspirin, clopidegrel and commencement of a heparin infusion.

At the conclusion of coronary angiography, the arterial sheath will be connected to a transducer and this will be used for arterial blood pressure monitoring and arterial blood gas analysis.

15. TRANSFER TO THE INTENSIVE CARE UNIT

After coronary angiography and CT scanning of the brain and C-spine (if head strike), the patient will be transferred to the ICU.

The subsequent treatment follows the usual practice of provision of ECMO and maintenance of therapeutic hypothermia in the ICU (see “Guideline for Therapeutic Hypothermia”). The patient who has had CPR for > 30 minutes and E-CPR must undergo therapeutic hypothermia (33°C) for 24 hours followed by slow rewarming.

16. BACKFLOW CANNULA:

After arrival in the ICU, if the superficial femoral artery is visible using ultrasound, then it is appropriate for a Consultant Intensivist to undertake percutaneous cannulation. If the superficial femoral artery is difficult to visualise, then an open approach by a Vascular Surgeon is appropriate. In that case, referral to Vascular Surgery will be made to determine the timing and technique for insertion of a backflow cannula.
The timing of the backflow cannulation will depend on the perfusion of the limb. In some cases where there has been rapid cardiac recovery, then early decannulation of the ECMO circuit may be considered.

If ECMO cannulation has occurred during the night, it may be appropriate to wait until morning to attempt backflow cannula insertion provided the leg appears adequately perfused.

17. PROGNOSTICATION:

The assessment of neurological recovery after prolonged CPR is generally undertaken at 108 hours (i.e. 72 hours after cessation of sedation) and is based largely on the clinical neurological examination. In E-CPR patients, the assessment of prognosis will follow the standard Alfred ICU pathways.

18. REFERENCES:


19. AUTHORS / CONTRIBUTORS

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