

Extra Corporeal Membrane Oxygenation (ECMO): Care of the Patient Receiving Veno-Arterial ECMO

Site Applicability

SPH Cardiac Surgery Intensive Care Unit

Practice Level

Specialized: Restricted to Critical Care Registered Nurses who have received supplemental education and work in PHC Critical Care Units.

This document does not cover the inpatient or outpatient ECPR protocols or V-V ECMO

Roles and Responsibilities

Perfusionist:

- Brings all required ECMO equipment and supplies to patient bedside
- Primes circuit, assists with supply and choice of cannulas
- Management of ECMO circuit and machine. Ongoing hemodynamic and volume status assessments
- Responsibility of ECMO circuit and machine during patient transfers (2 perfusionist required for all patient transports)
- Ensures patient has been given Heparin (or bivalirudin in cases of HIT)
- Initiates and terminates circulation
- ECMO circuit blood salvage (cell saver or ACD collection bag) at weaning of ECMO
- Documents ECMO parameters
- Troubleshoots ECMO circuit

Cardiac Surgeon: (MRP)

- Places ECMO cannulas and orders initiation and weaning of circulation
- Orders medications and patient care goals in collaboration with anesthesia
- Interpretation of diagnostic tests (ECHO, CXR, ECG, blood work etc.)

Anesthesia:

- Medical management in collaboration with Surgeon (medication prescription, ordering diagnostic and lab tests etc.)

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- Fluid resuscitation
- ACLS protocols

Respiratory therapists:

- Management of ventilator
- Administration of inhaled medications
- Usual RT responsibilities for patient transport

Registered Nurses:

- Manages equipment, sets up room
- Clears room and path to room
- Assists with bedside insertion as needed
- Administers medication/blood products/IV fluid
- Monitors and documents vital signs, procedure notes, labs
- Basic patient care(line management, dressing changes, personal care)
- Along with physicians update and support patient's family
- Management of CRRT (when applicable)
- Documents all patient parameters

Need to Know

Extra Corporeal Membrane Oxygenation or ECMO is a form of extracorporeal life support where an external artificial circulation circuit carries venous blood from the patient to a gas exchange device (oxygenator). Here blood becomes enriched with oxygen and carbon dioxide is removed, and blood then re-enters the patient circulation.

Veno-venous ECMO is used for isolated respiratory failure in the presence of adequate heart function. Venous blood is removed from the patient from the large central veins and returned to the venous system in the right atrium after it has passed through an oxygenator.

Venous-Arterial ECMO is applied for the management of cardio-respiratory failure or cardiac failure. Venous blood is removed from the patient from the large central veins and returned to a major artery (usually the aorta) after it is passed through the oxygenator. It provides support for severe cardiac failure often with associated respiratory failure.

Guideline

Assessment and Interventions

V-A ECMO is an advanced life support technology to provide short term hemodynamic support and may be used in the following situations

- Resuscitation in Cardiac arrest
- Inability to wean from bypass following OHS
- Bridge to transplant or acute rejection post heart transplant
- Arrhythmias- as a bridge to stabilization
- Myocarditis with severe myocardial dysfunction
- Pulmonary embolism

This reality means that there is not always the opportunity to prepare to the same degree for each insertion. Depending on the reason for initiating ECMO, there may be limited time to prepare patient, team and space (urgent vs emergent)

Page 4 of 18

Immediately following insertion of an ECMO:

<p>7. Assess and document:</p> <ul style="list-style-type: none"> • VS (BP, HR, RR, SpO₂ or SaO₂, T) • ECG rhythm, ST-segment • Hemodynamic monitoring parameters (e.g. CVP, PAP,) • ECMO parameters LOC (GCS, RAAS or CAM) and pain (if awake) • Breath and heart sounds 	<p>Surgeon/ anesthesia will order and write all hemodynamic goals including temperature</p>
<p>8. Assess for signs and symptoms of decreased peripheral perfusion</p> <ul style="list-style-type: none"> • Skin color and warmth • Peripheral pulses (pedal, brachial, or radial); color, warmth, movement, and sensation of limbs Q15 X4 , Q30 mins X2 and then Q1H • Right and left calf circumference measurement 	<p>In V-A ECMO femoral cannulation; circulation may be compromised to the limb with the outflow cannula in the femoral artery. This may be corrected by inserting a distal perfusion catheter.</p> <p>Monitor closely for limb ischemia and notify physician of any changes from baseline: pale or dusky pallor, cool skin, diminished or absent pulses.</p> <p>Monitor for hematoma at insertion site and observe for bleeding, swelling, redness.</p> <p>Mark calf measurement point with indelible marker to maintain consistent calf circumference measurements.</p>
<p>9. Apply saturation sensors for both cerebral and bilateral leg perfusion assessment</p>	<p>Assess for signs of altered cerebral tissue perfusion</p> <p>Apply sensors to the medial aspects of the left and right lower extremities midway between knees and ankle</p> <p>Sensor pads should be changed every 72 hours and PRN</p>

Ongoing Monitoring

ASSESSMENT	INTERVENTIONS
<p>Monitor the following until ECMO discontinued and for 24 hours following removal:</p> <ol style="list-style-type: none"> Assess and document Q1H and PRN: <ul style="list-style-type: none"> VS (BP,MAP, HR, RR, SpO₂ or SaO₂,) ECG rhythm, ST-segment hemodynamic monitoring parameters (CVP, PAP, PCWP*, CO) if applicable RASS, CAM, BPS and pain (if awake) Neuro checks Q 1H Core temperature Q1H (insert Foley or rectal tube with temperature sensor if no PA line) Skin color and warmth Breath and heart sounds Peripheral pulses (pedal, brachial, or radial); color, warmth, movement, and sensation of limbs Assess for alterations in renal perfusion by monitoring urine output hourly ECMO catheter insertion site, IV catheters, and puncture attempts 	<p>Observe for complications of ECMO therapy (Appendix A)</p> <p>Assess for signs of altered cerebral tissue perfusion (monitor neurological vital signs as per critical care assessment guidelines)</p> <p>Observe for signs of bleeding (blood at site, swelling or palpable hematoma, bruising) and infection (purulent drainage, redness)</p>
<ol style="list-style-type: none"> Nurse patients to avoid leg flexion and position head of bed no greater than 30° 	<p>To avoid kinking of catheters</p>
<ol style="list-style-type: none"> Monitor for signs and symptoms of hemolysis <ul style="list-style-type: none"> Dark urine (hemoglobinuria) Fever Jaundice <p>If hemolysis is suspected, a plasma free hemoglobin level may be sent</p> 	
<ol style="list-style-type: none"> Work with perfusion to assess for adequate fluid status to ensure optimal ECMO flow 	<p>Communicate with perfusion prior to giving platelets so they monitor for clots. Give them slowly to avoid thrombus formation.</p>

5. Temperature Management: Obtain orders for temperature management. Strategy depends on reasons why patient is on ECMO Arrest VS hemodynamic or respiratory deterioration	Ensure Core temperature sensor is in place (PA, Foley or rectal tube with temperature sensor) ECMO circuit temperature setting is not a reliable for patient core temperature
6. Monitor carefully all lines for air entrainment	Patients with CVC in the superior Vena Cava and ECMO inflow cannulas in the SVC are at higher risk of air embolus due to possible air entrainment into the ECMO circuit
7. Assess skin integrity Q2H and PRN	Reposition patient using log roll technique Q2H and consider use of air mattress to maintain skin integrity.
8. Assess and document Q4H and PRN: <ul style="list-style-type: none"> Measure and record right and left calf circumference. 	Mark measurement point with indelible marker to maintain consistent calf circumference measurements
9. Perform the following daily : Assess insertion site/dressing <ul style="list-style-type: none"> Apply clear occlusive dressing to insertion site and change Q7 days and PRN 	All efforts must be made to maintain a sterile dressing over the ECMO cannulation sites

Weaning ECMO

- Patient must show signs of organ/metabolic recovery this may show up as return of pulsatility in systemic and pulmonary circulation and signs of recovery on ECHO as improved LV or RV function.

In preparation for weaning; the following should be considered:

- Optimize sedation and analgesia: goal is patient comfort and safety for weaning trial
- Optimize ventilator settings (RT to adjust ventilator settings to increase support)
- Make sure bedside ECHO has been organized for the pre-determined weaning time
- Optimize inotropic support (drugs pre mixed and ready to initiate)
- Adequate anticoagulation have heparin bolus (or bivalirudin) available at bedside
- Discuss plan with family

ECMO Monitoring During Weaning

ASSESSMENT	RATIONALE/INTERVENTIONS
<ol style="list-style-type: none"> 1. Assess and document: 2. VS (BP, HR, RR, SpO₂ or SaO₂, ETCO₂, Temp) 3. ECG rhythm, ST-segment 4. Hemodynamic monitoring parameters (e.g. CVP, PAP, MAP, CO, if available) 5. RASS, CAM, BPS and pain (if awake) 6. Neuro checks 7. Skin color and warmth 8. Breath and heart sounds 9. Peripheral pulses (pedal, brachial, and radial); colour, warm, movement, and sensation of limbs 10. Urinary output 	<p>Indications that weaning may not successful include:</p> <ul style="list-style-type: none"> • Hemodynamic instability • Tachycardia • Arrhythmias • Decrease in CO, CI • Increase in PAW, PAD • Chest pain • Respiratory distress

Removal of ECMO

1. Assess ACT, PTT/ platelets prior to ECMO removal as per physician order
2. Discontinue heparin infusion as per physician order (if infusing)
3. Physician preference determines if manual pressure or compression device (e.g. CompressAR clamp) is used to control bleeding from the insertion site

Only nurses trained in using compression devices (e.g. CompressAR clamp) may manage the clamp

While clamping: site check (including color, warmth, sensation and movement) and VS Q15min and PRN

Post clamping: site check (including color, warmth, sensation and movement) and VS Q15min x 4, then Q1H X 3, Q4H X 24 hours and PRN
4. Maintain immobility of the affected limb, bed-rest and HOB no greater than 30 degrees for 6 hours
5. Measure calf circumference Q4H post removal x 24 hours and monitor for signs of compartment syndrome such as swelling, redness, pain, numbness or tingling, change in pulse characteristics, and/or restricted mobility of limb

General safety considerations while patient is on ECMO

- Patient to be kept flat or minimal increase in HOB to avoid kinking
- Patient repositioning should be done as a team with perfusion so they can monitor the cannulas
- Always have a minimum of 2 units RBCs nearby (CSICU fridge)
- NO alcohol at bedside or near the ECMO circuit
- Access and Return lines should be securely fastened to the patient skin to prevent accidental dislodgment
- Perfusion will have back up primed circuit close by and available
- Perfusion will have secured cannulas to the bed
- All equipment should be plugged into emergency back-up power
- A minimum of 4 clamps to be kept at bedside at all times (perfusion will have these on their cart)
- No unnecessary equipment in room to provide fast access to patient in emergency situation

Emergency Management

- Patient may be defibrillated while on ECMO
- Careful air vigilance even in code/emergency situations when giving any IV push meds, blood products or initiating IV infusions
- V-A ECMO will continue to provide systemic blood flow/perfusion regardless of rate or rhythm
- If ECMO flow becomes insufficient ...
 - Consult physician before commencing chest compressions
 - With Femoral/jugular cannulation usually OK
 - With Central cannulation not usually performed

Documentation

1. Nurses' Notes (PHC Form PHC-NF035): Date, time, routine assessments and interventions, signs and symptoms of complications and interventions taken, weaning attempts and responses, ECMO removal and complications, physician communication
2. Medication Administration Record: Medications administered

Patient and Family Education

1. Purpose and function of ECMO
2. Routine nursing actions and assessments
3. Process and expectations of weaning and removal
4. Daily updates on patient status
5. Connect family with all available supportive resources (e.g. spiritual care, social work)

Related Documents:

[B-00-13-10025](#) - Cardiac Surgery: Post-Operative Care (CSICU)

[B-00-13-10063](#) - Cardiac Cath Lab: Post Procedure Care

[B-00-12-10017](#) - Physical Assessment (Critical Care Areas)

[B-00-13-10011](#) - Cardiac Monitoring

References

1. Parsons. P. & Bartlett. R. Extracorporeal membrane oxygenation (ECMO) in adults. In: UpToDate, Parsons, P. (Ed.), UpToDate, Waltham, MA. Retrieved May 7, 2018
2. Forman Jackie; ECMO Resource Manuals for Nurses in CSICU SPH
3. University Of Pennsylvania Health System ECMO Guidelines for Care; Jan 2017
4. Extracorporeal Membrane Oxygenation: Unraveling the mystery with the help of perfusion and Nursing; Bedard, Annie and Lesage, Marianne, Nursing rounds Presentation, May 28th, 2018

Persons/Groups Consulted:

Cardiac Anesthesia

Cardiac Surgeons SPH

CSICU Staff at SPH

Perfusion Services

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Appendix A: Potential Complications Related to V-A ECMO

Complication	Causes	Actions/ Considerations
Lower extremity ischemia	Femoral arterial outflow cannula may limit blood flow to the lower leg	<p>Ensure</p> <ul style="list-style-type: none"> Minimum Q1H and PRN assessments: peripheral pulses (pedal, brachial, and radial); color, temperature, movement, and sensation of limbs Attach saturation monitoring to lower extremities Calf measurements minimum Q4H <p>Consider</p> <p>Insertion of Distal Perfusion Catheter</p> <p>If limb ischemia develops:</p> <ul style="list-style-type: none"> Notify physician immediately Removal of ECMO may be necessary May need fasciotomy if compartment syndrome develops Consider a vascular service consult to optimize access <p>Measure calf circumference Q4H x 24 hours post removal of cannulas as well</p>
Bleeding/Coagulopathies	<p>Increased risk due to anticoagulation, platelet dysfunction and thrombocytopenia</p> <p>Patients are at risk for hemolysis or thrombus formation</p> <p>Potential for bleeding from chest tubes or surgical sites</p>	<ul style="list-style-type: none"> Continually assess puncture sites and cannula insertion sites Close monitoring of blood values Ensure Cross match is current Ensure minimum 2 units PRBC available in unit blood fridge at all times

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Acute drops in Flows “chatter”	Hypovolemia Inflow line kink/obstruction Outflow line kink/obstruction Oxygenator clot/obstruction Malposition of cannula	In collaboration with perfusion staff Examine cannula and lines for kinks/obstruction Consider fluid bolus Reduce fluid removal if on CRRT
Decannulation	Extreme tension being placed on tubing, cannulas and cannulation	Anchor the cannulas to the patient Use spotter to ensure that lines remain free during patient maneuvers
Pump failure There is a no flow state due to failure of the electrical pump to drive pump head If ECMO is stopped for any period of time, clotting in the circuit is a possibility	Electrical motor failure Battery failure Pump head disengagement	Establish rescue ventilation+/- CPR if hemodynamic collapse
Worsening hypoxia	Differential hypoxemia- lower pO ₂ in the upper body compared to the lower body (also known as “North-South Syndrome”) May occur during peripheral Venous-Arterial ECMO when there is severe respiratory failure combined with a high cardiac output. The heart is supplying the upper body with deoxygenated blood, while the ECMO circuit supplies the lower body with oxygenated blood	Circuit Air Embolism Introduction of air embolus into the patient Massive air embolus into the pump head will de-prime the pump

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Circuit Air Embolism Massive air embolus into the pump head will de-prime the pump	Introduction of air into the circuit at the insertion site of the inflow Fracture of connector or circuit on the inflow side of the pump Air entrainment during central line insertion, CRRT circuit connection, IV bag change, and bolus IV administration	Extreme air vigilance must be observed when performing any risky interventions. Wet to wet CRRT circuit connections are performed. Complete de airing of all bags and syringes. Notify perfusion prior to performing any of these interventions
Decreased renal perfusion	Non-pulsatile flows sometimes interpreted by the kidneys as inadequate flow and can trigger the production of ADH. Higher levels of ADH make the kidney work harder to reabsorb more water. This results in the production of very small quantities of very concentrated urine	Maintain adequate fluid status Close monitoring of urine output
Infection prevention	Prophylactic antibiotic coverage All procedures must observe strict aseptic technique	
Skin Integrity	Early consideration of KCI bed Repositioning Q2H as tolerated Use of Allevyn or Mepore dressing to pressure areas prophylactically	Even minimal changes in weight distribution can make a difference and decrease skin breakdown

Appendix B: Pre ECMO Cannulation Checklist for Nurses in Critical Care Units

The ECMO CART, circuit and all the catheters will be brought to the bedside by perfusion for ICU/CICU and CSICU. No other staff should bring this equipment to the bedside. NO ECMO cannulation catheters should be kept in the units.

- ☐ Clear room of all unnecessary equipment
- ☐ Bring arrest cart,
- ☐ Bring large dressing table for placement of ECMO cannulas by perfusion (Silver table in CSICU)
- ☐ Bring extra dressing table for surgeon to use
- ☐ Bring "PACK" to bedside (large angio drape, gowns, gloves)
- ☐ Bring US/Sonosite to bedside
- ☐ Ensure all hemodynamic and monitoring equipment and cables are set up in the bed space
- ☐ Bring extra dressing table for surgeon to use
- ☐ Ensure larger sharps bucket at bedside
- ☐ Ensure large garbage can at bedside
- ☐ Ensure that patient has blood (RBC, Platelets) available at bedside
- ☐ Bring additional hemodynamic supplies nearby
- ☐ Anticipate need for inotropes and vasopressors and pre mix (NORepinephrine (Levophed), epinephrine, milrinone)
- ☐ Have intubation meds available at bedside if patient not already Intubated (proPOFol, rocuronium, ketamine) discuss with anesthesia
- ☐ Consider moving Rapid Infuser closer to the room
- ☐ Ensure recent ACT and other ordered blood work
- ☐ Discuss timing of Heparin bolus with perfusion and Surgery (or bivalirudin in cases of HIT)

Appendix C: Bedside Nurse Quick Guide for ECMO Nursing Care

(Must be used in conjunction with the standard)

Neurological:

- ☐ Q 1H neuro vital signs, RASS and BPS (ensure you have clear orders for RASS)
- ☐ Continuous cerebral oximetry monitoring, notify physician of any significant changes

Respiratory:

- ☐ Ventilator setting will be reduced to protect the patient's lungs against trauma. The ECMO flow is set at a level that will provide total oxygen and CO₂ exchange
- ☐ With Femoral cannulation; the saturation probe must be kept on the right thumb to obtain the most accurate readings

Cardiovascular:

- ☐ With femoral cannulation, arterial line should be placed either right radial or right brachial to obtain the most accurate ABGs
- ☐ Close monitoring for limb ischemia is essential/inform physician immediately of any changes
 - With femoral cannulation, continuous saturation by placing the sensors on the anterior portion of the leg which the most sensitive to ischemia
 - Q1H and PRN vascular checks
 - Q4H calf measurements
- ☐ MAP is the best pressure parameter to use with non-pulsatile ECMO and potential minimal native output
- ☐ Cardiac output and filling pressures may not be accurate
- ☐ Requirements for Vasopressor and Inotrope support may be decreased during full ECMO support
- ☐ All infusions should be administered through a pump
- ☐ Air vigilance with all IV bag changes, priming and push meds
- ☐ Always have a patent blood line connected, a current X-match and 2 units of RBC in fridge
- ☐ Platelets should be given slowly to avoid clumping and clot formation in the ECMO circuit (always notify perfusion prior to giving platelets)

Gastrointestinal:

- ☐ Ensure Oral gastric tube is in place for decompression, meds
- ☐ Consider enteral feeding tube to match caloric and protein requirements as well as GI protection

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- ☐ Discuss on rounds early initiation of feeds and dietician consult
- ☐ Monitor lactate for sign of ischemia

Genitourinary:

- ☐ Close monitoring of Urine output
- ☐ Close monitoring of urine for signs of hemolysis
- ☐ If Prismaflex is initiated ensure air vigilance and wet to wet connection is performed at all times

Skin integrity:

- ☐ Early consideration of KCI bed
- ☐ Reposition Q2H as patient tolerates (remember even slight adjustments changes pressure areas)
- ☐ Avoid excess linen and moisture to bed

Preventing Infection:

- ☐ Strict aseptic technique
- ☐ Antibiotic coverage will depend on patient diagnosis

Appendix D: Things to remember when going on transport

- ☐ Make sure with the team that the transport is in fact absolutely required
- ☐ Communicate with destination (CT or Cath Lab) the complexity of the patient situation and timely manner required to enter and leave the procedure area
- ☐ Coordinate suitable time with RT, perfusion, and anesthesia
- ☐ A physician should accompany all ECMO transport if unit acuity permits
- ☐ A second nurse should also accompany on transport when possible
- ☐ Minimize infusions and equipment to be taken on transports i.e. D/C non critical infusions, feeds, cerebral oximetry etc.
- ☐ Prepare and bring any required sedation / emergency drugs
- ☐ If patient on KCI bed transfer, transfer to regular bed for easier transport
- ☐ Shorten bed as much as possible to fit into elevator
- ☐ Make sure there is ceiling lift sheet under the patient prior to departure
- ☐ Bring extra linen to change bed when patient is on Cath table or in CT Scanner
- ☐ When porter arrives for transports have a "runner" take the elevator key to call and hold large elevator so there is no delay (elevator key found in top drawer of CNL desk)
- ☐ For head and chest CT enter room head first for CT abdomen enter room feet first

Appendix E: Bedside weaning of ECMO

A Nurse's Quick Reference Guide

- ☐ Discuss plan for potential wean on morning rounds
- ☐ Ensure clarity around approximate time that weaning will begin
- ☐ Ensure family has been updated on the plan
- ☐ Discuss and get clear written orders for pre weaning optimization
 - Initiation of Milrinone infusion
 - Discuss pre mixing levophed and epinephrine infusions
 - Ensure cross match is up to date and ensure availability of blood products as per physician orders. A minimum of 2 units RBC should be pre checked and at bedside prior to weaning beginning)
 - Ensure ECHO has been ordered and available for the intended time
 - Plan with CNL/CN what extra nursing staff will be free to assist with weaning process (minimum 1 staff to chart, 1 staff to adjust infusions and give meds and 1 staff to be the runner for anything else needed).
- ☐ Remove all unnecessary equipment from the room
- ☐ Ensure Surgeon, RT, perfusion and anesthesia are all present before weaning begins
- ☐ Bring crash cart to bedside or nearby