



EMORY
MEDICINE

ECMO Center

Extracorporeal Membrane Oxygenation Center

Emory ECMO Center Manual

Version 1.0

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ECMO REFERRALS & PHYSICIAN COVERAGE FOR CANNULATION & MANAGEMENT OF ECMO PATIENTS

- I. Policy Statements: Due to the limited number of ECMO circuits available, it is imperative that the ECMO Medical Director or his/her designee (known as the Acting ECMO Medical Director - AEMD) be notified of any potential ECMO patients.
- II. Purpose: To establish references for the ECMO Referral Process and Physician coverage for both cannulation and management of the ECMO patient.
- III. Definitions:
 - a. DCD = Donation following Cardiac Death
 - b. “NNP” means Neonatal Nurse Practitioner
 - c. “CDH” means Congenital Diaphragmatic Hernia
 - d. “ECPR” means Extracorporeal Cardiopulmonary Resuscitation
- IV. Policy Standards:
 - a. The CCM-ECMO Fellow is responsible for:
 - i. Assisting Referral Physicians in establishing communication with appropriate Services and personnel.
 - ii. Filling out referral information into REDCap when contacted by the transfer center.
 - iii. Responsible for notifying Perfusion and Respiratory Therapy when there is a potential ECMO patient
 - iv. Contacting the AEMD and the 4a/5a attending prior to accepting a patient
- V. Procedures/Actions:
 - a. RESPIRATORY REFERRALS
 - i. Most referral calls go to the CCM-ECMO fellow or 4A/5A attending. The fellow/attending is responsible for contacting the AEMD to review the case and confirm circuit availability.
 - b. CARDIAC REFERRALS
 - i. Referral calls must come from Cardiac Surgery or Cardiology. The attending cardiologist or cardiothoracic surgeon is responsible for contacting the AEMD to review the case and confirm circuit availability.
 - c. ECPR
 - i. Calls for all patients will be ordered by the AEMD based on individual case assessment.



- d. CANNULATION AND PATIENT MANAGEMENT:
 - i. The ECMO Call Calendar identifies the AEMD. The cannulator will be determined by the AEMD depending on the case type. The schedules are located in Qgenda.
 - ii. Cannulation and Patient Management Services for each ECMO Patient is as follows:
 - 1. Management of ECMO will be provided by a privileged ECMO attending at EUH
 - 2. Cannulation of ECMO will be provided by a privileged cannulator at EUH
- e. TRANSPORTS
 - i. Requiring Cannulation – Cannulator and another physician (if possible) for both cannulation and management for entire transport.
 - ii. Not Requiring Cannulation- Patient on ECMO at outside hospital. Any Critical Care or Cardiothoracic Fellow or Attending can accompany ECMO team for transport patient management

VI. Exhibits: None

VII. References: None

Author: James M. Blum, MD 7/6/2014



ECMO FOR ADULT RESPIRATORY SUPPORT

I. Policy Statements:

Consideration of usage of ECMO for adult respiratory support should take into account indications and contraindications for ECMO. The Acting ECMO Medical Director or designee approves ECMO support on a case by case basis.

II. Purpose:

To state the current ECMO program's indications/contraindications for ECMO support of adult respiratory patients.

III. Definitions:

- a. "Murray score" means a calculated score obtained by using PaO₂/FiO₂ ratio, chest x-ray infiltration assessment, Positive End Expiratory Pressure setting and ventilator compliance.
 - i. Calculated by taking the score for each variable and dividing by 4.
 - ii. Variables:
 1. PaO₂/FIO₂: > 300 = 0, 225-299 = 1, 175-224 = 2, 100-174 = 3, <100 = 4. The PaO₂/FIO₂ is calculated after the FIO₂ has been at 100% for at least 20 minutes.
 2. CXR infiltration: normal = 0, 1 point per quadrant with infiltration (max 4)
 3. PEEP: < 5 = 0, 6-8 = 1, 9-11 = 2, 12-14 = 3, > 15 = 4.
 4. Compliance (ml/cmH₂O): > 80 = 0, 60-79 = 1, 40-59 = 2, 20-39 = 3, and < 19
 5. 4. Compliance can be calculated by dividing tidal volume by (peak inspiratory pressure minus peep)

IV. Policy Standards:

- a. Indications:
 - i. **PaO₂/FiO₂ < 80** on FiO₂ > 90% on at least PEEP 10 +/- Murray score 3-4
 - ii. Failed intervention trials with (unless contraindicated): NMB trial, recruitment
 - iii. maneuvers, optimization of volume status and/or prone positioning
 - iv. Hypercarbia with **PaCO₂ > 80** and/or severe respiratory acidosis with inability to maintain pH ≥ 7.15
 - v. Probable reversible pulmonary failure



vi. Severe air leak syndromes or reversible airway failure (obstruction)

b. Strong Contraindications:

i. Age > 70 yo

ii. Age < 18 yo (should be referred to CHOA)

iii. Prior moribund condition including:

1. Skilled nursing or care facility

2. Moderate to severe dementia

3. ESLD

4. COPD requiring home O₂

iv. Irreversible illness or other fatal conditions with life expectancy < 2 years or inability to return home examples include but are not limited to:

1. metastatic/terminal malignancy

2. severe neurologic impairments (i.e. comatose without meds prior to onset, known anoxic brain injury)

v. ARDS with high pressure ventilation (Plateau Pressure > 30 cmH₂O, PEEP > 10) > 7 days

vi. BMI ≥ 40 (or weight > 135kg)

vii. Known contraindication to systemic anticoagulation

viii. Immunosuppression (Absolute neutrophil count < 4,000/cc, CD4 count < 500/cc)

ix. Cirrhosis with ascites, PSE, or h/o esophageal bleeding

x. Pre-existing irreversible moderate to severe pulmonary HTN

xi. Inability to receive blood products

c. Relative Contraindications:

i. End Stage Renal Disease

ii. Cardiac arrest requiring chest compressions

V. Procedures/Actions:

a. Mode of support determined by cardiac function, hemodynamics, and ability to access femoral, jugular veins and/or carotid or femoral arteries.



VI. Exhibits:

- a. S. Kolla, S. Awad, P. Rich, R. Schreiner, R. Hirschl, R. Bartlett. (1997). Extracorporeal Life Support for 100 Adult Patients with Severe Respiratory Failure. *Annals of Surgery*, 226 (4) p. 544-564.
- b. M. Srivastava, G. Ramani, et.al. (2010). Veno-venous extracorporeal membrane oxygenation bridging to pharmacotherapy in pulmonary arterial hypertensive crisis. *J Heart Lung Transplantation*. 29 (7) p. 811-813.
- c. L. Mongero, J. Beck, K Charette, A. Stewart. (2006) Respiratory failure of two s/p gastric bypass patients and subsequent rescue with extracorporeal membrane oxygenation. *Perfusion*, 21 (1) p73-76.
- d. K. Griffith, E. Jenkins, J. Haft. (2009). Treatment of massive pulmonary embolism utilizing a multidisciplinary approach: a case study. *Perfusion*, 24 (3) p. 169-172
- e. GJ Peek, D. Elbourne, M. Mugford, et. Al (2010). Randomized controlled trial and parallel economic evaluation of conventional ventilator support versus extracorporeal membrane oxygenation for severe adult respiratory failure. *Health Technology Assessment* 14 (35) p. 1-282.

VII. References:

- a. ECMO Extracorporeal Cardiopulmonary Support in Critical Care, 3rd edition
- b. [ELSO Patient Specific Guidelines 2009](#)
- c. [ELSO General Guidelines 2009](#)

Authors: Michael Connor, MD and James M. Blum, MD, FCCM 7/6/2014



ECMO FOR ADULT CARDIAC SUPPORT

I. Policy Statements:

Consideration of usage of ECMO for cardiac support should take into account indications and contraindications for ECMO. Allocation of ECMO resources for adult cardiac support will be made either by the ECMO Medical Director or designee (together recognized as the Acting ECMO Medical Director – AEMD) after a cannulation decision is made jointly by the 4a/5a ICU attending, CT surgery, Cardiology – HF service, and the AEMD as appropriate.

II. Purpose:

To state the ECMO Program's relative indications and contraindications for ECMO support for adult cardiac support.

III. Definitions:

- a. VAD = Ventricular Assist Device
- b. TAH = Total Artificial Heart
- c. BSA = Body Surface Area

IV. Policy Standards:

a. Indications:

- i. Cardiogenic shock
- ii. Bridge to recovery (revascularization, myocarditis, post-cardiotomy)
- iii. Bridge to transplant (un-revascularizable acute MI, chronic heart failure)
- iv. Bridge to device (VAD, TAH)

b. Strong Contraindications:

- i. Age > 70 yo
- ii. Age < 18 yo (should be referred to CHOA)
- iii. Prior moribund condition including:
 - 1. Skilled nursing or care facility
 - 2. Moderate to severe dementia
 - 3. ESLD
 - 4. COPD requiring home O₂
- iv. Irreversible illness or other fatal conditions with life expectancy < 2 years or inability to return home. Examples include but are not limited to:
 - 1. metastatic/terminal malignancy
 - 2. severe neurologic impairments (i.e. comatose without meds prior to onset, known anoxic brain injury)

- v. ARDS with high pressure ventilation (Plateau Pressure > 30 cmH₂O, PEEP > 10) > 7 days



- vi. BMI \geq 40 (or weight > 135kg)
 - vii. Known contraindication to systemic anticoagulation
 - viii. Immunosuppression (Absolute neutrophil count < 4,000/cc, CD4 count < 500/cc)
 - ix. Cirrhosis with ascites, PSE, or h/o esophageal bleeding
 - x. Pre-existing moderate to severe irreversible pulmonary HTN
 - xi. Unrecoverable heart and not a candidate for transplant or VAD
 - xii. Prolonged CPR without adequate tissue perfusion or oxygenation.
- c. Patient specific considerations:
- iv. Non fatal co-morbidities may be a relative indication based on the individual case. (I.e. Diabetes and renal transplant and retinopathy complicated by severe pneumonia).
- V. Procedures/Actions:
- a. ECMO should be continued while there is reasonable hope for recovery and stopped when treatment is futile. Likelihood of recovery is minimal when:
 - i. There is no LV ejection on appropriate inotropes and filling pressure during trial off after five or more days of ECMO and transplant is not an option.
 - ii. Patient has some function but is ECMO dependent after 10 days and transplant nor VAD an option.
 - iii. Major neurologic injury is documented at any time, including neuron specific enolase.
 - b. Vascular access considerations:
 - i. If the left ventricle is not ejecting and the diastolic, left atrial or pulmonary wedge pressures are elevated, then the left atrium should be vented with the addition of a left atrial venous catheter. Usually this will be accomplished by direct placement of a drainage catheter in the left atrium. In some circumstances this can be accomplished by atrial balloon septostomy or transeptal catheterization.
 - ii. Patients cannulated with a femoral arterial cannula can experience compromised distal perfusion. A distal reperfusion cannula may be used to improve perfusion to the affected extremity.
 - iii. Patients with respiratory compromise who are cannulated from the femoral vein to the femoral artery may experience hypoxia to the upper body (“north-south syndrome”).
 - 1. The patient may require the addition of a venous return cannula to provide oxygenated blood to the right heart and consequently the upper body. (VA-V ECMO)



- iv. Modifications to cannulation may be made in the event a patient has an existing cardiac assist device.

c. General Principles:

- i. If desired by managing team, extracorporeal flow will be sufficiently high to allow “cardiac rest”, with relatively low filling pressures, low afterload, and minimal inotropic drugs. Efforts should be made to maintain left ventricular ejection with moderate levels of inotropes and left sided filling pressure, if necessary.
- ii. There is a low threshold for direct left atrial access and/or left sided venting if left ventricular ejection is not easily maintained.
- iii. Although high flow veno-arterial access will be used, flow rates will be adjusted to assure that at least 25% of the venous return is going through the native lungs if possible.
- iv. A daily trial of decreased flow may be performed to evaluate right and left ventricular function. If a trial of decreased flow is tolerated, a full trial off bypass may be carried out daily with appropriate inotropic and filling pressure support. In general this will be evaluated by hemodynamics and by echocardiogram.
- v. Dry weight is desired, with CRRT used liberally.

VI. Exhibits:

- a. S. Kolla, S. Awad, P. Rich, R. Schreiner, R. Hirschl, R. Bartlett. (1997). Extracorporeal Life Support for 100 Adult Patients with Severe Respiratory Failure. *Annals of Surgery*, 226 (4) p. 544-564.
- b. M. Srivastava, G. Ramani, et.al. (2010). Veno-venous extracorporeal membrane oxygenation bridging to pharmacotherapy in pulmonary arterial hypertensive crisis. *J Heart Lung Transplantation*. 29 (7) p. 811-813.
- c. L. Mongero, J. Beck, K Charette, A. Stewart. (2006) Respiratory failure of two s/p gastric bypass patients and subsequent rescue with extracorporeal membrane oxygenation. *Perfusion*, 21 (1) p73-76.
- d. K. Griffith, E. Jenkins, J. Haft. (2009). Treatment of massive pulmonary embolism utilizing a multidisciplinary approach: a case study. *Perfusion*, 24 (3) p. 169-172
- e. GJ Peek, D. Elbourne, M. Mugford, et. Al (2010). Randomized controlled trial and parallel economic evaluation of conventional ventilator support versus extracorporeal membrane oxygenation for severe adult respiratory failure. *Health Technology Assessment* 14 (35) p. 1-282.

VII. References:

- a. ECMO Extracorporeal Cardiopulmonary Support in Critical Care, 3rd edition
- b. [ELSO Patient Specific Guidelines 2009](#)



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c. [ELSO General Guidelines 2009](#)

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FEMORAL CANNULA SPECIAL CONSIDERATION

- I. Policy Statements: Cannulation for ECMO using either the Femoral Artery or Vein presents unique challenges requiring specific interventions.
- II. Purpose:
 - a. To outline special considerations for a patient cannulated for VA ECMO support with the femoral artery.
 - b. To outline special considerations for a patient cannulated for VV ECMO support utilizing both femoral veins.
 - c. To explain how blood gasses from a patient with a femoral arterial cannula should be interpreted differently than those cannulated in different locations.
- III. Definitions:
 - a. “North-South Syndrome” describes a condition unique to VA ECMO patients with respiratory failure utilizing a femoral artery cannula and some native cardiac output. In this condition the native cardiac output competes with flow from the ECMO circuit. In this syndrome the native cardiac output is sufficient to perfuse the patients head and coronary arteries with deoxygenated blood from the left ventricle instead of having oxygenated blood supplied by the ECMO circuit provide circulation to these areas. These patients may present with skin discoloration between the upper torso (north) and the lower torso (south). Oxygen saturation measurements obtained from the right arm may be significantly lower than measurements in the left arm and lower extremities.
 - b. Distal Reperfusion Cannula – a cannula placed into the posterior tibial artery or the femoral artery distal to the ECMO arterial cannula to supply oxygenated blood and circulation to the patient’s leg.
 - c. VA-V ECMO: A patient on ECMO with a venous cannula for drainage and both an arterial reinfusion cannula and a venous re-infusion cannula. In this mode, the patient is receiving both VV and VA ECMO support.
 - d. VA = Veno-Arterial
 - e. VV = Veno-Venous
- IV. Policy Standards:
 - a. After the patient is cannulated in the femoral artery, circulation to the cannulated extremity should be assessed.
 - b. VA patients with femoral cannulation who have native cardiac output and respiratory failure should be assessed for the presence of “North-South Syndrome”.
 - c. Inability to obtain venous access in the neck may necessitate cannulation of both femoral veins to enable VV ECMO support.



V. Procedures/Actions:

- a. Assessment of perfusion distal to a femoral arterial cannula:
 - i. Should be performed hourly.
 - ii. Physician notification is required if decreased perfusion is observed.
 - iii. Placement of a distal reperfusion cannula may be indicated.
- b. Assessing support in patients with a femoral arterial cannula:
 - i. If North-South syndrome is suspected apply a pulse ox to the right hand and comparing the results with another extremity. If there is a significant difference between the two extremities:
 1. Increase flow if possible
 2. A second venous drain may be necessary to increase flow
 3. Ventilator management may be considered if native pulmonary function has improved.
 4. If native pulmonary function is impaired conversion to VA-V should be considered.
 - ii. Delivery of VV ECMO support utilizing bilateral femoral venous cannulae:
 1. Venous drainage is achieved using a short cannula.
 2. Venous re-infusion is achieved using a long cannula.

VI. Exhibits: None

VII. References: None

Author: James M. Blum, MD 7/20/2014



CANNULATION AND CANNULAE SELECTION

- I. Policy Statements: Standardized cannulation procedures and cannulae selection are required for optimum outcomes and safe patient care.
- II. Purpose:
 - a. To outline the policy for establishing bypass access in patients referred for ECMO.
 - b. To outline the method of cannulation to be used in the event that a patient requires
 - c. ECMO.
 - d. To provide the necessary resources needed for selecting appropriate cannulae for patients requiring ECMO.
- III. Definitions:
 - a. VA = Veno-Arterial
 - b. VV = Veno-Venous
 - c. AEMD = Acting ECMO Medical Director
- IV. Policy Standards:
 - a. The Cannulating physician, in consultation with the perfusionist and AEMD, will select cannulae to be used.
 - b. The Cannulating physician will determine if percutaneous cannulation is possible and in the best interest of the patient.
 - c. Cannulae will be selected based on type of support and flow desired, vessel size and vascular access.
 - d. Patients referred for cardiac ECMO may have existing chest cannulae which may be utilized for ECMO.
 - e. Patients connected to centrifugal ECMO circuits need to have cannulae designed to handle the high negative pressures generated by these circuits.
- V. Procedures/Actions:
 - a. Pre- cannulation:
 - i. The “precannulation” order set should be entered by the physician.
 - ii. A massive transfusion blood pack order should be entered by the physician.
 - iii. If the cannulation is percutaneous, the physician may ask the OR staff to be on “standby” in the event that percutaneous cannulation is not successful and cut-down cannulation becomes necessary.



iv. Percutaneous cannulation:

1. Refer to the Cannula Selection Guidelines to determine which cannula can be used for percutaneous insertion and which are not designed to be used for this type of cannulation procedure.
2. Consider having ultrasound available to assist with vessel location. After percutaneous cannulae are placed, correct vessel placement should be assessed by transducing the cannula prior to initiation of ECMO.
3. Patients cannulated using the femoral artery should have a distal re-perfusion cannula placed after femoral cannulation if there are signs of poor perfusion distal to the cannulation site in the affected limb. Typically 8 Fr. Arterial cannula are placed for distal reperfusion on adult patients.
4. If a double lumen cannula is placed, care should be taken to insure that the orientation of the cannula is correct in order to reduce the amount of blood recirculation. Specifically, the reinfusion lumen (“arterial”) of the double lumen cannula corresponding to the bifurcation should be oriented anteriorly in the event support is inadequate.

v. Supplies needed for all cannulations:

vi. Equipment:

1. Electrocautery (if open)
2. Headlamp or directional lightsource
3. Suction source
4. Over-bed table(s)

vii. Instruments:

1. 3 sterile tubing clamps
2. 2 sterile needle holders
3. 2 sterile scissors (large)

viii. Supplies:

1. Hats, masks, eye protection for everyone in the room
2. Scrub brushes
3. Sterile gloves and gowns for each cannulator
4. 1 prep razor



5. 2 prep kits
6. 4 sterile sheets
7. 8 sterile towels
8. Electrocautery grounding pad (if open)
9. 2 sterile basins
10. 2 sterile 60 cc catheter tip syringes (Tuomy)
11. 4 packages sterile 4x4's
12. 4 packages 0-silk suture popoffs on cutting needle
13. 1 liter Normal Saline
14. 2 10 cc vials Heparin (1000U / cc)
15. 1 30 cc vial 1% Lidocaine
16. 2 10 cc syringes
17. 2 Cook 5F catheter single lumen central line kits

ix. Have available but not open:

1. Electrocautery pen (if open)
2. Sterile suction tubing
3. Suction tip (Yankauer)

VI. Exhibits:

VII. References: None

Author: James M. Blum, MD 7/24/2014



PATIENT SAFETY

- I. Policy Statements: To set guidelines insuring the physical safety of patients while on ECMO
- II. Purpose: Patients on ECMO require additional precautions and vigilance to reduce the potential for harm.
- III. Definitions:
 - a. AP = Advanced Practitioner
- IV. Policy Standards:
 - a. ECMO patients need constant attendance by staff trained on when and how to isolate a patient emergently from the ECMO circuit.
 - b. Due to risk of cannulae dislodgement the use of restraints and/or sedation is to be considered.
 - c. Patients on ECMO require constant attendance by staff trained and competent to isolate the patient from the circuit in case of emergency.
 - d. Because ECMO patients are systemically anticoagulated:
 - i. No IM medications or extra Heparin should be given to the patient.
 - ii. No heel-sticks or vena-punctures should be performed without an explicit order and verification with the fellow, AP, or ICU attending.
 - iii. All invasive procedures should be performed by or under the direct supervision of the Attending Physician or designee.
 - iv. Bedside availability of electrocautery is required before starting any surgical procedure.
 - v. The ECMO Specialists perform a visual inspection of the ECMO circuit every 4 hours and as needed.
 - vi. An emergency rescue circuit will be available on the unit at all times a patient is on ECMO.
 - vii. A supply cart with all necessary components will be on the unit at all times a patient is on ECMO.
- V. Procedures/Actions:
 - a. Heparin Management:
 - i. To reduce the risk for bleeding, anticoagulation is closely monitored.
 - ii. In the event that an invasive procedure is to be performed, anticoagulation therapy may be adjusted. Refer to Policy on Anticoagulation.
 - iii. After any invasive procedure, particular attention should be given to monitoring



the patient for bleeding around the surgical site.

iv. Document procedural information.

b. Safety instructions and signage:

i. At all times a sign will be visibly posted at the patient's bedside with instructions on how to safely remove the patient from bypass. The respiratory therapist and the bedside RN review these instructions whenever there is a staffing change.

c. Visual inspection of the circuit:

i. A thorough visual inspection of the circuit is performed at least every 4 hours

ii. Adverse findings should be reported to the on-call perfusionist.

VI. Exhibits: Bedside Signs

a. [Isolation of patient from circuit](#)

b. [Emergency Vent Settings](#)

VII. References: none

Author: James M. Blum, MD 7/26/2014



**GUIDELINES FOR USE OF MEDICALLY NECESSARY
RESTRAINTS FOR PATIENTS ON EXTRACORPOREAL SUPPORT**

- I. Policy Statements: Medically necessary restraints are only to be used in a manner which complies with the Emory University Hospital policy on the use of physical restraints.
- II. Purpose: To provide guidelines and recommendations for the use of physical restraints with patients on ELS.
- III. Definitions:
 - a. "ELS" means Extracorporeal Life Support which includes any means of extracorporeal support.
 - b. EUH = Emory University Hospital
- IV. Policy Standards:
 - a. The detrimental consequences from cannulae dislodgment should be communicated to all staff working with an ELS patient. To this end, the use of physical restraints can assist in maintaining a safe environment for these patients whose sedatives and paralytics have been stopped.
 - b. Any initial and continued use of restraints should be in compliance with existing EUH Policy.
- V. Procedures/Actions:
 - a. It is recommended that an order for soft physical restraints be obtained from the patient's physician prior to withholding any sedation or paralytics on an ELS patient because of the increased risk of cannulae dislodgement or impairment of ELS circuit function.
 - b. When an order has been obtained, soft physical restraints may be placed and used on the patient in a manner that complies with EUH policy on the use of restraint. Once restraints are in place, sedation/paralytics may be safely turned off or decreased in rate.
 - c. As per EUH policy, continual assessment of the need for physical restraints is necessary. If and/or when the patient is re-sedated and/or chemically paralyzed, physical restraints should no longer be needed.
- VI. Exhibits: None
- VII. References: EUH restraint policy

Author: James M. Blum, MD 7/20/2014



IN HOUSE TRANSPORT OF THE ECMO PATIENT

- I. Policy Statements: ECMO patients may require travel within the healthcare environment to provide care. Due to risks inherent in the movement of ECMO patients these transports needed to be planned and conducted in a careful manner.
- II. Purpose: To ensure that all personnel involved with the in-house transport of an ECMO patient are aware of the risk and responsibilities involved and take the appropriate precautions during this event.
- III. Definitions: None
- IV. Policy Standards:
 - a. The primary nurse assigned to the patient in the ICU will accompany the patient during transport.
 - b. The respiratory therapist and on-call perfusionist should accompany any patient transported while on ECMO. The role of these two individuals is to ensure that the ECMO circuit and patient are moved as a single unit. One person should be dedicated to the circuit and the other dedicated to the patient.
 - c. The lead ECMO Specialist directs all moving of the ECMO patient and is positioned between the circuit and the patient.
 - d. In the rare event that a perfusionist is not available and the transport needs to occur, a licensed care provider (fellow, advanced practitioner) may take place of the perfusionist after receiving instructions from the Acting ECMO Medical Director. At no time will any personnel other than a perfusionist or ECMO trained respiratory therapist serve as the “lead” individual between the ECMO circuit and the patient.
 - e. The ICU attending must be aware of the transport.
 - f. An ACLS trained physician or advanced practitioner should accompany the patient during the transport.
 - g. Transport medication and staffing complies with Hospital Transport Policy
- V. Procedures/Actions:
 - a. Prior to initiation of transport:
 - i. Early notification of the perfusionist of the impending transport is required unless the transport is emergent due to acute patient changes.
 - ii. Transports requiring travel in an elevator requires the circuit to be placed on the patient’s bed. Many larger hospital beds are too big to fit with an ECMO circuit on a separate cart in an elevator. Equipment selection is on a case by case basis.
 - iii. O₂ tanks must have an adequate amount of gas for the transport and placed in a secure holder during transport. The O₂ tank must be turned on and the flow meter adjusted before starting the transport. The sweep may then be transferred to the tank.



- iv. Disconnect as many IV and monitor lines, not needed for the transport, as possible.
 - v. Transfer as many infusions directly into the patient (and not the circuit) as possible.
 - vi. If the patient is on Hemofiltration it will be discontinued for the duration of the transport.
 - vii. Cover the patient with extra blankets since the circuit warmer will be interrupted.
 - viii. The ECMO power cord is lastly unplugged. Verify continuous pump function and battery status.
- b. During Transport:
- i. Constant communication among all personnel involved is imperative in all stages of the transport.
 - ii. The respiratory therapist, positioned between the patient and the stretcher, is responsible for ensuring that the circuit and patient move as one unit. The respiratory therapist directs the movement of the patient and circuit. The perfusionist or designee will assist in moving the circuit. Together, both staff will keep a vigilant watch for potential problems.
 - iii. The largest elevator should be ready and waiting for the patient to board.
 - iv. Move slowly and be prepared to stop quickly.
 - v. Observe the patient's vital signs and support indicators.
- c. Completion of the transport:
- i. The cardiohelp should be plugged into an electrical outlet as soon as is possible.
 - ii. Reattach the sweep line to a wall mounted flow-meter.
 - iii. Once the battery is plugged back into an electrical outlet, ensure that the water bath is functioning at the desired setting.
 - iv. Complete appropriate documentation

VI. References:

Author: James M. Blum, MD 7/26/2014



PRONING PATIENTS ON ECMO

- I. Policy Statements: Prone positioning a patient while on ECMO can be a useful tool for improving pulmonary hygiene, improving both oxygenation and tidal volumes. Proper positioning of patients in a prone position is vital to patient safety.
- II. Purpose: To establish guidelines for prone positioning of patients on ECMO.
- III. Definitions:
 - a. “Proning”: To prone: The action of placing a patient face-down, in the prone position; prone positioning.
- IV. Policy Standards:
 - a. Any disturbance of cannula placement in an ECMO patient could be life threatening. Adequate patient sedation prior to proning is imperative, as the proning process may stimulate and frighten a patient.
 - b. An attending physician may order proning of these patients if they deem that the benefit of proning the patient outweighs the risks. Proning is contraindicated in the following types of patients:
 - i. Patients with open chests or chest cannulation
 - ii. Hemodynamically unstable patients
 - iii. Patients experiencing hemorrhage or excessive bleeding
 - iv. Patients with a fresh tracheotomy
 - v. Pregnant patients
 - c. Prior to initiating proning, the managing physician must write an order for prone positioning specifying frequency and duration. (typically every 6 hours, for 6-hour duration)
- V. Procedures/Actions:
 - a. Assess adequacy of patient sedation and oxygenation prior to proning.
 - b. Assess stability of cannulae, ETT/tracheotomy and of patient hemodynamics.
 - c. Prepare patient as above and inform patient of intent.
 - d. Discuss thoroughly the procedure first with all assisting personnel to ensure a smooth transition to the prone position.
 - e. Prior to prone positioning, secure the cannula and extensions using some type of elastic wrap (Coban).
 - f. The respiratory therapist should ideally be positioned near the patient’s head, groin or foot cannulae (whichever is applicable) to stabilize them during the proning process. If cannulated in multiple sites, a second person may be needed to stabilize all cannulae



under the direction of the respiratory therapist.

- g. When all attendants verbalize readiness, the patient should be log rolled, in a manner to maintain cannula integrity.
- h. A three-quarter patient turn is adequate to achieve desired effect. Place pillows or long rolled blankets lengthwise along patient's chest and abdomen to support the patient. Insure that cannulae are also adequately supported and eliminate any stress or torque on sutures. Use foam or gel devices to support patient's head and tracheotomy tube. Care should be taken as well to prevent the medial aspect of the patient's knees from pressure sores.
- i. Excess tubing must be secured to avoid torque and weight pulling against the cannula sutures.
- j. Endo tracheal or tracheotomy tube tension must be fully assessed while prone.
- k. Care should be taken to provide adequate padding to delicate areas of the face and to bony prominences while prone.
- l. l. While in prone position, they should still have slight position changes as tolerated to preserve skin integrity.

VI. Exhibits:

VII. References: None

Author: James M. Blum, MD 7/28/2014



MANAGEMENT OF PATIENTS ON VENOARTERIAL-VENOUS (VA-V)
ECMO

- I. Policy Statements: Managing patients on VA-V bypass requires a thorough understanding of both veno-venous and veno-arterial bypass.
- II. Purpose: To outline the management issues of patients on VenArterial-Venous ECMO support.
- III. Definitions:
 - a. VA-V ECMO: A patient on ECMO who has a venous cannula for drainage and both an arterial re-infusion cannula and a venous re-infusion cannula. In this mode, the patient is receiving both VV (veno-venous) and VA (veno-arterial) ECMO support.
 - b. “North-South Syndrome” describes a condition unique to VA ECMO patients with respiratory failure utilizing a femoral artery cannula and some native cardiac output. In this condition the native cardiac output competes with flow from the ECMO circuit. In this syndrome the native cardiac output is sufficient to perfuse the patients head and coronary arteries with deoxygenated blood from the left ventricle instead of having oxygenated blood supplied by the ECMO circuit provide circulation to these areas. These patients may present with skin discoloration between the upper torso (north) and the lower torso (south). Oxygen saturation measurements obtained from the right arm may be significantly lower than measurements in the left arm and lower extremities.
- IV. Policy Standards:
- V.
 - a. The ECMO managing physician should be consulted for minimum flow parameters through multiple cannulae.
 - b. Flow to the right atrial cannula (venous re-infusion) should be regulated to achieve the right upper extremity (north) saturation at parameter levels as physician directed utilizing a Hoffman clamp.
 - c. When caring for a patient on VA-V support, flow through the femoral arterial cannula must be monitored with a transonic flow-meter.
 - d. The Hoffman clamp site should be inspected and the position of the clamp moved at least every 4 hours to prevent clot formation.
- VI. Procedures/Actions:
 - a. For a patient with an arterial cannula in the femoral artery, increasing the flow to the femoral artery cannula will result in increased oxygen delivery to the abdomen and lower extremities.
 - b. To improve oxygenation to the patient’s head and coronaries, a venous re-infusion cannula may be placed, typically into the patient’s right internal jugular vein. Blood return to the patient will then be directly partially through the venous cannula, and partially through the femoral arterial cannula.
 - c. Adding a third cannula when a patient is already on support and anticoagulated should be done with caution. Additional anticoagulation is not required.



d. Monitoring Flow:

- i. The resistance of each cannula and the patient's vascular bed affects blood flow from the ECMO circuit. The arterial cannula has higher resistance than the venous cannula; blood will preferentially perfuse the venous re-infusion cannula. A Hoffman clamp is used to adjust the resistance in the venous re-infusion cannula thereby directing blood flow to both the arterial and venous re-infusion cannulas.
- ii. Retrograde flow from the femoral artery to the venous re-infusion cannula is possible, particularly at decreased pump speed and with increased cardiac output.
- iii. The Hoffman clamp is adjusted until flow is distributed as directed. Minute adjustments on the Hoffman clamp translate into marked changes in the flow rates through the cannula.
- iv. Flow must be monitored at all times with an alarm capable flow meter.

VII. Exhibits: None

VIII. References:

Author: James M. Blum, MD 7/30/2014



MANAGEMENT OF DISTAL REPERFUSION CANNULA

- I. Policy Statements: Patients cannulated with a femoral arterial cannula can experience compromised distal perfusion. A distal reperfusion cannula may be used to improve perfusion to the affected extremity.
- II. Purpose: To outline the management issues and interventions of patients who have a distal reperfusion cannula in place.
- III. Definitions: Distal Reperfusion Cannula – a cannula placed into the posterior tibial artery or the femoral artery distal to the ECMO arterial re-infusion cannula to supply oxygenated blood and circulation to the patient’s leg.
- IV. Policy Standards:
 - a. After the patient is cannulated in the femoral artery, circulation to the cannulated extremity should be assessed.
 - b. When inadequate distal perfusion is identified, the physician should be notified immediately. The physician will then determine the need for a distal reperfusion line.
 - c. The extremity in which the distal reperfusion cannula is placed should be assessed hourly. The warmth and color of the affected leg should be documented to determine if adequate perfusion exists to the extremity.
 - d. A transonic flow probe should be attached to the re-infusion line to monitor flow. Alarms should be set to alert the clinician of changes in flow through the re-infusion catheter.
 - e. In the event that the patient’s leg does not improve in warmth and color or becomes dusky, mottled and/or cold after the placement of the cannula, and/or the flow cannot be maintained at set parameter, the managing physician should be notified immediately.
 - f. Parameters for minimal flow rates will be determined by the managing physician.
- V. Procedures/Actions:
 - a. A Hoffman clamp may be required on the arterial tubing going into the femoral artery to divert adequate flow into the distal reperfusion cannula. The clamp will be moved at least every 8 hours.
 - b. Supplies required:
 - i. 6 and 8 Fr. Arterial cannulae and/or Cordis introducer set.
 - ii. Post-tibial tubing set.
 - iii. A transonic .” flow probe and monitor with alarm capability.
 - c. Suggested procedure after placement of the reperfusion cannula:
 - i. Connect the post-tibial tubing set to the Luer-lock connector on the arterial cannula.



- ii. Use the patient's blood to prime the post-tibial tubing set.
- iii. The physician will make a bubble free connection to the cannula.
- iv. Attach transonic flow probe.
 - v. Apply Hoffman clamp to arterial cannula tubing if needed to regulate flow.
 - vi. Set transonic flow alarms.
 - vii. After cannula is sutured, secure with coban.
 - viii. Complete necessary documentation.

VI. Exhibits:

- a. Haley, M., Fisher, J., Ruiz-Elizalde, A., Stolar, C., Morrissey, N., Middlesworth, W.,(2009). Percutaneous distal perfusion of the lower extremity after femoral cannulation for veno-arterial extracorporeal membrane oxygenation in a small child. *Journal of Pediatric Surgery*, 44 (2), 437-440

Author: James M. Blum, MD 8/10/2014



TRIALING OFF VV ECMO

- I. Policy Statements: A patient on VV ECMO that has demonstrated improvement in native pulmonary function, oxygenation and hemodynamics may be ready to trial off of ECMO.
- II. Purpose: To outline the steps for conducting a trial off VV ECMO.
- III. Definitions: VV= Venovenous.
- IV. Policy Standards:
 - a. The managing physician will make the decision to trial the patient off and must be available throughout the trial.
 - b. The ECMO Specialist must be at the bedside prior to starting the trial off procedure for Primary Care Managed patients. The ECMO Specialist remains at the bedside for neonatal and pediatric patients.
- V. Procedures/Actions:
 - a. The patient should display improved lung function as indicated by one or more of the following:
 - i. A rise in the SVO₂ when the FiO₂ is increased to 100%.
 - ii. The patient's tidal volume has increased.
 - iii. The patient is adequately supported by progressively less ECMO flow and sweep.
 - iv. The patient's chest x-ray has improved.
 - b. Increase the ventilator settings.
 - c. Remove the sweep from the oxygenator.
 - d. Circuit blood flow is unchanged.
 - e. The heparin management is unchanged.
 - f. Hemofiltration can continue during the VV trial.
 - g. Infusions into the ECMO circuit may continue.
 - h. Record observations, vital signs, ABGs, ventilator changes and other interventions in the appropriate sections of the medical record.
 - i. A VV trial is concluded when sweep is reconnected to the oxygenator.
- VI. Exhibits: None
- VII. References:



TRIALING OFF VA ECMO

- I. Policy Statements: A patient who has demonstrated improvement in cardiopulmonary function may be ready to trial off of ECMO.
- II. Purpose: To outline the steps necessary to conduct a trial off VA ECMO.
- III. Definitions:
 - a. “Flashing” means allowing blood to flow through the ECMO cannulae by resuming support for a brief time.
 - b. VA = Veno-Arterial
 - c. “CRRT” Continuous Renal Replacement Therapy
 - d. Prismaflex- Brand name of a CRRT device manufactured by Gambro.
 - e. AEMD – Acting ECMO Medical Director
- IV. IV. Policy Standards:
 - a. The managing physician will make the decision to trial the patient off and must be available throughout the trial.
 - b. During the trial off, blood flow through the ECMO cannulae is interrupted. Frequent “flashing” of the cannula is required to maintain patency. During flashing of the circuit, the patient’s blood pressure may increase. Decrease ECMO pump flow prior to flashing.
 - c. The perfusionist must be at the bedside during the entire trial off procedure.
- V. Procedures/Actions:
 - a. a. IV infusions should be administered directly to the patient.
 - b. b. Hemofiltration with a Prismaflex connected to the ECMO circuit should have the blood pump running during the trial to preserve the Prismaflex circuit.
 - c. Hemofiltration via the circuit will be interrupted requiring IV drips and all other pumps related to Hemofiltration to be placed on hold. This includes Ultrafiltrate, Replacement, Calcium, Bicarbonate, Citrate, and Dialysate.
 - d. Patients that are not systemically anticoagulated must have the Prismaflex system disconnected from the ECMO circuit prior to starting the trial off. The Prismaflex system can be placed in recirculation mode per hospital CRRT guidelines during the trial off.
 - e. Ventilator settings are adjusted prior to beginning the trial off.
 - f. The physician may request that the ECMO pump flow be gradually weaned down prior to starting the trial off.
 - g. Blood products and all medications are given directly to the patient.



- h. Prior to commencement of the trial off, the heparin infusion may be adjusted in anticipation of reduced flow to the ECMO circuit.
- i. Flow may be reduced to 1 liter/minute in a manner deemed suitable by the managing physician.
- j. Prolonged periods of low flow may indicate the need for installation of a stopcock bridge.
- k. Patient tolerance will be monitored, as evidenced by changes in hemodynamic and respiratory support markers for a period of 1-2 hours.
- l. For patients with questionable cardiac output and only after consultation with vascular surgery and the AEMD:
 - i. The patient can be isolated from extracorporeal support entirely by placing a tubing clamp on the arterial limb of the circuit for a period of time not to exceed 2 minutes.
 - ii. Pump speed should be adjusted to 1000 RPM during this interval to reduce hemolysis and prevent excess negative inlet pressure.
 - iii. At the end of this interval, remove the tubing clamp and adjust RPM for a flow of 1 liter/minute.

VI. Exhibits:

VII. References:

Author: James M. Blum, MD 8/10/2014



TRIALING OFF VA-V ECMO

- I. Policy Statements: A patient who has demonstrated improvement in their cardio pulmonary function may be ready to trial off of ECMO.
- II. Purpose: To outline the steps necessary to conduct a trial off VA-V ECMO.
- III. Definitions:
 - a. VA-V ECMO: A patient on ECMO who has a venous cannula for drainage and both an arterial re-infusion cannula and a venous re-infusion cannula. In this mode, the patient is receiving both VV (veno-venous) and VA (veno-arterial) ECMO support.
 - b. “Flashing”: allowing blood to flow through the ECMO cannulae by resuming support for a brief time.
- IV. Policy Standards:
 - a. The managing physician will make the decision to trial the patient off and must be available throughout the trial.
 - b. During the trial off, blood flow through at least one of the ECMO cannulae is interrupted. Frequent “flashing” of these cannulae is required to maintain patency. During flashing of the cannulae, the patient’s blood pressure may increase. It may be necessary to decrease ECMO pump flow prior to flashing.
 - c. The patient should have stable vital signs and adequate sedation for a trial off.
 - d. Perfusion must be at the bedside during the entire trial off procedure.
- V. Procedures/Actions:
 - a. Keep in mind that these patients are partially on V-V and V-A support.
 - b. There are two options for trialing off VAV ECMO support; the trial can involve only the VA portion of support or both the VV and VA portions of support.
 - c. Preparation for Trial Off:
 - i. To trial off there is no need to start any additional heparin infusions.
 - ii. Hemofiltration via the circuit can continue without interruption.
 - iii. Medication infusions into the circuit can continue.
 - iv. The physician may request that the flow through the arterial cannula be gradually weaned down prior to starting the trial off.



d. Trial off procedure:

i. VA component of support only:

1. Clamp the arterial limb of the circuit between the wye connector and the arterial cannula. This essentially makes the circuit a VV circuit.
2. Remove the Hoffman clamp on the venous re-infusion tubing.
3. Adjust flow if needed to desired rate through the remaining VV circuit.
4. Flash the arterial cannula every 10-15 minutes (or when settling out of blood occurs) for up to a minute. To flash, release the clamp on the tubing leading to the arterial cannula and place it partially on the venous re-infusion limb (allow some flow to continue through the venous reinfusion limb and distal reperfusion cannula, if present). Avoid arterial cannula back flow (A-V shunt).

ii. VV and VA components of support:

1. To trial both VA and VV support, perform steps 1-4 above and remove sweep from the oxygenator.
2. Flashing of the arterial cannula is still necessary. Adjust RPM's to maintain forward flow through arterial cannula. During this trial flow is maintained through the venous cannulae so no additional flashing is necessary.
3. Record observations, vital signs, ABGs, ventilator changes and other interventions in the appropriate sections of the medical record.
4. To end the trial reattach sweep (if removed), release the clamp on the tubing leading to the arterial cannula and replace the Hoffman clamp on the venous re-infusion tubing, adjust flows and alarms as indicated.

VI. Exhibits: None

VII. References:

Author: James M. Blum, MD 8/15/2014



BLOOD PRODUCT AND TRANSFUSION PRACTICES

- I. Policy Statements: Transfusion and handling of blood products will conform to the policies of EUH Blood Bank as outlined in the Blood Transfusion Policies and Standard Practices.
- II. Purpose: This policy is an enhancement to the EUH Massive Transfusion Protocol (MTP) with a focus on issues that are specific to the ECMO population based on consensus input from the ECMO physician and pharmacy team.
- III. Definitions:
 - a. ECMO Pack means a blood order that consists of multiple blood products required for ECMO initiation.
 - b. “Reconstituted blood” means a unit of PRBC’s with medications added to make the blood more physiologically compatible for massive transfusion. The medication mixture is listed in policy 3.3C ECMO blood priming and prime gas correction.
 - c. “Cryo” is Cryoprecipitated Anti-Hemophilic Globulin
 - d. A transfusion is described for patients under 50 Kg as 10-20 ml/kg of blood products.
 - e. A transfusion is described for patients over 50 Kg as 1 unit of blood products.
 - f. “Excessive bleeding” is defined as blood loss of more than 30 ml/kg/hr.
- IV. Policy Standards:
 - a. The attending physician and/or fellow or other medical management leads (PA, NP) must be notified for any blood loss of more than 20 ml/kg/hr.
 - b. All blood products for Primary Care Managed patients are given by the bedside RN via patient access.
 - c. All blood products for Non-Primary Care Managed patients are given by the ECMO specialist via circuit access.
 - d. Any references to blood product administration via the circuit refer exclusively to Non-Primary Care Managed patients.
 - e. Platelets and Cryo must not be refrigerated.
 - f. Extracorporeal circuits for patients weighing below 25 Kg. will be blood primed except in a clinical emergency. ECMO circuits for patients of 25 Kg. or more may be blood primed at the discretion of the managing physician.
 - g. Back-up blood (PRBC) in the following minimum quantities will be available at all times on the nursing unit caring for ECMO patients - 2 units -patients on a 3/8 inch circuit.
 - h. The bedside nurse is responsible for ensuring back up blood is on the unit.
 - i. A current type and screen will be maintained on all patients on ECMO or with ECMO cannulae indwelling.



- j. Blood Bank should be notified as soon as possible by phone of the need for an emergency ECMO Pack. A physician order is required in the medical record.

V. Procedures/Actions:

- a. Patients receiving transfusions for blood loss of more than 20 ml/kg/hr require notification of attending and/or fellow.
- b. Patient with excessive bleeding, as defined (30 ml/kg/hr):
 - i. Blood replacement should approximate as follows:
 - 1. 1 U PRBC's
 - 2. 1 U FFP
 - 3. 1 pack of platelets
 - 4. Cyro replacement depending on last fibrinogen level, replace if less than ordered parameters, standard level is >100.
 - 5. Calcium replacement should be continued during transfusion through separate access and should be evaluated after PRBC's and FFP are administered.
 - 6. Factor VIIa administration to ECMO patient is covered in its own section of the pharmacologic management policy
 - ii. A physicians order for the massive transfusion blood pack must be entered into the medical record. The unit administrative assistant is to be instructed by the ordering physician, perfusion/rt or bedside RN to obtain blood products. The perfusionist should verify that blood products required for the initiation of ECMO have been ordered and requested to be sent from the blood bank.
 - iii. Type and Screens should be sent at approximately 1700 on the evening that the current type and screen expires.
 - iv. Ideally a Type and Screen sample should be obtained prior to the patient receiving any emergency blood products.
 - v. Blood products sent from Outside Hospitals will be kept in their shipping container and used only if cross-matched blood is not yet available. When cross-matched blood products become available, all remaining products from the outside hospital will be sent to the blood bank in their shipping container for processing.
 - vi. Physician ordered parameters dictate transfusion practices.
 - vii. Types of blood products used in ECMO:
 - 1. PRBC (packed red blood cells) are transfused to keep the patient's Hematocrit (Hct) within the ordered parameters. Typically ordered as 1 to 2 units in adult patients.



2. Platelets are given to keep the platelet count within the ordered parameters. 5 units for adults.
3. FFP (fresh frozen plasma) can be ordered when there is either a blood volume deficit or coagulation factor deficiency (documented or suspected). Typically ordered as 1 to 2 units in adult patients. Refer to the ACT and lab ordering policy.
4. Cryoprecipitate (Cryoprecipitated Anti-Hemophilic Globulin) is transfused to elevate fibrinogen levels within ordered parameters or used to make “surgical fibrin glue” for topical hemostasis. Dosing is usually up to 10 units for pediatric/adult patients based on clinical indicators.
5. When a patient is requiring multiple transfusions it may be helpful to check their calcium levels. Calcium is needed as part of the coagulation cascade. Citrate binds to Calcium and is used to anti-coagulate some banked blood products, additional Calcium may need to be administered to maintain systemic (and Ionized) Calcium levels within normal limits.

viii. Blood Product Administration:

1. Blood products are administered directly to the patient. Administration through the circuit requires approval of the AEMD and may only be done by perfusion (see below).
2. During platelet transfusion ACTs may be checked more frequently (every 20-30 min) since platelets may increase Heparin consumption. The rate of a platelet transfusion is dictated by the patient's hemodynamic response, and ACT changes.
3. In situations where it is not possible to administer blood products at a rate needed to support patient needs; administration of products utilizing the circuit is indicated. Contact the AEMD and perfusion STAT for permission prior to transfusing via the circuit.
 - a. Administering blood products using the circuit has a risk of introduction of air into the ECMO circuit because of the negative pressures within this section of the circuit.
 - b. A perfusionist and RT are required to administer blood products using the circuit. One is responsible for pump management and the other is solely responsible for administering blood products.
 - c. To prepare to administer blood products via the circuit, double clamp the pigtail with hemostats and remove the dead-end cap. Place a saline primed stopcock on the pigtail.
 - d. Obtain a blood transfusion set (Y tubing set) and IV bag of saline. Remove all air from the saline bag and prime the blood tubing set ensuring it to be air free.



- e. Attach the blood tubing set to the pigtail.
 - f. Administer blood products being mindful of volume remaining in the bag and the potential for air entrainment into the ECMO circuit. One ECMO Specialist maintains constant attention to the transfusion.
 - g. When it is no longer necessary to administer blood products via the pre-bladder pigtail, double clamp the pigtail with hemostats, remove the stopcock and blood tubing set, replace with a dead-end cap.
4. Fibrin Glue:
- a. Blood bank should be notified that the cryoprecipitate being ordered is for use as fibrin glue.
 - b. Fibrin Glue is prepared as follows:
 - i. Cryoprecipitate - 20 ml (2-3 units)
 - ii. 10ml (one vial) of Topical Thrombin (obtained from pharmacy).
 - iii. 10ml Calcium Gluconate or Calcium Chloride (1 Gram).
 - iv. After the Thrombin is reconstituted, the Calcium and the Thrombin are drawn up together in one syringe. Then 20 ml of Cryoprecipitate is drawn up in a second syringe. The physician or designee then injects the contents of the two syringes simultaneously into the wound to establish hemostasis. Mixing of these ingredients causes congealing to occur almost instantaneously.

VI. Exhibits:

VII. References:

Author: James M. Blum, MD 8/20/2014



MEDICATION ADMINISTRATION

- I. Policy Statements: Medication administration is a vital part of ECMO support requiring best practices for safety and efficiency.
- II. Purpose: To establish guidelines for the administration of IV medications via the ECMO circuit per the ECMO Specialist and bedside RN.
- III. Definitions: None
- IV. Policy Standards:
 - a. It is the bedside RNs' responsibility to verify the Five Rights of Medication Administration (the right patient, medication, dosage, route, delivery time), as well as to program any pump used, document and supervise the administration of medications in a timely manner.
 - b. Only the perfusionist may attach and/or disconnect IV medication syringe or tubing being administered into the ECMO circuit.
 - c. Each medication has its own contraindications and precautions in administration. The bedside RN is responsible for informing the ECMO Specialist of any unique medication administration requirements.
 - d. If an adverse medication reaction occurs during or after the medication has been administered, the bedside RN is responsible for physician notification and treatment.
 - e. Medications are not to be infused into the ECMO circuit except in an emergency.
 - f. Emergency IV medications may be given through the ECMO circuit via pigtail ports. These sites can be utilized for intermittent and continuous medications.
 - g. The nurse is responsible for obtaining an order, initiating and titration of the infusion of the ordered anticoagulant.
 - h. The ECMO Specialist will review the Five Rights of Medication Administration of Heparin with each change of the syringe and at each start of his/her shift
 - i. IV bags accessed for flush solution expire 24 hours after spiking.
- V. Procedures/Actions:
 - a. Stopcocks that will be exposed to lipids should be designated "lipid safe" by their manufacturer.
 - b. Only the ECMO Specialist may attach and/or de-access connections to the ECMO circuit.
 - c. Medication Administration:
 - i. Once a medication has been supplied, the syringe and/or primed tubing is aseptically connected to the circuit pigtail in a bubble free manner by the ECMO Specialist



- ii. Intermittent or continuous infusions should be administered by infusion pumps with selections based on patient weight and pre-programmed dosing ranges selected by the bedside nurse and then administered within the appropriate time frame.
 - iii. Flushes should be administered at the same rate as the completed medication. Flush volumes should be considered for the various tubing and stopcocks used for medication administration. (Approximate volumes - mini-bore tubing are 0.3 ml, Macro tubing 2 ml for, stopcock 0.2 ml, 6 inch pigtail 0.4 ml)
 - iv. Amicar, Calcium and vasoactive medications must be administered directly into the patient's access and not into the circuit unless there is no other alternative access.
 - v. The bedside RN is responsible for titration of continuous infusions.
- VI. Exhibits: None
- VII. References:
- a. Micromedex Medication Reference website

Author: James M. Blum, MD 8/20/2014



CONTINUOUS RENAL REPLACEMENT THERAPY

- I. Policy Statements: Many patients with severe cardiopulmonary failure become overloaded with fluid as a result of resuscitative efforts. CRRT, also referred to as hemofiltration, may be used to effectively manage fluid and electrolyte balance in concert with their ECMO support.
- II. Purpose: To establish guidelines for the safe application of CRRT on ECMO patients.
- III. Definitions:
 - a. CRRT- Continuous Renal Replacement Therapy.
 - b. Prismaflex- Brand name of a CRRT device manufactured by Gambro.
- IV. Policy Standards:
 - a. ECMO circuits are not configured to enable CRRT by default. If CRRT is required, preferred access will be thorough a separate dialysis catheter.
 - b. In the event a dialysis catheter cannot be placed, a perfusionist can connect or disconnect a Prismaflex circuit to the ECMO circuit.
- V. Procedures/Actions:
 - a. Aggressive diuretic therapy is often attempted prior to using CRRT.
 - b. CRRT has the capability to quickly alter the level of fluids, electrolytes and some medications and potentially vital signs. Consequently, fluid management, electrolyte and drug levels must be carefully monitored.
 - c. Euvolemia with normalization of electrolytes and renal lab values are typically the goals of CRRT.
 - d. Daily patient weights should be followed to assess overall fluid loss.
 - e. Orders for CRRT should be updated daily and as needed by the Nephrology service or managing service.
- VI. Exhibits: None
- VII. References:

Author: James M. Blum, MD 8/20/2014



SWEEP GAS MANAGEMENT

- I. Policy Statements: A thorough understanding of sweep and how it affects the circuit is crucial to providing safe patient care.
- II. Purpose: To outline the use of sweep within the ECMO circuit and to explain the proper use of oxygenators regarding rated (blood) flow, sweep gas flow rates, and related safety devices.
- III. Definitions:
 - a. Sweep Gas – The gas blown through the oxygenator. The FIO₂ may range from 0.21 to 1.0. This gas can be Oxygen, Carbogen, and/or room air.
 - b. Carbogen – Compressed gas that consists of 95% O₂ and 5% CO₂.
 - c. Air/O₂ Blender – a device which blends air and 100% O₂ to create FIO₂ between 0.21 and 1.0.
 - d. “Trial off” refers to a prescribed and measured removal from ECMO support to evaluate the patients level of recovery and ability to remain stable with conventional cardiopulmonary support.
- IV. Policy Standards:
 - a. To assure patient safety during ECMO support, the blood flow rate and sweep gas flow rate and FIO₂ will be closely monitored and adjusted as needed.
 - b. Patient arterial blood gasses should be evaluated after every sweep gas flow rate change. The patient should be monitored for clinical responses to changes in the sweep gas.
 - c. Interventions to correct alkalosis require evaluation of underlying causes.
- V. Procedures/Actions:
 - a. Sweep gas is the source of oxygen added to the blood through the oxygenator. Sweep gas should only be disconnected during a trial off procedure.
 - b. Oxygen Delivery information is located in policy 3.1U Oxygenation Management.
 - i. An air/O₂ blender can be used to lower the FIO₂ of sweep gas as indicated in Policy
 - ii. The FIO₂ controlled by an air/O₂ blender does not affect CO₂ removal.
 - iii. CO₂ Removal:
 1. CO₂ diffuses passively from the blood into the gas phase of the oxygenator and is flushed away by the flow of the sweep gas.
 2. The sweep gas flow rate across the oxygenator is used to regulate the PaCO₂ in the ECMO patient’s blood
 3. Increasing sweep gas flow rate will increase CO₂ removal.



4. Decreasing the sweep gas flow rate will decrease the amount of CO₂ removed.
5. If CO₂ removal is inadequate at maximum rated gas flow rate, notify the managing physician and AEMD, and draw pump gasses to evaluate the amount of CO₂ being removed. If the overall gas exchange function of the oxygenator is in question replacing the oxygenator or addition of a second oxygenator may be indicated.
6. The minimum sweep for the Quadrox iD adult is 0.5 L/min. Sweep below this minimum must be specifically ordered by the managing physician. Oxygen delivery and CO₂ clearance will be evaluated with patient and pump blood gasses with each incremental setting below 0.5 L/min.
7. If CO₂ remains less than the written parameters when the sweep is 0.5L/min and the blood bicarbonate is within normal range:
 - a. Consider trialing off ECMO.
 - b. Consider ventilator management to reduce native lung CO₂ removal.
8. Treatment of metabolic alkalosis should not be accomplished by inducing respiratory acidosis (hypercarbia).
 - a. Consult with managing physician to evaluate and treat the metabolic alkalosis.

VI. Exhibits: None

VII. References:

Author: James M. Blum, MD 8/20/2014



OXYGENATION MANAGEMENT

- I. Policy Statements: A thorough understanding of oxygenator function and patient pathophysiology related to oxygen delivery and consumption is crucial to providing safe patient care.
- II. Purpose: To describe the methods both physiological and mechanical used to achieve oxygen delivery through the ECMO circuit.
- III. Definitions:
 - a. Air/O₂ Blender – a device which blends air and 100% O₂ to create FIO₂ between 0.21 and 1.0.
 - b. Sweep Gas – The gas blown through the oxygenator. The FIO₂ may range from 0.21 and 1.0. This gas can be Oxygen or room air.
 - c. “Trial off” refers to a prescribed and measured removal from ECMO support to evaluate the patients level of recovery and ability to remain stable with conventional cardiopulmonary support.
 - d. “North-South Syndrome” describes a condition unique to VA ECMO patients with respiratory failure utilizing a femoral artery cannula and some native cardiac output. In this condition the native cardiac output competes with flow from the ECMO circuit. In this syndrome the native cardiac output is sufficient to perfuse the patients head and coronary arteries with deoxygenated blood from the left ventricle instead of having oxygenated blood supplied by the ECMO circuit provide circulation to these areas. These patients may present with skin discoloration between the upper torso (north) and the lower torso (south). Oxygen saturation measurements obtained from the right arm may be significantly lower than measurements in the left arm and lower extremities.
 - e. “Recirculation” describes a condition in a patient on VV ECMO where oxygenated blood from the arterial cannula is drained back into the ECMO circuit via the venous cannula reducing delivery of oxygenated blood to the systemic circulation.
- IV. Policy Standards:
 - a. To assure patient safety during ECMO support, the blood flow rate and sweep gas flow rate and FIO₂ will be closely monitored and adjusted as needed.
 - b. Patient arterial blood gasses should be evaluated after every sweep change. The patient should be monitored for clinical responses to changes in the sweep gas.
 - c. Evaluation of oxygen delivery is primarily monitored through SPO₂ and SVO₂ readings which are directly influenced by the blood flow rate.
- V. Procedures/Actions:
 - a. Sweep gas is the source of oxygen added to the blood through the oxygenator. Sweep gas should only be disconnected during a trial off procedure.
 - b. CO₂ removal information is covered in policy on Sweep Gas Management.



- c. Oxygenator mechanics:
 - i. Oxygen blown across the membrane oxygenator diffuses passively from the gas phase into the blood phase.
 - ii. Increasing the blood flow through the oxygenator increases O₂ delivery to the patient.
 - iii. Decreasing the blood flow through the oxygenator decreases O₂ delivery to the patient.
 - iv. The maximum rated blood flow for an oxygenator is determined by the manufacturer.
 - v. Exceeding the rated blood flow of a membrane oxygenator will not correct hypoxemia. This occurs because venous blood passes through the membrane oxygenator too quickly to become fully saturated with oxygen.
 - vi. Blood flow on ECMO circuits should NOT go below the following rates for extended periods: 500 ml per minute
 - vii. Maximum blood flow rates are set by the manufacturer: maximum is 7 L/min
- d. Patient factors affecting oxygenation:
 - 1. Recirculation on VV patients.
 - 2. Body temperature.
 - 3. Sedation and level of activity.
 - 4. Hematocrit levels.
 - 5. Seizures.
 - 6. Sepsis, Inflammation and other disease processes.
 - 7. Patient body mass (Basal Oxygen Consumption).
 - 8. Cannula locations for North/South syndrome.
- e. Determining Function of an Oxygenator:
 - i. Observe color of blood entering and exiting the oxygenator.
 - ii. Ensure sweep is attached to oxygenator and functional.
 - iii. Verify forward blood flow rate.
 - iv. Obtain a pre and post Oxygenator blood gas.
 - v. Evaluate adequate saturation change and CO₂ clearance pre/post.



- vi. Consider function of the blender if used.
- f. Determining Function of an Oxygenator when an O2 Blender is Used:
 - i. With few exceptions sweep is comprised of 100% Oxygen.
 - ii. When a blender is used to decrease the FiO_2 , the post oxygenator PO_2 will not be the customary 300-500mmHg and in fact can be as variable as 60-500mmHg.
 - iii. Factors that affect the diffusion gradient include how de-saturated the blood is entering the oxygenator, blood flow, sweep FiO_2 .
 - iv. If oxygenator function is in question:
 - 1. Turn up the sweep FiO_2 to 100% for 5 minutes before drawing pre and post oxygenator gasses.
 - 2. The pump arterial gas can now be interpreted in the usual manner.
 - 3. Return the blended FiO_2 to the previous setting if able.
- g. Considerations when patient PO_2 is above ordered parameters:
 - i. Reduce ventilator FIO_2 or change ventilator management.
 - ii. Consider lowering pump flow.
 - iii. Reduce FIO_2 of sweep.
 - iv. The patient may require volume.
- h. Considerations when patient PO_2 is below ordered parameters:
 - i. Optimized patient factors affecting oxygenation (i.e. sedation...).
- j. Pump flow at maximum.
 - i. An additional drainage cannula may be indicated.
 - ii. Patient may be fluid overloaded, consider diuretics or increase CRRT net loss.
 - iii. Evaluate oxygenator function
 - iv. Consideration of need for replacement or a second oxygenator.

VI. Exhibits:

VII. References:



HEMOLYSIS DURING EXTRACORPOREAL LIFE SUPPORT

- I. Policy Statements: Hemolysis is a potential complication of ECMO support.
- II. Purpose: To delineate the approach to evaluating and managing hemolysis during ECLS
- III. Definitions:
 - a. “Hemolysis” is the rupture of red blood cells and the release of their contents (hemoglobin) into the plasma. Left untreated, excess hemolysis can lead to renal failure and hyperbilirubinemia. A Serum hemoglobin > 50 mg/dl indicates the need to assess the circuit as a potential source of hemolysis.
- IV. Policy Standards:
 - a. A Serum Hemoglobin sample is obtained at the beginning of the ECMO run and daily thereafter while on ECMO.
 - b. The ECMO Specialist is responsible for screening the results. Results > 50 mg/dl will be reported to the supervising physician.
 - c. The perfusionist is responsible for evaluating potential sources of hemolysis and taking corrective action as necessary in consultation with the supervising physician.
 - d. Any intervention or consultation is documented in the medical record. A plasma or serum hemoglobin result >50 mg/dl should also be recorded as a complication on the ELSO registry.
- V. Procedures/Actions:
 - a. If the Serum Hemoglobin is reported > 50 mg/dl, evaluation for potential sources of hemolysis should include the following:
 - i. Presence of bleeding and clot formation.
 - ii. Cannulae size and placement relative to flow. Small cannulae have higher shearing forces. Evaluate for kinking of the cannulae.
 - iii. Outlet pressure.
 1. If the circuit outlet pressure is >350 mmHg evaluate the following:
 - a. Evaluate the blood pressure (for V-A support). If the BP is above the desired parameter, consult the managing service.
 - b. Evaluate the ECMO pump flow rate as appropriate at reasonable RPM’s for required flow.



- c. Presence of and condition of Hemofilter.
 - i. If the Hemofilter filter is > 3 days old, consider replacing the hemofilter.
 - ii. If the Hemofilter has significant visible clots, consider replacing the hemofilter.

- b. Abrupt elevation in Serum Hemoglobin
 - i. If the Serum Hemoglobin is not consistent with the recent values evaluate for specimen or lab error. Re-send a sample to the lab in a green top tube.
 - ii. Observe the urine; tea colored or clear pink urine is indicative of hemolysis.
 - iii. If the Serum Hemoglobin is consistent with previously obtained readings, there is no need to re-send the specimen.
 - iv. Evaluate excessive negative pressure by observing flow, RPM, Inlet pressure, and observe of the venous line for chatter.
 - v. Evaluate inlet pressures relative to RPM's. If the flow does not increase significantly with RPM increase, increasing RPM's is not the solution to increase flow. Additional measures such as elevation of the bed, fluid administration should be considered instead.
 - vi. If the venous line is collapsing or chattering, consider decreasing the RPM in addition to evaluating volume status. If the volume status is acceptable, evaluate venous cannula position and size.

VI. Exhibits: None

VII. References: None

Author: James M. Blum, MD 8/20/2014



Factor VIIa Administration

- I. Policy Statements: Administration of factor VIIa to any patient on extracorporeal life support requires prior authorization by a physician designated as AEMD.
- II. Purpose: To describe a protocol for administration of Factor VIIa to patients receiving extracorporeal life support (ECLS).
- III. Definitions:
 - a. Factor VIIa - promotes local hemostasis through the extrinsic pathway of the coagulation cascade. Factor VIIa is complexed with tissue factor leading to activation of the coagulation cascade and the generation of thrombin ultimately leading to a stable fibrin clot.
- IV. Policy Standards:
 - a. Administration of Factor VIIa may be indicated in the management of uncontrolled surgical bleeding (or other single site/organ bleeding such as GI hemorrhage, or pulmonary hemorrhage) which is refractory to other interventions including temporary suspension of heparin, the administration of antifibrinolytic agents, the aggressive replacement of clotting factor, and/or surgical exploration.
 - b. Factor VIIa is contraindicated in patients with hypersensitivity to mouse, bovine, or hamster proteins.
- V. Procedures/Actions:
 - a. Authorization for factor VIIa is received from the ECLS medical director or co-director for the specific unit.
 - b. The order for factor VIIa administration is obtained. Unless otherwise specified, dosing will be 25 mcg/kg possibly up to 3 doses administered in relatively close proximity; administered every 8 hours for a total of 9 doses. If there are concerns about circuit clots, it could be recommended to reduce the initial dosing with another reduced dose given an hour later if initial dose is tolerated as an alternative.
 - c. In the operating room, the each dose will be limited to a maximum of 2mg of factor VIIa.
 - d. The perfusionist on call must be notified.
 - e. Patient size appropriate aliquot of platelets is ordered.
 - f. An assembled ERL and perfusionist is required at the bedside before factor VIIa is administered.
 - g. All necessary supplies, including pump-head for centrifugal circuits, clamps, sterile scissors, 60 cc syringes, normal saline flush solution, and connectors should be readily accessible. A managing physician must be at the bedside during factor VIIa administration.
 - h. Factor VIIa must be administered by the bedside RN via patient IV access only.



- i. Platelet infusion should commence prior to administration of factor VIIa. Subsequently, factor VIIa is given as a slow push over 2 to 5 minutes with concomitant administration of platelets.
- j. The ECLS circuit should be monitored for thrombus formation.
- k. Suspicion of circuit failure secondary to significant clot formation should be brought to the immediate attention of the attending physician and the perfusionist on call.

VI. Exhibits: None

VII. References:

Author: James M. Blum, MD 8/20/2014



CARE OF ECMO CANNULAE AFTER DISCONTINUANCE OF ECMO

- I. Policy Statements: ECMO cannulae pose risk to the patient, such as clot formation in and around the cannulae, air introduction, and blood loss. Maintenance of cannulae not being used for ECMO support is required to mitigate risk to the patient.
- II. Purpose: To provide guidelines for the care of ECMO cannulae not actively being used for ECMO support.
- III. Definitions:
 - a. “HIT+” Heparin Induced Thrombocytopenia.
- IV. Policy Standards:
 - a. The ECMO Specialist will assess the ECMO circuit every hour.
 - b. At the conclusion of an ECMO run, cannulae are occasionally left in place.
 - c. An arterial cannula left in place should be removed within 24 hours.
 - d. A venous cannula left in place should be removed within 48 hours.
 - e. A lumen of a double lumen cannula no longer being used for ECMO support can be maintained until the entire cannula is no longer needed and removed.
 - f. For HIT+ patients using Argatroban for anticoagulation consult attending physician for orders regarding flush solution and rate.
- V. Procedures/Actions:
 - a. Reasons for not removing cannulae may include patient instability with potential return to ECMO support.
 - b. Only 0.9%NaCl with Heparin is to be infused through an arterial cannula.
 - c. A venous cannula may have additional continuous infusions in addition to the 0.9%NaCl with Heparin infusion with the perfusionist on call’s list approval.
 - d. The perfusionist on call should be notified prior to ANY manipulation of the cannula or the infusions to the cannula.
 - e. Supplies needed per cannula lumen:
 - i. Perfusion adapter
 - ii. Female-female LL connector
 - iii. Stopcock
 - iv. 70% isopropyl alcohol and sterile 4x4’s
 - v. Sterile scissors



- vi. 3 Tubing clamps
 - vii. Sterile gloves
 - viii. Sterile towels.
 - ix. Body substance isolation equipment.
 - x. Bedside sign
 - xi. 20 or 60ml syringe
 - xii. 0.9%NaCl with Heparin 1unit/ml flush solution.
 - xiii. Infusion pump, tubing set.
- f. Suggested Procedure:
- i. Prep the lines near the cannula with 70% isopropyl alcohol. Carefully place sterile towels under the prepared line.
 - ii. In an aseptic manner assemble perfusion adapter, F-F LL connector, stopcock, and syringe of 0.9%NaCl with Heparin.
 - iii. Triple clamp tubing.
 - iv. Cut the tubing with sterile scissors, leaving two clamps on the tubing proximal to the cannula.
 - v. Attach prepared perfusion adaptor assembly to tubing stub attached to cannula.
 - vi. While holding the plunger on the syringe, release the clamps on the cannula and allow the blood to slowly backfill the connector. Observe for clots. If clots are present DO NOT flush the cannula, notify the cannulator. Do not remove excess volume from the patient. A venous cannula may have to be gently aspirated using a syringe.
 - vii. Slowly and carefully flush the cannula until clear.
 - viii. Cannula size will influence amount of flush used.
 - 1. 8-14 Fr. 15 ml per lumen
 - 2. 14-19 Fr. 15-50 ml per lumen
 - 3. 21 Fr. or larger 50-75ml per lumen
 - 4. Note: For HIT+ patients contact the attending physician regarding
 - 5. amount and type of flush solution to be used.
 - ix. Attach an infusion of 0.9%NaCl with 1unit/ml of Heparin, and infuse at the following recommended order driven rate of 10 ml/hr. per lumen



- x. Blood should not back up into the circuit tubing; the flow rate may require adjustment accordingly.
- xi. Note: For HIT+ patients contact the attending physician regarding amount and type of flush solution to be used.
- xii. Additional infusions can be attached to venous cannula. TPN and lipids are the best choice since they are continuous infusions. Infusions that require titration should not be infused into the cannula because of the amount of dead space in the cannula (5-30 ml).
- xiii. A Heparin infusion is always required regardless of other infusion into the cannula.
- xiv. Infusions may only be attached by an ECMO Specialist.
- xv. The end of the cannula (near stopcocks) must remain elevated above the patient at all times. This is to avoid blood settling in the cannula tubing and potential inadvertent infusion of air bubbles. The infusion tubing should never be suspended from the ceiling.
- xvi. 1 tubing clamp will be left at the bedside for each cannula (or lumen for dual lumen cannula) along with “cannula left in” signage.
- xvii. Complete appropriate documentation.
- xviii. The ECMO Supply cart will be left in the unit until decannulation occurs.
- xix. After decannulation, the perfusionist on call is responsible for completing the decannulation checklist.
- xx. If a cannula is to be used for reinstatement of support it must be aspirated for clots.

VI. Exhibits:

VII. References:

Author: James M. Blum, MD 8/20/2014



OUT OF HOSPITAL TRANSPORTS

- I. Policy Statements: Patients referred from outside institutions may be transported to the EUH while on ECMO support.
- II. Purpose: To outline the process involved in transporting a patient on ECMO from a referring hospital to EUH in a safe manner.
- III. Definitions: None
- IV. Policy Standards:
 - a. Consultation between the perfusionist, transport agency and the requesting physician at EUH must occur prior to accepting a transport referral.
 - b. The perfusionist on call determines circuit and staffing availability.
 - c. The selected transport service determines the feasibility and mode of transport (ground, helicopter, fixed wing or combination).
 - d. Patients will be transported using the EUH ECMO program transport system.
 - e. An ECMO team member must remain with the circuit during all phases of the transport.
 - f. The perfusionist will direct all movement of the patient during loading and unloading or other patient movements. Transport service staff are responsible for securing the patient for transport with input from the ECMO team.
 - g. The transport service in consultation with the perfusionist and accepting physician will determine essential personnel for the return trip, including at least one perfusionist and one RN/Paramedic.
- V. Procedures/Actions:
 - a. Prior to accepting a transport referral the following activities will take place:
 - i. Referral requests are communicated to the appropriate physician.
 - ii. The physician is responsible for contacting the perfusionist.
 1. If a transport is requested the perfusionist will consult with the transfer center regarding resources and timetable.
 2. The perfusionist will initiate the Transport Checklist.
 3. Once the patient transport is accepted:
 - a. The perfusionist will fax information to the referring hospital. (See exhibit Transport fax packet).
 - b. The perfusionist will complete staffing arrangements.
 - c. The perfusionist or designee assembles necessary equipment.



- d. The perfusionist or designee assembles all necessary supplies. (Refer to exhibits b and c).
- e. ECMO Staff going on a transport must:
 - i. Wear attire and flight suits and appropriate footwear as dictated and approved by the transport organization.
 - ii. Have their Emory ID card along with a state issued ID or passport.
 - iii. Have clothing appropriate for current and expected weather conditions.
 - iv. Yield to the pilots' direction as they are the ultimate authority on all airborne transports.
- f. Perfusionist responsibilities during transport:
 - i. Assists with cannulae selection and cannulation.
 - ii. Prepares circuit for initiation of support.
 - iii. Manages the ECMO circuit in support of the patient per physician driven parameters.
 - iv. Titration of anticoagulation.
 - v. Responsible for connecting any infusions into the circuit.
 - vi. Directs team during movement of the patient while on ECMO support.
 - vii. Collaborates with transport agency's RNs and managing physician for patient care.
 - viii. Ensures appropriate and reasonable supplies of blood products.
- g. Perfusionist responsibilities upon arrival to the receiving unit:
 - i. Assist the ECMO Specialist assigned to the patient with stabilization, provide an informative report.
 - ii. Completes appropriate documentation including the ECMO Transport Log.

VI. Exhibits:

VII. References:



ANTICOAGULATION FOR ECMO

I. Policy Statements:

Anticoagulation is a key component of ECMO therapy. For patients on VV ECMO it is reasonable to consider periods of time without continuous anticoagulation. For patients on VA ECMO this should be a rare phenomena.

II. Purpose:

To provide a guide for managing anticoagulation while a patient is on ECMO and provide guidelines for the management of bleeding complications.

III. Definitions:

- a. ECMO – Extracorporeal membrane oxygenation
- b. ACT – Activated clotting time
- c. VA – Veno-arterial
- d. VV – Veno-venous
- e. POC – Point of Care
- f. aPTT – Activated partial thromboplastin time
- g. PT/INR – Prothrombin time / international normalized ratio
- h. CBC – Complete blood count

IV. Policy Standards:

- a. Anticoagulation is physician order driven and managed by the primary service including during initiation of support.
- b. Patients should have ACT measurements at least every four hours to monitor anticoagulation.
- c. Amicar is to be infused via patient IV access not through the circuit.
- d. Suspension of heparin (or heparin substitute) anticoagulation for any Primary Care Managed ECMO patient requires prior notification of the perfusionist of “intent to suspend ECMO heparin” followed by entry of the order.
- e. ECMO suspend orders for patients must be reviewed at least each morning during physician rounds.
- f. The perfusionist should be paged immediately if the decision to restart ECMO anticoagulation is made.



V. Procedures/Actions:

a. Daily Coagulation Labs

- i. aPTT
- ii. PT/INR
- iii. Fibrinogen
- iv. Anti Xa
- v. Plasma Free Hemoglobin (run at CHOA)
- vi. CBC

b. Initial Heparin dosing

- i. Heparin 100 units/kg (Maximum 10,000 units) should be bolused during cannulation or at the discretion of the provider
- ii. Initiate heparin drip at 10 units/kg/hr once the POC ACT falls below 300 seconds (low bleeding risk) or 220 seconds (high bleeding risk) and then follow ECMO POC ACT heparin titration protocol
- iii. Provider will select appropriate POC ACT goal
 1. Low Bleeding Risk (Default) - 180-220 seconds
 2. High Bleeding Risk (Observed active bleeding) – 140-180 seconds
- iv. Argatroban / Bivalirudin protocol will be selected for patients with a history or strong clinical suspicion of HIT or heparin resistance

c. ACT Monitoring

- i. POC ACT will be measured every 1 hour by the ECMO specialist initially
- ii. Once POC ACT is within therapeutic range for 2 consecutive readings, POC ACT will be measured every 4 hours
- iii. After any dose adjustment, POC ACT will be measured every 2 hours until within therapeutic range for 2 consecutive readings
- iv. Any values outside of the goal range will be reported to the critical care team

d. Heparin Titration

- i. Modifications to the heparin infusion via infusion pump are to be made by the bedside RN in response to ACT value measured by ECMO specialist
- ii. Notify critical care team for any heparin dose less than 6 units/kg/hr or greater than 35 units/kg/hr



1. Critical care team to evaluate for heparin resistance or circuit DIC
 - iii. Notify critical care team if morning Anti Xa level is <0.3 or >0.7 with therapeutic POC ACT
 - iv. Additional adjustments to the heparin infusion may be made by the critical care team based on anticipated changes in patient specific factors (platelet transfusions)
 - v. Do not adjust heparin more than once every 2 hours
 - vi. Any time heparin is held outside of adjustment protocol it must be by physician order
 - vii. The ACT goal may be changed by the critical care team after consideration of patient specific factors (ie bleeding events)
 - viii. Weight programed into infusion pump should not be changed after start of heparin infusion
 - ix. If the POC ACT remains out of range for three consecutive draws despite appropriate adjustments to heparin infusion notify the critical care team and obtain the following STAT:
 1. Anti Xa
 2. Antithrombin
 3. Fibrinogen
 4. PT/INR
 5. CBC
- e. Circuit DIC
- i. Consider circuit DIC if:
 1. Decreased platelet count, unresponsive to transfusion
 2. Low fibrinogen unresponsive to transfusion
 3. Visible clot formation on oxygenator
 4. Increased POC ACTs, despite decreasing heparin
 5. Clinical bleeding from surgical/other sites
 6. The only effective treatment for circuit DIC is replacement of ECMO circuit
- f. Heparin Alternatives
- i. Either argatroban or bivalirudin may be used for patients on ECMO



- ii. Bivalirudin – Preferred agent, especially with patients with hepatic dysfunction
- iii. Argatroban – Preferred for patients with renal dysfunction or patients also on CRRT. Avoid in patients with hepatic dysfunction
- iv. Patients on either of these agents will have the medication titrated based on Emory protocols

g. Management of the bleeding ECMO patient

i. For any bleeding patient the following labs should be ordered STAT:

1. POC ACT
2. Anti Xa
3. Antithrombin
4. Fibrinogen
5. PT/INR
6. CBC
7. aPTT
8. Hepzyme aPTT (requires Hepzyme sticker)

ii. Heparin goal should be lowered to ACT 140-180

1. Lower goals may be considered by the critical care team
2. Any order to hold heparin must be ordered in eEMR by critical care team
3. Consider topical products
4. Consider Aminocaproic acid 5gm over 1 hour load followed by 1gm per hour
5. Consider intravenous phytonadione (Vitamin K) 1-5mg to promote clotting factor production if INR remains elevated
6. Consider DDAVP 0.3 unit/kg for patients with uremia or suspected vonWillebrand disease

VI. Exhibits:

- a. S. Kolla, S. Awad, P. Rich, R. Schreiner, R. Hirschl, R. Bartlett. (1997). Extracorporeal Life Support for 100 Adult Patients with Severe Respiratory Failure. *Annals of Surgery*, 226 (4) p. 544-564.
- b. M. Srivastava, G. Ramani, et.al. (2010). Veno-venous extracorporeal membrane oxygenation bridging to pharmacotherapy in pulmonary arterial hypertensive crisis. *J*



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- c. L. Mongero, J. Beck, K Charette, A. Stewart. (2006) Respiratory failure of two s/p gastric bypass patients and subsequent rescue with extracorporeal membrane oxygenation. Perfusion, 21 (1) p73-76.
- d. K. Griffith, E. Jenkins, J. Haft. (2009). Treatment of massive pulmonary embolism utilizing a multidisciplinary approach: a case study. Perfusion, 24 (3) p. 169-172
- e. GJ Peek, D. Elbourne, M. Mugford, et. Al (2010). Randomized controlled trial and parallel economic evaluation of conventional ventilator support versus extracorporeal membrane oxygenation for severe adult respiratory failure. Health Technology Assessment 14 (35) p. 1-282.

VII. References:

- a. ECMO Extracorporeal Cardiopulmonary Support in Critical Care, 3rd edition
- b. [ELSO Patient Specific Guidelines 2009](#)
- c. [ELSO General Guidelines 2009](#)

ECMO POC ACT Heparin Titration

Goal 180-220 (Low Bleeding Risk)	
POC ACT Result	Adjustment
<140	Notify CCM and increase infusion by 2 units/kg/hr Consider Heparin 40 unit/kg bolus (VA patients)
140-179	Increase infusion by 1 unit/kg/hr
180-220	No change
221-260	Decrease infusion by 1 unit/kg/hr
261-300	Decrease infusion by 2 units/kg/hr
>300	Hold infusion for 60 minutes Notify CCM Restart when POC ACT <300 AND decrease by 3 units/kg/hr



Goal 140-180 (High Bleeding Risk)	
POC ACT Result	Adjustment
<120	Notify CCM and increase infusion by 2 units/kg/hr
120-139	Increase infusion by 1 unit/kg/hr
140-180	No change
181-200	Decrease infusion by 1 unit/kg/hr
201-220	Decrease infusion by 2 units/kg/hr
>220	Hold infusion for 60 minutes Notify CCM Restart when POC ACT <220 AND decrease by 3 units/kg/hr

General Considerations for evaluating hemostasis in ECMO All treatments should be done in discussion with critical care team	
If the ACT remains elevated AND	Then
Anti Xa is <0.3	Evaluate fibrinogen, INR, platelets
Anti Xa is >0.7	Decrease heparin infusion by 2 units/kg/hr, repeat Anti Xa in 4 hours
Fibrinogen <150	Give 5 units cryoprecipitate for fibrinogen <150 Give 10 units cryoprecipitate for fibrinogen <100
Fibrinogen >150	Evaluate platelets and INR
INR <1.5	Evaluate fibrinogen and platelets
INR >1.5	Give 1 unit FFP for INR 1.5-2.4 Give 2 units FFP for INR >2.5
Platelets <100	Give 1 platelet pack for platelets <100 Give 2 platelet packs for platelets <50
Platelets >100	Evaluate fibrinogen and INR
If the ACT remains low	Then



AND	
Anti Xa is <0.3	Increase heparin infusion by 2 units/kg/hr, repeat Anti Xa in 4 hours, consider heparin bolus 20-40 units/kg for low risk patients
Anti Xa is >0.7	Evaluate antithrombin level, fibrinogen, INR, platelets
Antithrombin <50%	Give 1 unit FFP
Antithrombin >50%	Evaluate fibrinogen, INR, platelets

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RESPIRATORY THERAPY BASED CARE MANAGEMENT

- I. Policy Statements: The safe design and simplicity of the ECMO circuit obviates the need for the continuous presence of a perfusionist at the bedside. A qualified respiratory therapist will remain in the room at all times.

- II. Purpose:
 - a. To identify roles and responsibilities of those individuals who have direct involvement in the delivery of extracorporeal membrane oxygenation (ECMO) support in the Emory University Hospital (EUH) 4a/5a ICU.
 - b. When the decision to initiate ECMO is made, the ICU Attending, Cannulator, Perfusionist, Advanced Practitioner (AP) or Fellow, bedside RN and respiratory therapist will perform tasks specific to their roles in the ECMO Team Care Model.
 - c. Delineation of responsibility is tiered in 3 areas: Initiation of Support, Ongoing Support, and Discontinuation of Support.

- III. Definitions:
 - a. “Alarm/Alert” means a text message displayed on the ECMO console which is accompanied by an acoustic signal that warns the ECMO care provider of an undesirable state of operation.
 - b. “Acknowledge” means to clear and/or silence an alarm/alert signal by depressing a key pad on the ECMO console.
 - c. “Trial off” refers to a prescribed and measured removal from ECMO support to evaluate the patient's level of recovery and ability to remain stable with conventional cardiopulmonary support.

- IV. Policy Standards:
 - a. The respiratory therapist will assess the ECMO circuit every 4 hours.
 - b. A perfusionist will assess the ECMO circuit every 24 hours.
 - c. An ECMO trained RN must be in attendance with the patient at all times.
 - d. The ECMO trained RN will demonstrate competence in basic troubleshooting and emergent circuit intervention in the event that life threatening failure of a circuit component occurs.
 - e. The ECMO circuit will be oriented within the patient's room to allow it to be in full and clear view from the doorway. This orientation enables visual monitoring of the system, circuit and alarms as well as affording unencumbered access to the circuit during any emergency.
 - f. The sweep flowmeter(s) which supply oxygen to the Membrane Oxygenator will be kept easily visible and free of any other equipment or tubing. This is required to prevent inadvertent change or disruption to the critical source of oxygen.



V. Procedures/Actions:

a. Initiation of Support:

i. Role of the Perfusionist:

1. Prepares the ECMO circuit (assembly, crystalloid or blood primes, addition of medications, and delivery to the bedside).
2. Gathers supplies necessary for cannulation at the request of the cannulator.
3. Assists in wet connection of the cannulas to the ECMO circuit.
4. Advises nursing personnel to administer volume expander as necessary to facilitate management of the ECMO circuit.
5. Ensures that sweep gas is connected.
6. 6. Records pump speed and flow; circuit pressures and observes initial support markers; communicates with cannulator and nursing staff. This is to assure that key data is collected upon initiation of support.
7. Requests RN to draw 30 minute post-initiation labs and arterial blood gases. This is to establish laboratory baselines. By design there is no access to the circuit blood.
8. Adjusts sweep and flow to achieve desired support.
9. Ensures that all circuit connections are secure; ensures that cannulas are safely secured to the patient; ensures that ECMO circuit tubing is secured to the bed. These are all measures needed to ensure patient safety.
10. Sets pressure alarm limits on ECMO circuit inlet and outlet and flow alarm limits on the pump. Alarm limits are set to ensure appropriate support for patient safety.
11. Ensures that the patient is supported; confers with AP or Fellow regarding order driven ECMO support needs.
12. Records events on ECMO documents; remains at the bedside until order driven ECMO support is achieved and all activities related to initiation of ECMO are completed; ensures that ECMO contact phone number and pager are communicated to AP/ Fellow and nursing staff. Contact information is communicated to enable the bedside RN, NP, or physician to contact a perfusionist for consultation or emergency mitigation.

ii. Role of the ICU Attending, Nurse Practitioner, or Fellow:

1. Initiates all ECMO order sets.
2. Ensures that ECMO support orders are complete including



anticoagulation.

3. Communicates with ECMO Specialist, cannulator, and bedside RN as it relates to patient stability during initiation of support.
4. Confers with the perfusionist regarding ECMO support requirements.
5. ICU Attending/NP/Fellow directs order driven changes to perfusionist or respiratory therapist regarding ECMO support including sweep and flow; administration of appropriate volume expander to treat hematocrit, platelet count, fibrinogen levels etc.
6. Contacts the perfusionist or AEMD at any time for issues, questions or concerns related to ECMO support.

iii. Role of the Bedside RN:

1. Provides direct patient care, maintaining IV access.
2. Ensures adequate sedation, analgesia, and paralytic administered prior to ECMO cannulation as ordered.
3. Ensures that Lidocaine is available for local anesthesia.
4. Ensures that the patient receives a heparin loading dose prior to cannulation, as directed by the cannulating physician. The standard heparin loading dose is 100 units/kg.
5. Ensures access to IV for medication, fluid and blood administration.
6. Ensures access to the patient's airway.
7. Ensures that the patient is properly positioned for ECMO cannulation.
8. Ensures that patient monitoring is ongoing during cannulation process.
9. Administers volume expander (usually PRBC) at the request of the respiratory therapist, ICU attending, NP, or Fellow.
10. Confers with NP/Fellow, cannulating physician and ECMO specialist regarding patient support markers.
11. Draws labs and ABG 30 minutes after initiation of support. This is to establish laboratory baselines. The ECMO Specialist does not access the circuit blood.

iv. Role of the Respiratory Therapist:

1. Obtain report on expected circuit pressures and flows from the initiating perfusionist.
2. Ensure necessary clamps are available for emergent circuit



management.

3. Completion of initial ACT.
4. Assist the perfusionist with any necessary duties at initiation of support.
5. Ensure emergency ventilator settings are established and posted.

b. Ongoing Support:

i. Role of the Perfusionist:

1. Evaluates ECMO circuit every 24 hours, ensuring that all components are functioning properly as itemized on the bedside checklist.
2. Inspects the ECMO circuit for presence of clots, air and loose connections. Clots and air represent embolic risks; loose connections represent risk for catastrophic system failure, with potential for exsanguination and air embolism to the patient. Close monitoring of these items are for patient safety.
3. Verify tystraps at all connections. Tystraps secure connections for patient safety. Tystraps are positioned to prevent tissue breakdown.
4. Ensures consoles are plugged into red hospital outlets. Red outlets have generator backup in the event of power failure.
5. Inspects Oxygenator for integrity, clot formation or air accumulation or leaks. Inspection evaluates for a functioning oxygenator.
6. Ensures ERL (Emergency Rescue Lung) system is on the ICU at the bedside. A failed oxygenator requires emergent replacement.
7. Ensures that flow alarms (both console and auxiliary) are set appropriately. Ensures Inlet and Outlet monitors are zeroed, and have appropriate alarm limits set. Alarm limits are set to assure patient safety.
8. Ensures that 4 tubing clamps are at the bedside. Tubing clamps are required to manage circuit emergencies.
9. Ensures supply cart is stocked assuring adequate supplies are available to deal with emergencies.
10. Ensures proper operation of water heater. Appropriate patient thermoregulation is a vital support marker.
11. Advises ICU Attending, AP, Fellow, RT, and bedside RN of any abnormal finding within the ECMO circuit; coordinates a plan with ICU Attending and RN to remove the patient from support in order to perform any circuit repair.
12. Responds to requests to assist in troubleshooting the ECMO circuit, or



to advise the team in ECMO circuit management strategy.

13. Must be at the bedside to assist in major patient position changes such as placing the patient prone or moving to another bed. This is to preserve circuit integrity for patient safety.
14. Must be at the bedside for any procedure that may complicate ECMO support (i.e., chest tube insertion, all surgical procedures, bronchoscopy, etc). Immediate response to impaired support is required for patient safety.
15. Must be advised when anticoagulation administration is suspended or modified with Argatroban, or Amicar.
16. Must be present during Factor VIIa administration. Circuit integrity is closely monitored for rapid response to emergencies. Close evaluation of the circuit is required due to increased risk of clot formation and circuit failure.
17. Must accompany the patient to any destination for diagnostic testing. To decrease potential for accidental decannulation or circuit disruption.
18. Recommends changes in ECMO flow or sweep to NP/Fellow based on support markers.

ii. Role of the ICU Attending, AP or Fellow:

1. Assesses extracorporeal support; adjusts ECMO flow and sweep to establish order driven level of support.
2. Directs bedside RN to administer blood products or other volume expander.
3. Directs bedside RN to titrate anticoagulation administration, order driven, to achieve established ACT or Factor Xa range.
4. Immediately responds to RN request for assistance in troubleshooting ECMO circuit problems or patient support needs; consults with RT or perfusionist as necessary.
5. Recognizes the need to emergently isolate the patient from the ECMO circuit (tubing disconnect, decannulation, ECMO pump failure, gross air in circuit) by placing tubing clamps on both limbs (in either order) of the circuit; requests perfusion assistance immediately. Immediate isolation from a compromised circuit prevents adverse thromboembolic events and/or exsanguination.
6. In collaboration with ICU attending the AP or Fellow, modifies any order driven ECMO support increase or reduction.
7. Perfusion when plans are made to reduce ECMO flow below 1 LPM. Close evaluation of the circuit at low flow conditions is intended to prevent adverse conditions for patient safety.



8. Advises perfusion when plans are made to trial off ECMO.
9. Advises perfusion of any procedure that may impact ECMO support (i.e., chest tube insertion, all surgical procedures, bronchoscopy, etc.). Immediate response to impaired support is required for patient safety.
10. Advises perfusionist when anticoagulation administration is suspended or modified (Argatroban, Amicar or Factor VIIa administration). Circuit integrity is closely monitored for rapid response to emergencies. Close evaluation of the circuit is required due to increased risk of clot formation and circuit failure.
11. Advises RT of plans for transport of patient to diagnostic testing areas. Equipment and patient preparation plus coordination of support staff are required to ensure patient safety during transport.

iii. Role of the Bedside RN:

1. Provides order driven patient care.
2. Collaborates with ICU Attending, NP, or Fellow while following order driven administration
3. Draws all ordered labs.
4. Obtains an ABG 30 minutes after any sweep adjustment or ventilator change plus every 6 hours. To evaluate effectiveness of the change in a timely manner.
5. Advises NP or Fellow if ABG result is outside of ordered parameters.
6. A qualified RN will remain at the bedside at all times or arrange for bedside coverage by the respiratory therapist. Patient safety requires the presence of someone trained to remove the patient from the circuit in an emergency.

iv. Role of the Respiratory Therapist

1. Observes and documents the ECMO circuit hourly for:
 - a. RPM's – reflects the energy required to deliver the order driven flow.
 - b. Flow rate – primary function of ECMO support.
 - c. Sweep flow rate – primary controller of ECMO ventilation.
 - d. Inlet pressure – reflects patient volume status and resistance to blood in-flow.
 - e. Outlet pressure – reflects resistance to blood out-flow and oxygenator integrity.
 - f. Pulse checks – To ensure adequate circulation distal to



for any other purpose is not permitted beyond the 300 RPM unless order driven. Adjustment of any alarm setting on the ECMO circuit is restricted to the perfusionist only!

- j. Responds to ECMO circuit alarms/alerts and acknowledges; assesses patient, inspects ECMO circuit for obvious causes of alarm status, corrects as necessary.
 - k. Ensures ECMO cart wheels are locked with the circuit in a safe spatial relationship to the bed and other equipment. This prevents damage to circuit components and circuit emergencies.
 - l. Recognizes the need to emergently isolate the patient from the ECMO circuit (tubing disconnect, decannulation, ECMO pump failure, gross air observed in ECMO circuit tubing) by placing tubing clamp on both limbs of the circuit; calls for assistance immediately; notifies AP or Fellow and perfusionist immediately, follows AP or physician orders to manage the patient until ECMO support is resumed.
 - m. Recognizes the need to emergently transition pump from primary machine to back-up machine and performs this task when indicated. Immediately notifies the perfusionist that the pump was moved so the perfusionist can respond accordingly.
- c. Trial off Procedure and Preparation for Discontinuation of Support:
- i. Role of the Perfusionist:
 1. Is present at the bedside for initiation of trial off ECMO procedures; advises NP or Fellow in strategies related to ECMO circuit management during trial off procedures.
 2. VA trial off ECMO: Must remain at the bedside for duration of the trial off.
 3. VV trial off ECMO: May leave the ICU when satisfied that the patient is tolerating the trial off well. Confers with AP or Fellow to ensure patient is supported. Reinforces with bedside RT procedure for urgent reconnection of sweep gas to oxygenator in the event that the patient decompensates.
 4. At the direction of the managing physician, cuts the circuit away from the ECMO cannulas.
 5. Discards the ECMO circuit.
 6. Retrieves surgical instruments from the ECMO supply cart as requested.
 7. If physician requests to leave the cannulas in the patient, the perfusionist primes IV tubing sets with heparinized NS (1:1) and initiates infusion of solution to each cannula at prescribed flow rate of



20 ml/hr.

ii. Role of the ICU Attending, AP or Fellow:

1. Advises ECMO Specialist of plans for trial off ECMO procedure.
2. Is present at the bedside for trial off ECMO procedures.
3. Manages conventional support of the patient.
4. Assesses tolerance of trial off procedure, collaborates with managing physician as necessary.
5. Directs RN and Respiratory Therapist in management of conventional support (medications, ventilator settings, laboratory testing etc.).
6. When indicated, orders heparinized NS for continuous infusion to cannulas if cannulas are left in.
7. Advises RT if the patient shows poor tolerance of VV trial off ECMO and requires resumption of ECMO support.
8. With order driven direction to bedside RT, connects ECMO sweep gas to oxygenator in the absence of the perfusionist in the event that the patient rapidly decompensates during a trial off VV ECMO. Ensures that the perfusionist is notified immediately.

iii. Role of the Bedside RN:

1. Is present at the bedside for trial off ECMO procedures.
2. Performs order driven care in collaboration with ICU attending, AP, or Fellow including pharmacologic support, volume administration.
3. Assesses patient tolerance of trial off procedure and documents vital signs and other support markers.

VI. Exhibits: None

VII. References:

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