ECMO – Overview

What is ECMO?

- Extracorporeal Membrane Oxygenation
- ECMO is used to provide cardiopulmonary support for patients with REVERSIBLE life threatening heart or lung disease that is NOT responsive to maximal conventional treatment
- Physiology: Blood is drained from the patient to an external pump which is pushes the blood through a membrane oxygenator and returns blood to the patient's circulation

Veno-Arterial (VA) ECMO

- Deoxygenated blood is drained from venous circulation into the ECMO circuit
    - Passes through the oxygenator and is returned directly to the arterial circulation
    - Drain from major vein and returns to major artery
    - Supports heart and lung
- Peripheral Cannulation
    - Fem V → Fem A
    - Fem V → Cartoid A
    - Fem V → Axillary A
    - Better for emergent situations
        - Less invasive and faster insertion
    - Relies upon retrograde flow
        - Admixing in aortic arch
    - Risk of limb ischemia
- Central Cannulation
    - Direct cannulation into the ascending aorta or subclavian artery, usually seen in post cardiac surgery patient that failed to wean from Cardiopulmonary Bypass
    - Main advantages: good venous drainage and reliable arterial return to proximal aorta in ante grade fashion
    - Disadvantage: bypasses the lungs and heart, risk for thrombus

Veno-Venous (VV) ECMO

- Deoxygenated blood is drained from the venous circulation into the ECMO circuit
    - Drains from major vein and returned to major vein
    - Supports only the lungs
    - Adequate circulation is provided by the native cardiac output
- Cannula Placement
    - Drainage Cannula
        - As central as possible, not too close to the return cannula
    - Return cannula
        - Close to the tricuspid valve, but not too close to drainage cannula

Modes of ECMO

- VV ECMO
    - Less arterial injury
    - Goal pump flow rate 2/3 of pt's CO
    - Decreased likelihood air or clot emboli from circuit
    - Decrease hemodynamic instability as blood is drained and returned from same side
    - Changing flow rates affects pO2

- VA ECMO
    - Bridge to recovery
    - Pump flow is the pt's CO
    - Gas exchange is delivered to arterial circulation
    - Changing flow rate affects CO
    - ECMO flow less than .5 – 2 L/min for long periods should be avoided to prevent clots in circuit

VV ECMO: Indications

1. Hypoxic Respiratory Failure
    a. Should be considered when risk of mortality is > 50%
    b. Indicated when risk of mortality is > 80%
2. ARDS
3. Severe Pneumonia
4. Aspiration syndromes
5. Pulmonary contusion
6. Smoke inhalation
7. Airway obstruction
8. Status Asthmaticus
9. CO2 retention

VV ECMO: RECOMMENDED Contraindications

1. Cardiac arrest
2. Severe right or left heart failure (EF < 25%)
3. Severe pulmonary hypertension (mPAP > 50 mmHg)
4. Terminal disease with expectation of short survival
5. Weight > 140 kg
6. Advanced liver disease
7. Contraindications to systemic anticoagulation
8. Unresponsive septic shock
9. Central nervous system injury
10. Non-recoverable cardiac or respiratory disease
11. Non-recoverable neurological disease
12. Advanced age
13. Mechanical ventilation > 5 – 7 days with high pressure

VA ECMO: Indications

1. Cardiogenic shock (AMI, cardiomyopathy, myocarditis)
2. Failure to wean from CPB
3. Bridge to VAD or transplant
4. High risk PTCA
5. ECPR: defined as rapidly-deployed application of VA ECMO in patients with cardiac arrest, during cardiopulmonary resuscitation before return of ROSC
    a. ECPT is one of the most rapidly growing segments of ECLS and is becoming more widespread

VA ECMO: RECOMMENDED Contraindications

1. Unrecoverable heart

2. Prolonged cardiac arrest without adequate perfusion
3. Terminal disease with expectation of short survival
4. Weight > 140 kg
5. Contraindications to systemic anticoagulation
6. Central nervous system injury
7. Advanced age
8. Chronic organ dysfunction
9. Compliance
10. Aortic dissection
11. Severe Aortic regurgitation
12. Severe PVD

Goal of ECMO

- Primary goal: Provide oxygenated/ventilated blood to the body, performing the work of the lungs (VV ECMO), or both the lungs and the heart (VA ECMO), as a TEMPORARY measure until the heart/lungs can heal, or potentially as a bridge toward transplant
- ECMO is NOT a therapy or a treatment but rather a supportive measure to allow time to rest and heal
- Difficult for families to grasp
    - They want an answer; how long will they be on ECMO?
    - The answer is until the heart and/or lungs recover – ECMO doesn't fix a failing system

Equipment

- Centrifugal Pump
    - Mechanism for drawing the blood into the circuit and then back to the pt
    - Preload and afterload dependant
- Pump Head/Drive
    - Where the pump sits and the blood flow is measured
- Oxygenator (membranous lung)
    - Oxygenates incoming blood via hollow fibers
    - Blood flows across one side while a SWEEP gas moves in the opposite direction
    - Blood becomes enriched with oxygen and CO2 is removed
- Heater Cooler
    - Attached to oxygenator to regulate patient's temperature
- Blender
    - Determines the amount of O2 delivered to oxygenator
    - Oxygenation is affected by the FiO2 and the blood flow
    - Used to wean O2 as patient improves
- Sweep
    - Removes CO2 as blood flows through oxygenator
- Emergency Hand Crank
    - Utilized when there is a pump failure
- **An increase in blood flow will also increase the oxygenation as a greater volume of blood is exposed to the surface of the membrane. A flowmeter regulates gas flow to the membrane. CO2 diffuses faster than O2 because it is more soluble. Transfers approximately 10x more efficiently than O2. Sweep gas mechanism correlates with your rate on the ventilator
- Pump console
    - Houses the control knob for RPM

  - Displays flow (LPM), RPM, and pressures
  - 90-minute back-up battery life
  - Flow rate 0 – 10L
    - Flow in an ECMO circuit function to deliver oxygenated blood and can be thought of as cardiac output in VA ECMO and the primary driver for O2 deliver in VV ECMO
    - Flow rate through the cannula is directly proportional to the internal diameter of the cannula
- Pressure Monitor
  - Measures venous pressure (P1), pre-oxygenator pressure (P2), and post-oxygenator pressure (P3)
- Delta P
  - The gradient P2-P3 is indicative of issues within the oxygenator

<u>Bedside Care of ECMO patient</u>

- **A**irway
  - Maintain patency of ETT/tracheostomy tube
  - Keep HOB elevated at least 30 degrees, if possible (central cannulation)
  - Gentle suctioning as needed; should have safe suctioning depth posted on ventilator
  - Bronchoscopy may be necessary to loosen secretions, open bronchi, or evaluate lung tissue
  - Oral care: Be calm; traumatizing the carina will result in bleeding and once it starts it's very hard to control and stop as patient is heparinized
- **B**reathing
  - Goal is to maintain or recruit clear open lungs without further damage
  - Rest settings on vent
  - You may see "white-out" on X-ray early on in ECMO run; related to cytokine release to exposure of plastics (will get worse before it's better)

        - Initiation of ECMO can result in SIRS response including hypotension due to exposure of blood in circuit membrane
    - Watch for signs of pneumo/hemo
    - Be prepared to place back on full vent support if emergency occurs
    - ECMO cannula has X-coating, a bio-passive coating designed to mimic endothelium of blood vessel
        - If blood "sees" anything but endothelium, it thinks it's a cut and will start to clot at location to try to stop bleeding
        - This is the reason for heparin bolus at cannulation

- **C**irculation
    - VA ECMO supports cardiac output directly
        - May have pulsatile or nonpulsatile arterial line (flat)
        - Peripheral VA: Retrograde flow, monitor for Harlequin Syndrome
    - VV ECMO has no direct cardiac support but may increase CO with increased O2 delivery (If patient was on high pressure support on vent, CO will increase with decreased pressures but may cause sats to drop
        - Goal is to capture 2/3 of the CO
    - Preload and afterload dependent
        - Everything you do to the patient affects the pump, and everything you do to the pump affects the patient
    - Arrhythmias: electrolyte imbalance, irritation from cannula, secondary to cardiac surgery
    - Assess extremities for ischemia, thrombus formation, compartment syndrome, and other complications
        - If nonpulsatile there will be no pulse to feel Doppler – should here ECMO flow
        - Reperfusion catheter ensures downstream flow to arterial cannulated leg

- **D**a Brain
    - Patient may initially be paralyzed and sedated
        - Train of Four (Paralytics) every hour – 2/4
        - BIS monitoring (Sedation) and pupil checks every hour – 40 to 60
        - Best to take away paralytic as soon as possible to monitor neuro status
        - CNS complications are serious and are primarily related to the degree of hypoxia and acidosis
        - Restraints/mittens aren't a bad idea – watch your lines!

- **E**lectrolytes
    - ECMO initiation causes a reduction in renal blood flow
    - ECMO causes cytokine activation, resulting in capillary leak
    - Typical patient ends up with renal issues and CRRT
        - Monitor lytes as ordered and PRN; coordinate with specialist and I-Stat checks
        - High K+ could indicate hemolysis

- **F**luids
    - Strict I's and O's hourly
    - Max concentrated drips and keep ahead
    - Daily weight
    - Remember preload and afterload dependent; These patients require volume so you can PULL

        - The pump generates negative pressure on the patient's venous side (How hard pulling – venous pressure)
        - There is a max flow rate that the circuit can pull from the patient. Past this point, the negative pressure causes the venous vessel to collapse on itself, temporarily stopping flow. When pressure builds back up again, flow begins again
        - This causes cavitation (erratic blood flow) of the pump AKA Chugging
            - Besides limiting flow, chugging causes significant damage to the blood vessels and increased hemolysis
            - How do you fix it? Decrease RPM (however this may not provide adequate O2 and hemodynamic support); correct hypovolemia, patient positioning, kink in cannula/tubing, upsize cannula, monitor for thrombus/clot

- **G**astro
    - Gastric decompression prior to initiation and heparinization
    - Monitor bowel sounds
    - Maintain optimal nutrition
    - Gentle suction until enteral feeding started
    - Protonix prophylactically
    - Possible BMS
- **H**GB and HCT
    - HGB and HCT goal is patient specific
    - Keep 3 units ahead at ALL times
        - Keep up with crosspatch; Expires midnight of 3rd day
    - PLTS: Keep 80,000 to 100,000 (check orders)
    - Fibrinogen: > 100,000 (if bleeding, will need to be kept higher – check orders)
    - ACT 180-220 seconds (May be lower to 160-180 if patient's bleeding – check orders)
    - HCT may need to be raised to maximize O2 carrying capacity
- **I**nfection
    - Antibiotics may be considered for cannulation and if infection is suspected
    - CBC daily
    - Temperature is not a good indicator of infection because temperature is regulated through ECMO heaters (specialist will be monitoring water bath temp trends)
        - An increase or decrease of 1 degree can increase or decrease cerebral metabolic rate of O2 consumption by 7-14%
        - ECMO patient is likely to be on the cold side
- **J**oint and Skin
    - Place on rotation bed prior to cannulation if able
    - Sacral/scapular mepilex prior to cannulation
    - Heel and elbow Allevyn
    - Gentle ROM as tolerated to non-cannulated areas
    - Log roll patient
    - Turn every 2 hours or offload if patient doesn't tolerate turn
        - YOU MUST DOCUMENT HOW THE PATIENT DID NOT TOLERATE TURNING, NOT "TOO UNSTABLE TO TURN"
            - Example: HR drops or patient goes asystolic on VA ECMO

  - Moving patient, even the slightest bit, is a team effort
  - Front side bath on night shift; back side bath/linen change/BIG turns only on dayshift, unless absolutely necessary

- **K**idneys
  - Goal is dry weight
  - First 24-48 hours oliguria, secondary to inflammatory response from circuit; Results in capillary leak → intravascular volume decreases → can result in ATN
  - After 48 hour diuretic phase may begin – sign of early recovery
  - Will require diuretics
    - May see a lower ACT, requiring increase in Heparin drip; Make sure your specialist is aware you're giving a diuretic
  - As lungs heal, diuresis can occur again
  - Hemoconcentrator may be used to remove excess fluid; Perfusion initiations through the circuit if ordered
  - CRRT is frequently required
  - Monitor for hematuria (hemolysis present)
  - Patient's on ECMO may be on CRRT or plasma exchange therapy without the need for other access; These therapies can occur with access to the ECMO circuit
    - Frequent alarms with CRRT on ECMO:
      - Too negative/positive access (access disconnection)
      - Too negative/positive return (unable to detect return
    - Alarm settings can be adjusted in Custom Mode. This has to be done at set-up.

- **L**ines
  - Lines should be inserted prior to heparinization if possible
  - Best practice: Fluids/Blood Products given via IV pump and NOT by gravity
  - Aspirate air from ports prior to IV push
  - Bleeding form cannulation site is the most common complication
  - Cannulas must be secured at all times and monitored by ECMO specialist during any patient movement
  - Dressing change requires 2 nurses and Specialist
    - Routine changes done on day shift every 48 hours (remove bottom to top to decrease chance of pulling out the line)
    - No alcohol or CHG on tubing (weakens plastic; May use CHG on it if cutting into the line but not with routine dressing changes)
  - Knee immobilizer for femoral cannulated patient

- **M**edications
  - Paralytic/Sedation – gentle titration
  - Pressors if indicated; VA ECMO may require inotropic support
    - Avoid big swings in titration, helps to avoid circuit issues
  - Have Heparin drip ready at bedside post ECMO initiation
    - Standard initial dose is 20 units/kg/hr when ACT < or equal to 240; Heparin infusion maintenance per order set
      - Heparin acts by activating the plasma molecule AT3 (high doses of heparin and low ACT, think AT3)
      - MD may order FFP (inexpensive) or concentrated AT3 (very expensive) if low

        - If giving a diuretic, with good results, expect drop in ACT requiring increase in Heparin drip
    - Antibiotics PRN
    - Eye lubricant – use liberally
- **N**ursing
    - 1:1, may require 2:1

ECMO Emergencies

Basics – Know what mode your patient is on

- Verbiage: "We are off pump" or "We are off ECMO"

1. **Pump Failure**
    a. Call for help
    b. Ventilate and hemodynamic support
    c. Clamp line and turn off pump (pump failure)
    d. Hand crank – if you can't resolve immediately
    e. Place on back-up circuit if needed
    f. Turn on pump to 1000 RPM and remove clamp
    g. Gradually increase RPMs
2. **Air Embolism**: Introduction of air into circuit through connections or cannulation sites and/or air embolus to patient
    a. Clamp arterial line
    b. Call for help
    c. Stop pump
    d. Positon patient's head down
    e. Increase vent and inotropic support
    f. Volume
    g. Evacuate air from circuit if able, or replace circuit
    h. If air embolus, consider aspiration of right heart using lines if venous (Perfusion/MD) and hypothermia
3. **Circuit Rupture**: Disruption of any part of circuit
    a. Clamp circuit on either side of disruption
    b. Call for help
    c. Increase vent and inotropic support
    d. Volume
    e. If possible, place sterile gloved finger over leak
    f. Connection/circuit change
    g. Prep for connection change
4. **Oxygenator Failure:** Gas transfer failure, identified through routine blood gas analysis and pressure monitoring
    a. Oxygenator clotting: increase preoxygenator pressure and decrease post oxygenator pressure (Delta P will trend up); monitor post oxygenator ABG
    b. Prepare for oxygenator; should ideally be a scheduled change out and this is why we monitor pressures
5. Codes
    a. VV: Follow ACLS protocol, reversible causes
    b. VA: If you have flow, support BP and defibrillate if necessary
        i. If no flow: CPR; No CPR if centrally cannulated

Recirculation

- VV ECMO
  - Reinfused oxygenated blood is withdrawn through the drainage cannula without passing through systemic circulation
  - Suggested by increasing SVO2 with falling arterial saturation
    - If blood in drainage and infusion cannula become same color; might also notice "flashes" of arterial blood in your venous line
- VA ECMO
  - You may hear the term "recirculation" if the ART line is femoral and NOT radial, due to mixing of blood from arterial ECMO cannula; You're aspirating out O2 rich blood for your ABGs
- Factors that affect recirculation
  - Pump flow
    - Higher pump flow increases chance of draining oxygenated blood
  - Cannula positon
    - Single lumen cannula positioned in too close proximity
    - Double lumen return port not at right atrium
  - Cardiac output
    - Low CO output: slowing of the oxygenated blood circulating, therefore can be drained out
  - Volume status/RA size
    - If adequate, dilutes oxygenated blood and makes it less likely to drain out
    - RA reduced results in higher concentration of mixing and may drain out more oxygenated blood
- Treating recirculation
  - Deal directly with root cause!
    - Flow: decrease flow by 10% and see if the arterial saturation improves
    - Position: Call surgeon to adjust cannula, may need TEE
    - Cardiac output: May need to go up on inotropes
    - Volume: may need to give little volume to reduce blood stealing/optimize volume status

Differential Oxygenation

- VA ECMO creates a separate circulation system parallel to the native circulation by siphoning a certain portion of venous return and reinfusing it as a contribution to the overall cardiac output of the body
- Oxygenation depends on the interaction between the body's capacity to oxygenate, ventilate, and perfuse, and the contribution from VA ECMO (membrane flow and function)
- Accurate assessment of net gas exchange support depends on where the two systems meet
- Strictly a problem with peripheral cannulation VA ECMO
  - Oxygenated blood is delivered retrograde up the descending aorta and into the aortic arch
  - If little to no native cardiac function, nonpulsatile: mixing will occur in arch and result in equal system perfusion
  - If LV is ejecting and pulsatile: retrograde oxygenated blood may not reach aortic arch and mixing will occur in descending aorta
- Particularly in diseased lungs

- Monitor with right radial ABG (R radial ART line) and a sat probe on the right
- Fixes:
  - May result in deoxygenated blood delivery in upper half of body including coronaries and brain
    - Increase pump flow
    - Decrease native cardiac output – beta blockers
    - Place an additional VV limb via IJ to support the lungs (VA-V ECMO)
    - Increased vent settings may be required

LV Venting

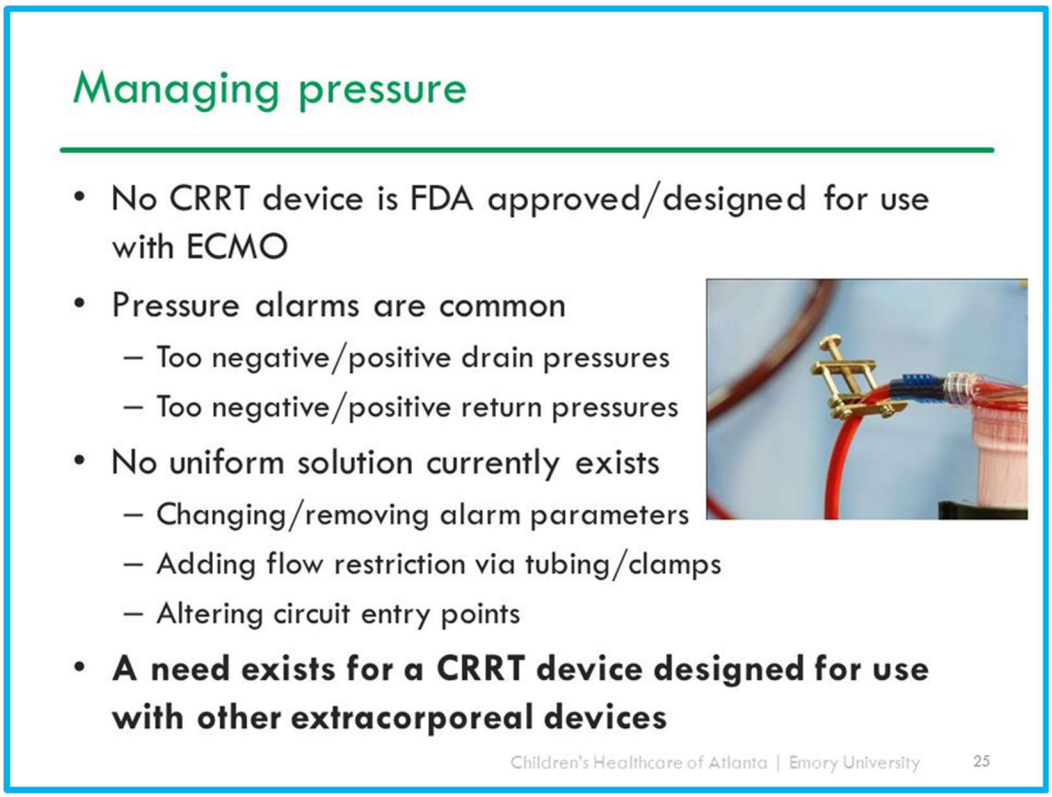
- In a patient with profound cardiac dysfunction who can't adequately ejec blood from their left ventricle, blood can back up, causing left atrial HTN and subsequently pulmonary venous HTN that can lead to pulmonary edema and hemorrhage (nonpulsatile flow or minimal pulsatility, low pulse pressure
- Retrograde flow causes an increase in afterload
  - These patients can't eject against this afterload
- This LV distention results in significant rise in intraventricular pressure and wall tension, which could be detrimental to damaged myocardium
- This increased pressure could reduce coronary blood flow causing myocardial ischemia
- Without adequate pulsatility, blood within the LV and aortic root may stagnate and result in thrombus formation
- Flow can be reduced in an attempt to reduce afterload but this may compromise oxygen delivery and end-organ perfusion
- Inotropic support can be added to increase contractility (watch for North-South Syndrome)
- Afterload reduction with vasodilator or IABP
- Atrial septostomy or LV venting (trans-aortic vent through he axillary artery or pigtail cath into LV through aortic valve and connected to ECMO circuit
- LV venting with Impella device = ECPELLA

Reperfusion Line

- Borrows oxygen-rich blood from arterial line to allow selective perfusion of lower limb

CRRT Set-up with ECMO

- CRRT return line (blue) connects to ECMO venous line pig-tail (this is the ECMO pulling side/negative). Blue to Blue
- CRRT access line (red) connects to ECMO arterial line pig-tail (this is the ECMO "squirting" side/positive. Red to Red
- RN will assist Specialist and Perfusion with connecting lines to ECMO circuit
    - Be prepared to assist with "wet priming the lines/wet to wet connect"



Weaning from ECMO

- ELSO guidelines for weaning: When ECMO support is less than 30% of total native heart or lung function, may be adequate to allow coming off support and trial off is indicated
    - No flow less than 2L per min for extended period of time due to risk of thrombus
    - Cilley Test: Turn vent to 100%; if significant rise in SpO2 then the lungs are clearly contributing whereas lack of response indicates lack of significant lung recruitment or alternatively ECMO flow is too high and capturing nearly all the cardiac output
- If ECMO support is more than 30-50%, there is no indication to trial off, except in special circumstances such as uncontrolled bleeding

VA ECMO: As heart and lung function improves, support is weaned

- Decrease ECMO flow, monitor native function via TEE and add inotrope for support
- May require pressors while weaning

VV ECMO: As native lung function improves; Indications for improvement include

- Return to dry weight
- Improved CXR
- Improved compliance
- Ability to wean ECMO O2 and sweep with acceptable ABG, and maintain flow

ELSO Guidelines

- Decrease flow in steps to 1L/min at sweep FiO2 100% or decrease flow to 2L/min then decrease sweep FiO2 to maintain SaO2 > 95%
- When SaO2 stable on these settings, on VV trial off by clamping sweep on vent rest settings
    - If SaO2 > .95 and PaCO2 < 50 x 1 hour = time to come off
- Weaning can take place in different variations of FSO2 and CO2 titration
- Trial off VV:
    - Adjust vent to settings you would accept off ECMO
    - Maintain flow and anticoagulation, stop sweep gas, and cap off oxygenator
    - Follow pt's SaO2 and CO2
    - If lung function is adequate at acceptable vent setting for an hour or more, patient is ready to decannulate

<u>End of Life Issues</u>

- Families need to be educated and supported!
- VV will be longer runs - weeks to even months
- VA ECMO is shorter – until either heart function improves, or if patient is candidate for VAD or transplant
    - If not, time to stop ECMO (typically 4-7 days)
    - Decision to terminate is part of daily discussion trending in that direction
    - Begin palliative care approach
        - Patient may be neurologically intact
- Support the grieving process with the flexibility of timeline for withdrawal

<u>Decannulation</u>

- All venous cannulas can be removed using simple aseptic technique
- This can be done in an awake and cooperative patient and does not require sedation
- A team is required to ensure that resuscitation measures can be established without delay in case of a problem.
    - The operator requires an assistant. The team needs to plan for possible issues.
    - Protective equipment should be used by all team members, as there is a high risk of blood splash on removing a long indwelling cannula.
- The operator must be aware of the risk of air embolism (which could be entrained into the patient's own circulation with devastating consequences) and a positive pressure needs to be applied when the cannula is withdrawn.
- A conscious patient is then asked to perform a Valsalva maneuver to prevent air embolism, the tubing is clamped, the cannula is smartly withdrawn by an assistant and the suture is tied.
- No manual pressure should be applied to the skin, as the lips of the wound will usually close the track and avoid bleeding. Pressure might occlude the vein and lead to the formation of a thrombus
    - Post-decannulation Doppler: lower limb venous Doppler should be performed (prolonged femoral venous cannulation promotes distal DVT formation)

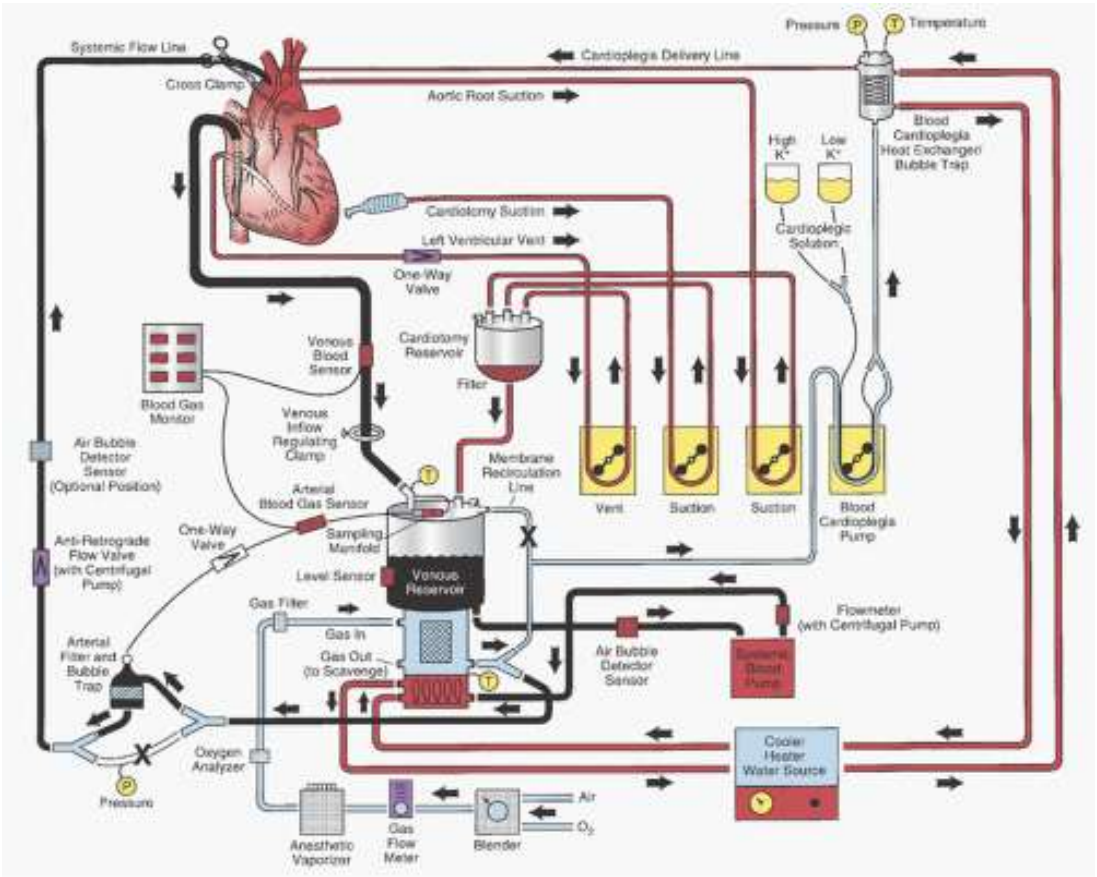
ECMO – Tips, Tricks, and Considerations for CVICU

- Always have a back-up pump/circuit in the unit
- Maintain ECMO flows (3 – 3.5)
- Assess cannulation site every hour
- Turn every 2 hours, as tolerated
- Immobilize lower extremity, if needed
- STAT X-ray after any transport
- Dayshift dressing changes and bath
    - Every 4 days dressing changes unless saturated
- Neurovascular checks every hour
- Vitals every hour and per ICU Model of Care
- Neurological checks every hour
- Cerebral oxygen saturation if able
    - Leg sats if femorally cannulated VA patient
- Patient to pump head is negative (blue); anything post pump is positive (red)
- Always notify RT sitting pump when flushing lines or giving meds
    - Aspirate 1 cc to pull out any air bubbles prior to flush
    - Any air bubbles or increased pressure can cause the pump to clamp down and lower pt's BP
    - No air bubbles!!
- Femoral cannulations
    - Always have a right upper extremity arterial line to monitor for North/South Syndrome (Mixing cloud)
- Labs every 4 hours
    - Replace electrolytes per protocol
    - Hepatic function panel once per shift
- Provider goals:
    - ACT 180 - 220; check every hour until normal, then every 4 hours; RT to draw
    - HCT 30 or greater: check every morning that blood bank is staying ahead 2-3 units
    - PLTS > 50,000
    - iCal 1.3 or greater
    - Mag 2 - 2.5

Perfusion 101

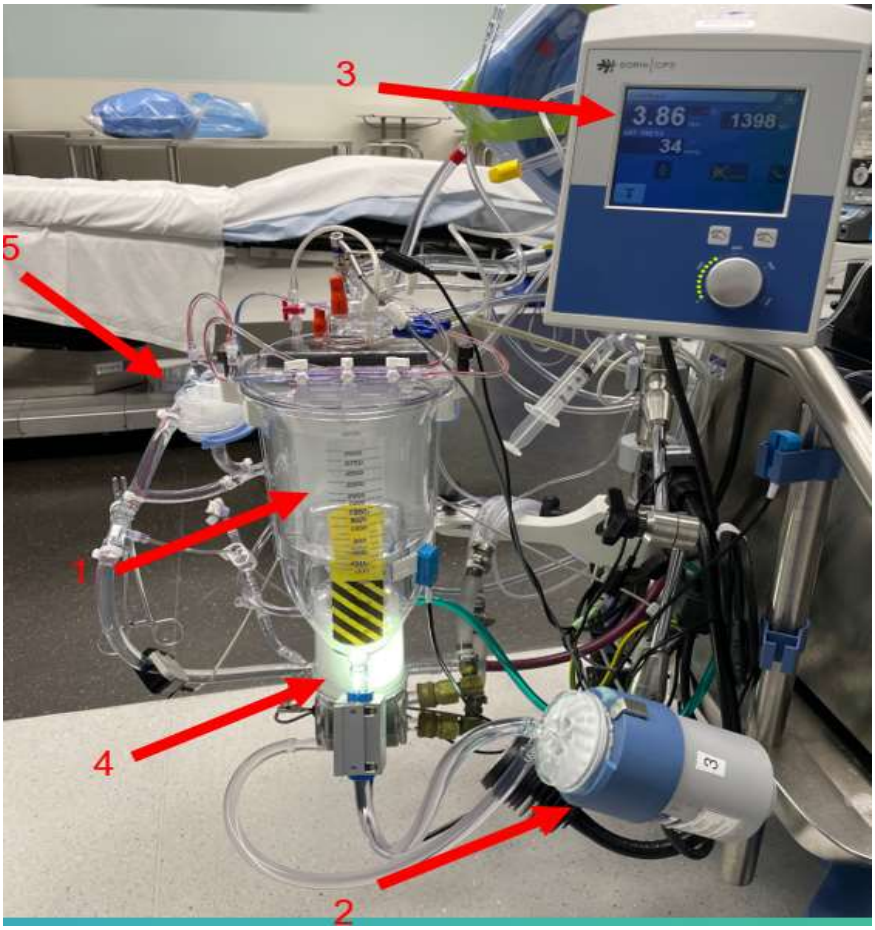
Purpose of Cardiopulmonary Bypass

- Drain the heart (bloodless field) and stop the heart (protection)
- Bypass heart and lungs



Differences between ECMO and Cardiopulmonary Bypass

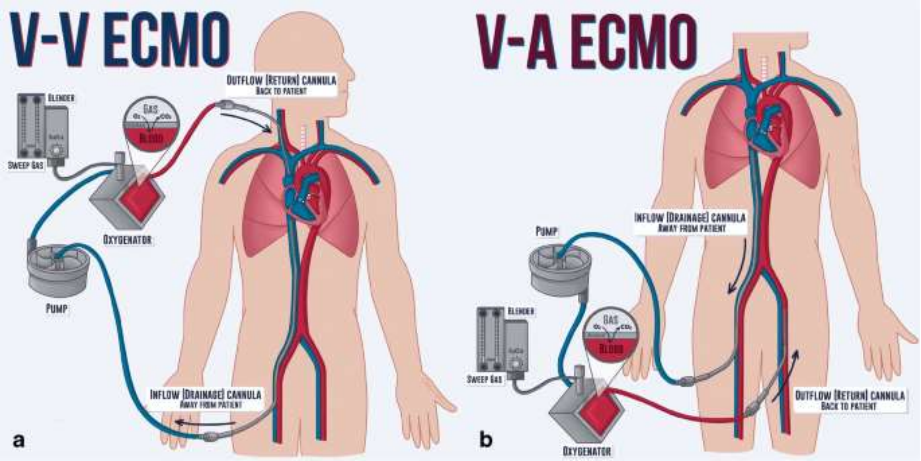
- Support level (full vs. partial)
- Cannulation type (central vs. peripheral)
- Short term vs. long term (oxygenator fibers)
- Open circuit vs. closed circuit (reservoir)
- Anticoagulation (ACT 480 vs. ACT 180-220)

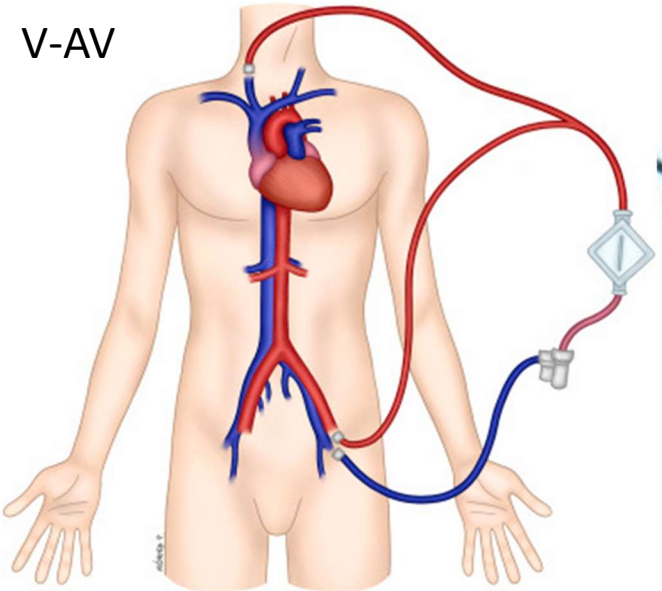


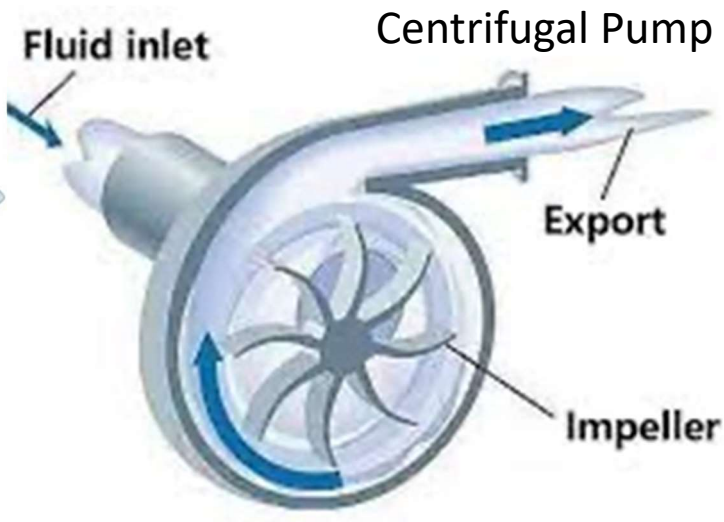
6. Right atrium → Venous line to reservoir
7. Centrifugal pump head
8. Arterial pump head controls RPMs, flow, and arterial line pressure
9. Through heat exchanger to oxygenator
10. Arterial line filter → arterial line to Aorta

Types of ECMO

- V-V: Provides respiratory support/gas exchange, "pre-oxygenates"
  - To increase support: increase flow to increase oxygenation
  - To wean: sweep trail
- V-A: Provides cardiopulmonary support
  - To increase support: increase flow to increase MAP
  - To wean: decrease flow, NOT sweep
- V-AV: Provides both respiratory and cardiac support
  - Venous drainage with reinfusion in venous AND arterial (clamp and extra flow probe needed)
  - To wean: Typically, remove one component first







Centrifugal Pump

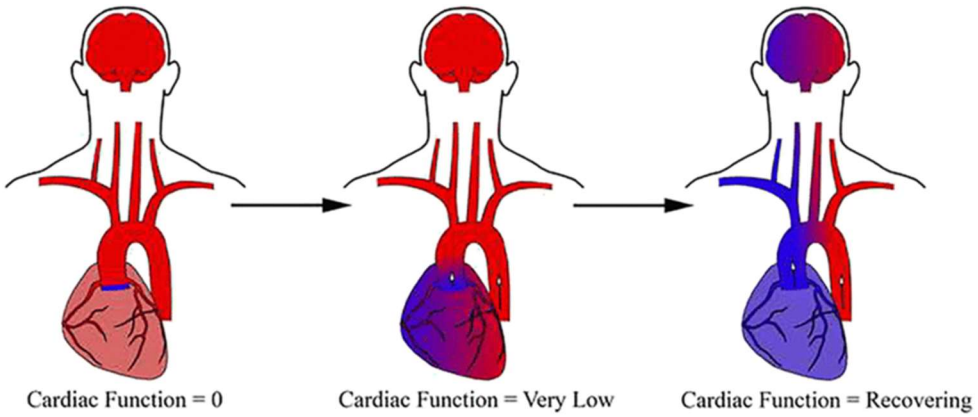
- Preload dependant and afterload sensitive
- Needs adequate volume
    - Flow will change depending on afterload (MAP, tubing kink, clot)
- Venous line chugging
- Centrifugal pump head and closed circuit (ECMO) has a risk of air entrapment
- Be mindful of anything going into the central line, giving fluid, stopcocks, CRRT, run through IV pump

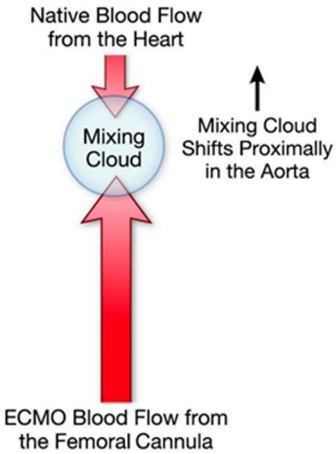
Troubleshooting: Bubble Detector

- Safety features: flow and pressure alarms, tie-bands, bubble detector
- If bubble detector is triggered, emergency clamp will fire and stop forward flow to the patient
- Clamp out patient
    - Look for air
    - If there's no air, override and reinitiate (viscosity can sometimes cause this)
    - If air, perfusionist will de-air circuit

Troubleshooting: VA ECMO

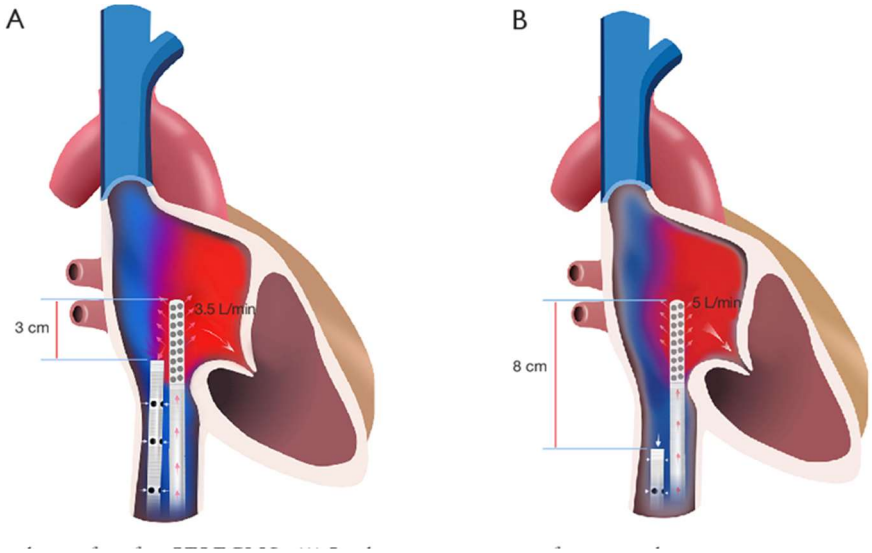
- North-South, Harlequin, Mixing Cloud Phenomenon
- Flow competition in Aorta in femoral VA ECMO when LV starts to recover with poor pulmonary function
- Draw labs form right side to see what the heart and brain are actually receiving
- Optimize vent, bronch, reduce afterload (IABP, Impella), consider V-AV ECMO





Troubleshooting: VV ECMO

- Recirculation
- VV through Fem-IJ or Fem-Fem
- Venous cannulas in same circulation where return is capturing too much of inflow
- Verify position with X-ray or Fluoro.; Move cannulas farther apart
- Use dual lumen cannulas (Crescent, Avalon)



How can you help perfusion?

- Continue any code support
- Clear the room and patient bed
    - Bring bedside table
- Find hats and mask; help "protect" the room
- Have blood available (1L plasmalyte given)
- Blood gas/ACT after goal support reached
- Do not remove items from the red bag