

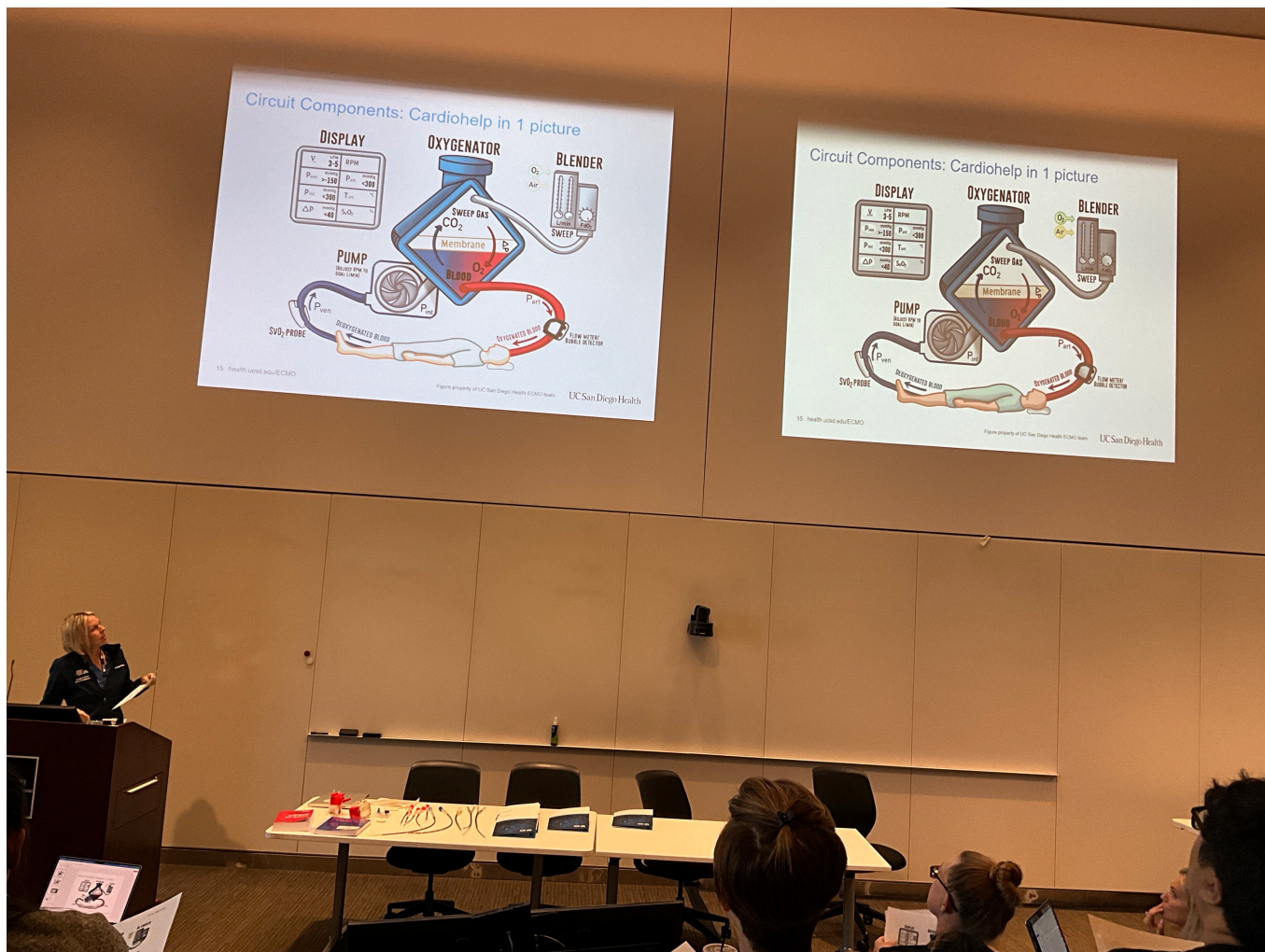
Note: Buy ECMO Red Book

ECMO UC San Diego

- ELSO
- staff intro
- ELSO Red Book

Objectives

- define the main component of ECMO circuit
- ELSO Gold Level Center of Excellence
- What is ECMO





## CARDIOHELP BRAND ECMO

- Cardiohelp is most thorough brand machine
- Blood and air
- Always pulling from vein only
- VENOUS SIDE
  - Deoxy blood
  - SVO<sub>2</sub> probe
  - ECMO pump
    - Centrifugal
    - Preload dependent
    - Afterload sensitive
    - Small magnet (compared to big machine which it couples with)
      - Next to Oxygenator (it couples with it and its magnet to make pump turner)
    - Venous pressure (sucking, negative pressure)
    - Boba metaphor (makes venous pressure more negative - ALARM)
      - **Kink of Clot**
      - **Diameter (surgeon chooses)**
      - **Against wall (positioning)**
      - **Volume**
      - If venous pressure goes negative it will stop flow
  - Oxygenator (membrane lung)
    - Has numerous filters/straws that blood pumps through
    - Expels air out the bottom
    - 3/8 cannula goes to this straw
    - Diffuses
      - Adding oxygen
        - Higher concentration, taking CO<sub>2</sub> out
      - Removing CO<sub>2</sub>
        - Lower concentration, bringing O<sub>2</sub> inside
  - Blender (Seachrist)
    - Mechanical knob or electronic monitor
    - Wall connection: Green line is O<sub>2</sub>, yellow is air
      - You determine the mix
    - FdO<sub>2</sub> - fraction of diffusion O<sub>2</sub>
      - Changes O<sub>2</sub> sat and PaO<sub>2</sub>
  - Flowmeter
    - If you *slow the Sweep*, you put in more O<sub>2</sub>
      - Up on Sweep remove more CO<sub>2</sub>
      - Goes up by 0.2 to 1
    - Two work independently of each other
    - How to move to CT (scenario)
      - Use tank O<sub>2</sub>
      - L/min goes 1:1 to O<sub>2</sub>
        - So 60% flow switch knob to 6 L/min
        - FdO<sub>2</sub> goes 100%
          - Cannot go higher
          - But you can increase FiO<sub>2</sub> on ventilator
        - Dependent on 2 things? \_\_\_\_\_ , \_\_\_\_\_
    - Return side is arterial side (or vein, even though we say arterial side)
    - Pushing pressure is positive pressure
    - Two things that make it hard to push
      - Clot or kink (positioning)
    - Third thing to artery return complication
      - SVR resistance (increase afterload)
        - Scenario

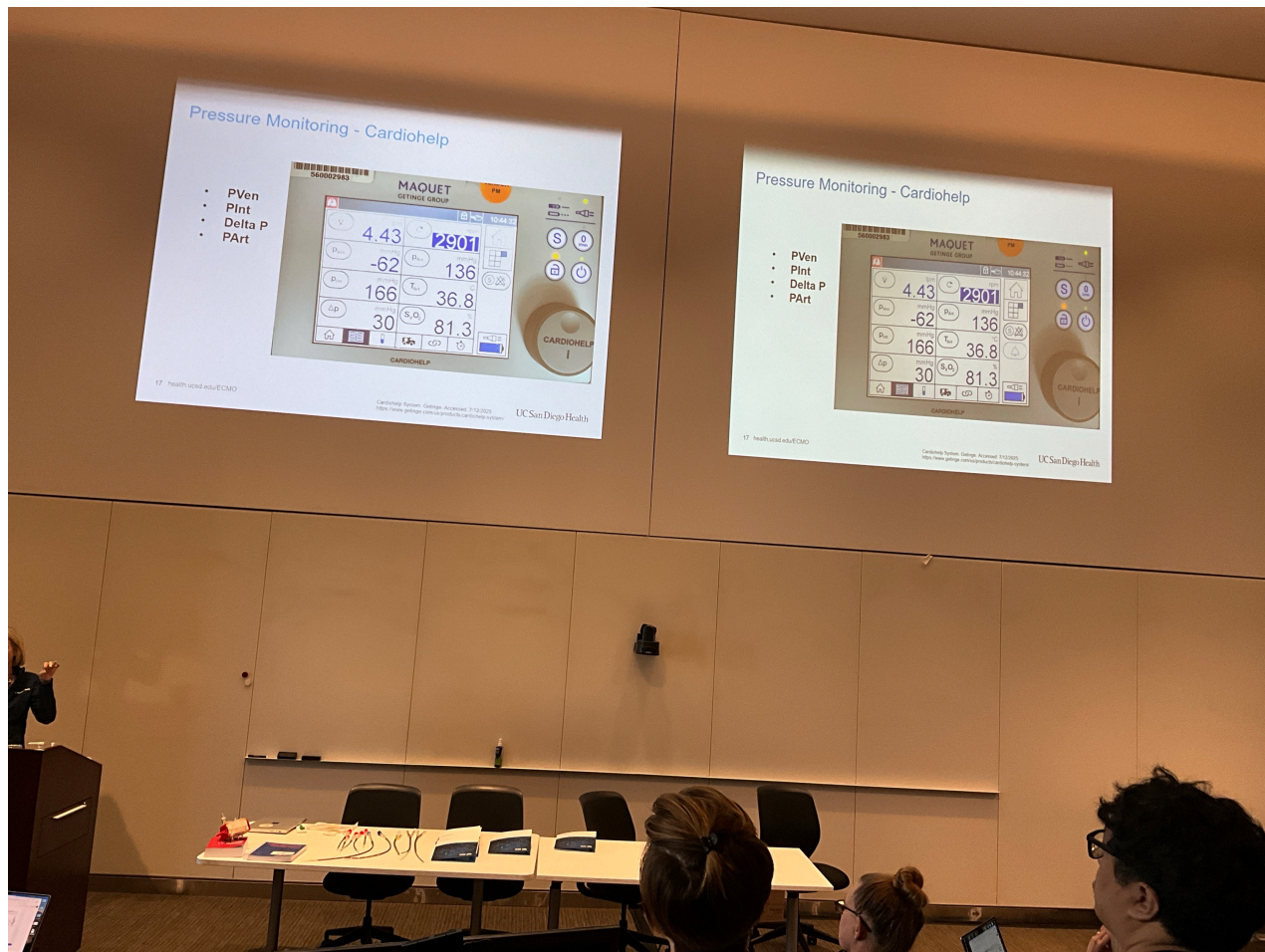


- High BP, must crank it up (high SVR)
- P-int vs P-art delta (difference)
  - Change in pressure is b/c of clot
  - Over 40 (or increasing)
- Flow Meter/Bubble Detector
  - Rpm increases w/air (optional intervention) - VA only
- Can also measure temperature of Oxygenator

## MODULAR ECMO SYSTEM

- All negative?
- **All ECMO brands have**
  - RPM
  - FFLOW (L/min)





## Pven

- Always negative, suctioning
- Four

## P-int

- Resistance
  - Kink and clot
  - SVR

## Delta P

- Change of resistance

## SVO2 Probe

## Vital Flow SO2

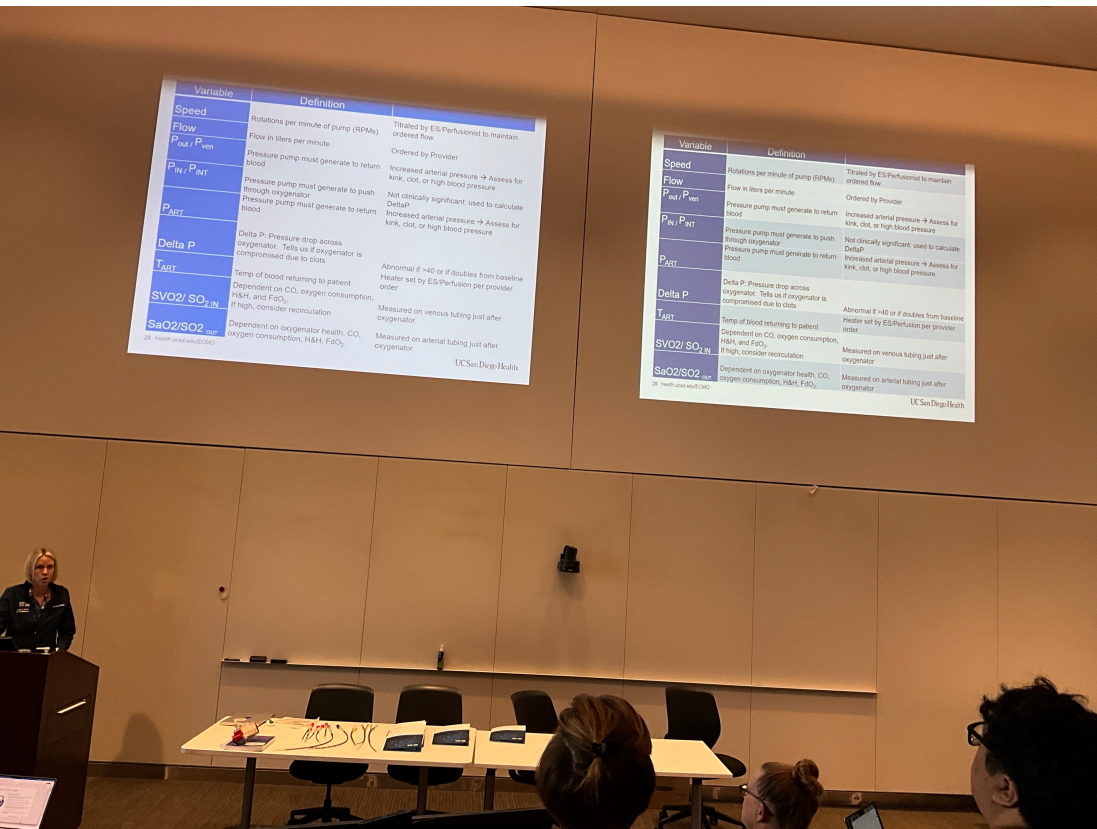
- In (venous) and out (arterial)



Quantum brand screen

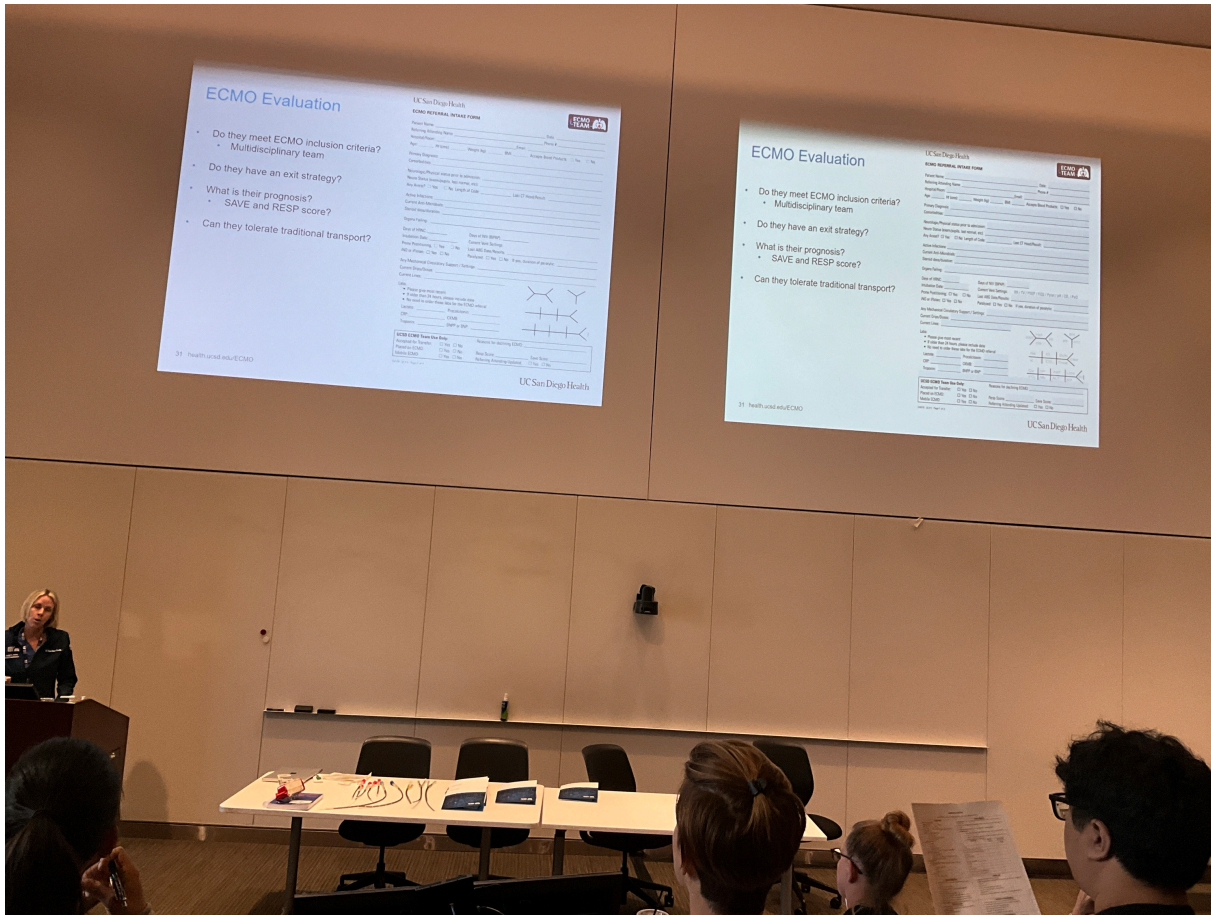


All the variables in each machine:





## ECMO Evaluation



- More like suggestions but think critically
- SAVE (VA) and RESP (VV) score
  - Score of 0 means half will survive?
  - Don't use for COVID

## ECPR

- ECMO w/in 20 minutes of ROSC

## ECMO CANNULATION

- Can do anywhere
- VA and VV
  - Always pulls blood from venous side

### VV ECMO: Veno-Venous

- Femoral-internal Jugular
- Lung support
- Adjust
  - O<sub>2</sub> (FdO<sub>2</sub> %)
- How do you know if it's enough
  - Standard is 2/3 ratio exchange (6L cardiac output)
    - 4 L of the cardiac output
    - 2/3 of blood out of full CO
    - Patient has higher diffusion concentration in the bloodstream (CO<sub>2</sub> going in to pump to expel), opposite of O<sub>2</sub>
- Dead space
  - Increases, so pt status goes down then improves
  - 85% arterial side PaO<sub>2</sub> but can still survive
    - Needs at least 80% is ok
- How to Cannulate
  - Two cannulas, return and remove, two sites of bleeding
  - Groin use common femoral vein (CFV, larger)

### Single Lumen Cannula

- **Venous:** multiple ports, longer, and larger diameter
- **Arterial:** limited distal ports, shorter with a luer-lock access

18F (6.0mm)  
20F (6.7mm)  
22F (7.3mm)  
24F (8.0mm)  
25F (8.3mm)  
28F (9.3mm)  
29F (9.7mm)

16F (5.3mm)  
18F (6.0mm)  
**19F** (6.3mm)  
20F (6.7mm)  
**21F** (7.0mm)  
23F (7.7mm)

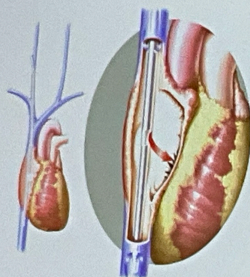


- Venous vs Arterial
  - Note you cannot see the color of the cannulas when inserted
  - Only arterial cannulas have luer lock
    - If venous have luer lock you could introduce air
      - Lock allows connector to perfuse lower extremity
    - Arterial is shorter
  - Venous have multiple holes if it gets stuck
    - Venous have direct effect on your flows
  - larger French is not always needed, more complications
  - Venous
    - Don't use same vein?
      - Preferred femoral and IJ (preferred over SC b/c it's direct)
      - SC is more bent, but tighter vessel and helps w/moving pt w/o risk of cannula migrating
        - Recirculating problem if it migrates
          - Less effective treatment
        - Mostly lung pts
      - Some do fem fem
    - Lower extremities
      - Still have to use same vein now?
    - Ambulating patients
      - Some have dual lumen cannula
  - Dual Lumen complications (Avalon or\_\_\_?)
    - One cannula higher one lower, arterial cannula should be past tricuspid valve
      - Lower returns back to tricuspid valve
        - If not, it **recirculates** up or down, back to ECMO

## Dual Lumen Cannula Options

Avalon

Crescent



Sizes	Insertable Length
13 Fr. (4.3 mm)	4" (10 cm)
16 Fr. (5.3 mm)	5" (13 cm)
19 Fr. (6.3 mm)	7.75" (20 cm)
20 Fr. (6.7 mm)	11.5" (29 cm)
23 Fr. (7.7 mm)	11.5" (29 cm)
27 Fr. (9.0 mm)	11.5" (29 cm)
31 Fr. (10.3 mm)	11.5" (29 cm)

- Pulls blood from Superior and Inferior Vena Cava
- Returns blood to Right Atrium (pointed at Tricuspid valve)

- Must be put in upper extremities
- 31F but also shares w/arterial lumen so not really
- Pulls from RA
- Returns to PA
  - Higher tip
  - Might not recirculate as much cuz smaller "vein"
- RV failure
- Made for VAD support but added O<sub>2</sub>, so it becomes ECMO



- Not meant for long term use
- Choosing
  - Site (type)
  - Size
  - Flow (size)
    - GOAL: Adult 120-140 ml/kg/min
    - Find which requires flow
    - Pressure flow curves
      - Surgeon will decide
- Heart has to function normally
  - Tolerate 80% SpO<sub>2</sub>

NOTE: VV-ECMO has complication of RE-Circulation, but VA-ECMO is Dual-Circulation

## VA ECMO

- Bypassing both heart AND lung
- Flow
  - VV - How much blood you're putting back in (oxygenating)
  - VA - 4L systemic support
    - This is your cardiac output
- Fem Fem is common
- X-ray view can show you what type
  - Shorter cannula in fem fem means VA (arterial return)

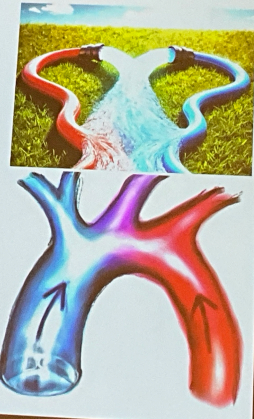


- Why not all pts go to VA ECMO?
  - Opposing flows (mixed circulation)

- Normal physio has heart going down, cannula arterial going up
  - RPM is the same
  - When recovering, heart EF will get stronger, pushing blood forward, resulting in competing flows

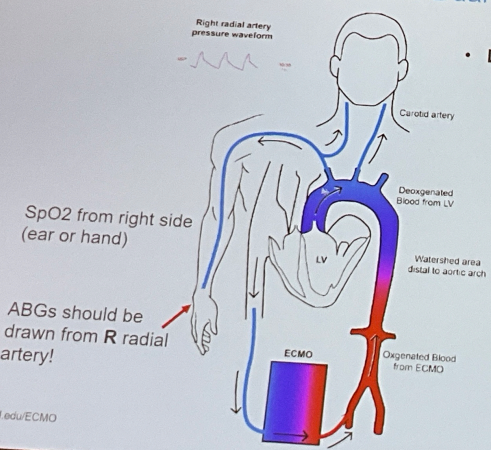
### Opposing Flows

- **Antegrade blood flow:** The direction of blood flow ejected from the heart during normal physiology
- **Retrograde blood flow:** The direction of blood flow infused by the V-A ECMO circuit which is opposite the normal direction of blood ejected from the heart
- **Competitive flows:** The presence of antegrade flow generated by native cardiac output from the left ventricle and retrograde blood flow reinfused from the peripheral V-A ECMO circuit
- **Mixing Point:** where the two opposing flows meet and mix



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### Consequences of Retrograde Flow: Dual Circulation



- **Dual Circulation!**
  - Native Heart
  - ECMO circuit

Right radial artery pressure waveform

Carotid artery

Deoxygenated Blood from LV

Watershed area distal to aortic arch

Oxygenated Blood from ECMO

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SpO2 from right side (ear or hand)

ABGs should be drawn from R radial artery!

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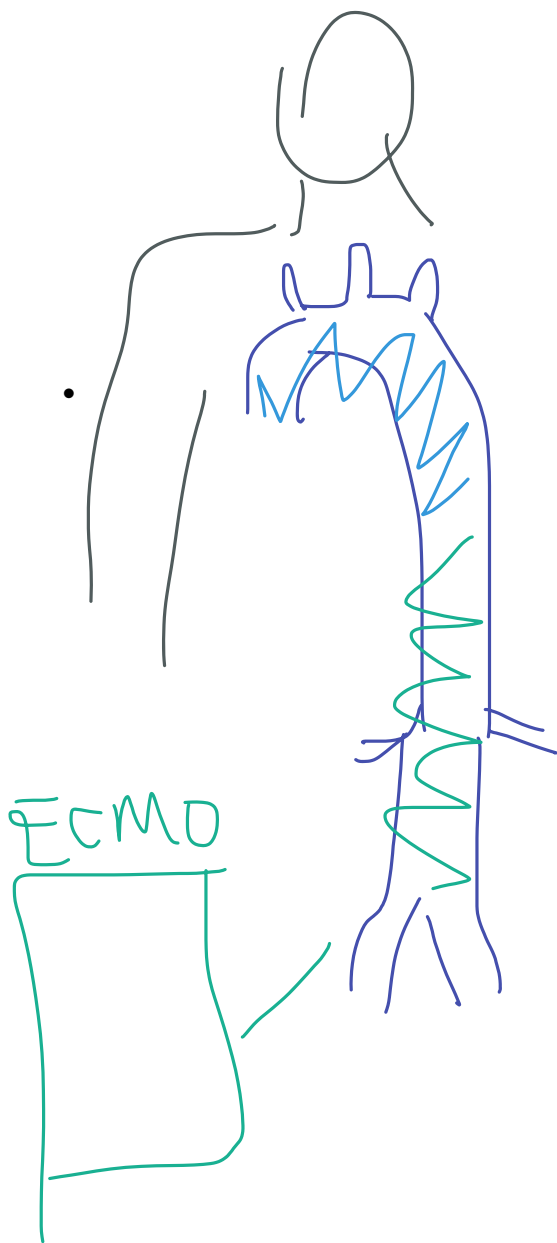
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### Consequences

SpO2 from (ear or ha

ABGs sho drawn fro artery!

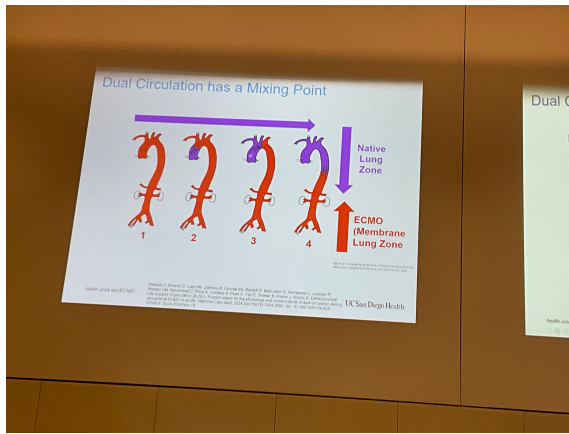
60 health.ucsd.edu/ECMO



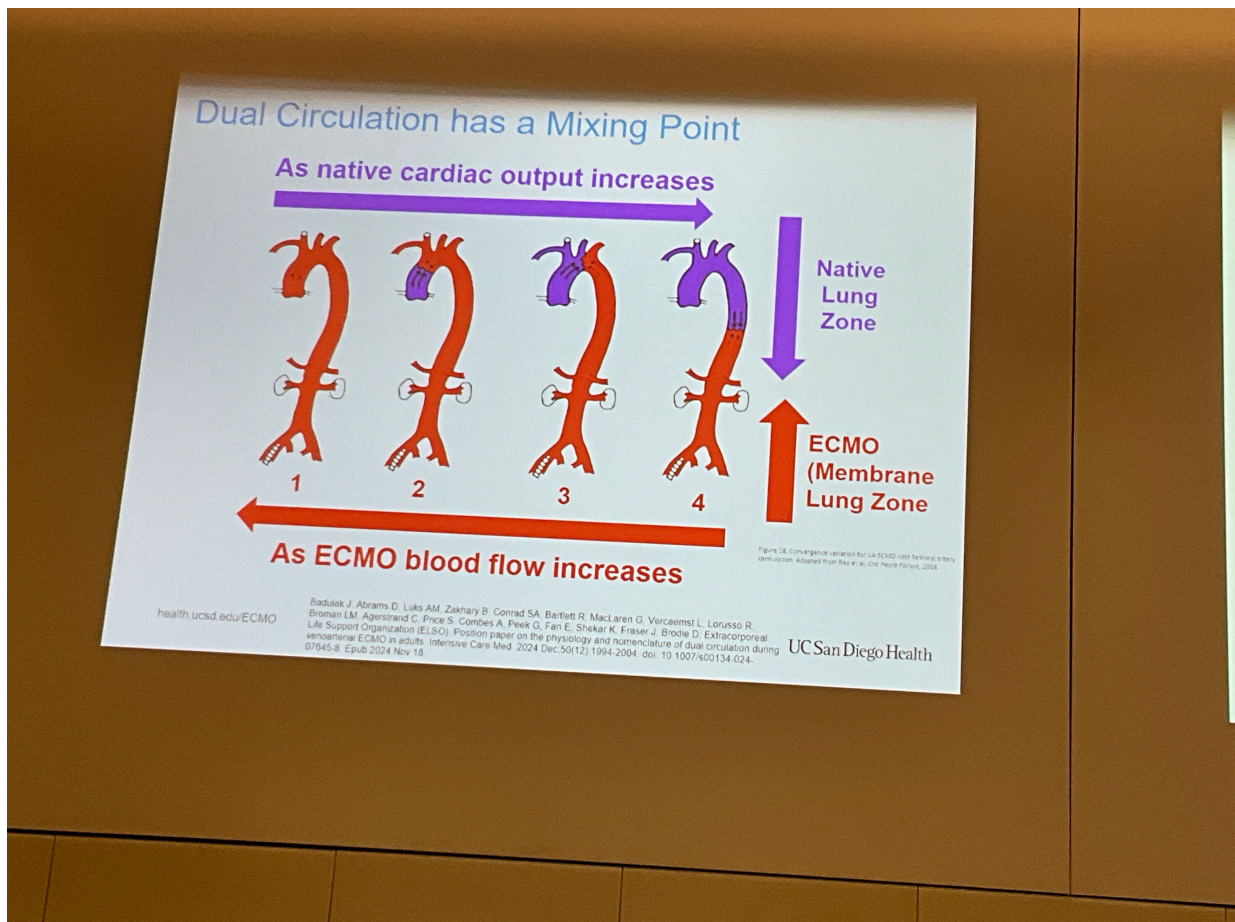
- Dual circulation (VA-ECMO) is a BIG DEAL



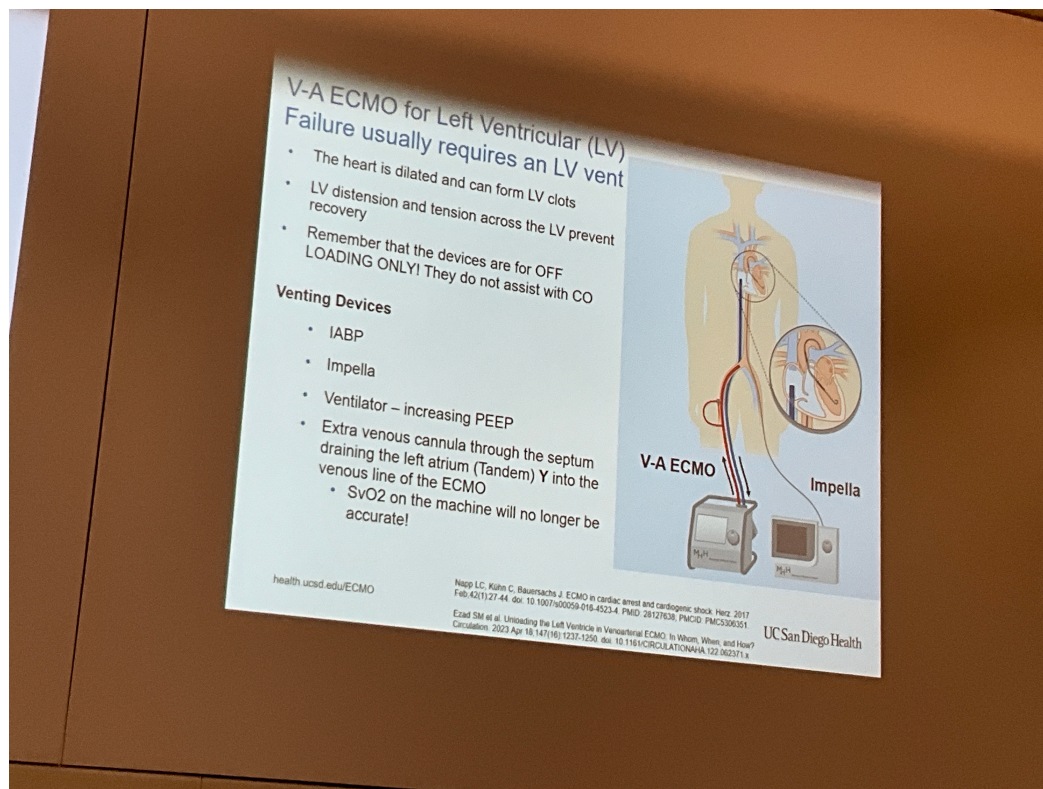
- Catch early
- Only circulates half of the body
  - Heart keeps competing, constantly competing w/ECMO flow



- Delivering deoxygenated instead
- Must **increase RPM!**
  - So it pushes against native heart
    - But not really done
  - Increase vent settings
    - FiO2 increase
    - Normal PEEP is 8-12 H2O cm , depends on body habitus
      - Inotropes if trouble circulation
- Ok to keep 80% fio2 or increase if dual circulation
  - Or increase vent settings
- North South vs East West?



- Depends on RV vs LV failure
- ART lines
  - Put on R side, where ECMO is
  - Flat line w/pulse is ECMO doing it
- Mixing dual circulation (pic)



- Dual circulation getting worse will backflow into LV, causing increased pressure and damage
  - Increased elasticity
  - Clot
  - Will have LV Impella or Balloon Pump act as “vent” to “unload” (removing extra stagnant blood output)
    - Impella (LV vents), is cardiac support so you don’t have muscle stretch
  - why can’t we drain from the groin/
    - Axillary? Veins too small, but only option for upper extremities
      - Follows normal artery, no competition
      - Difficult to place & blocks flow into arm
        - Must use conduit but cannot manage direct flow, risking compartment syndrome

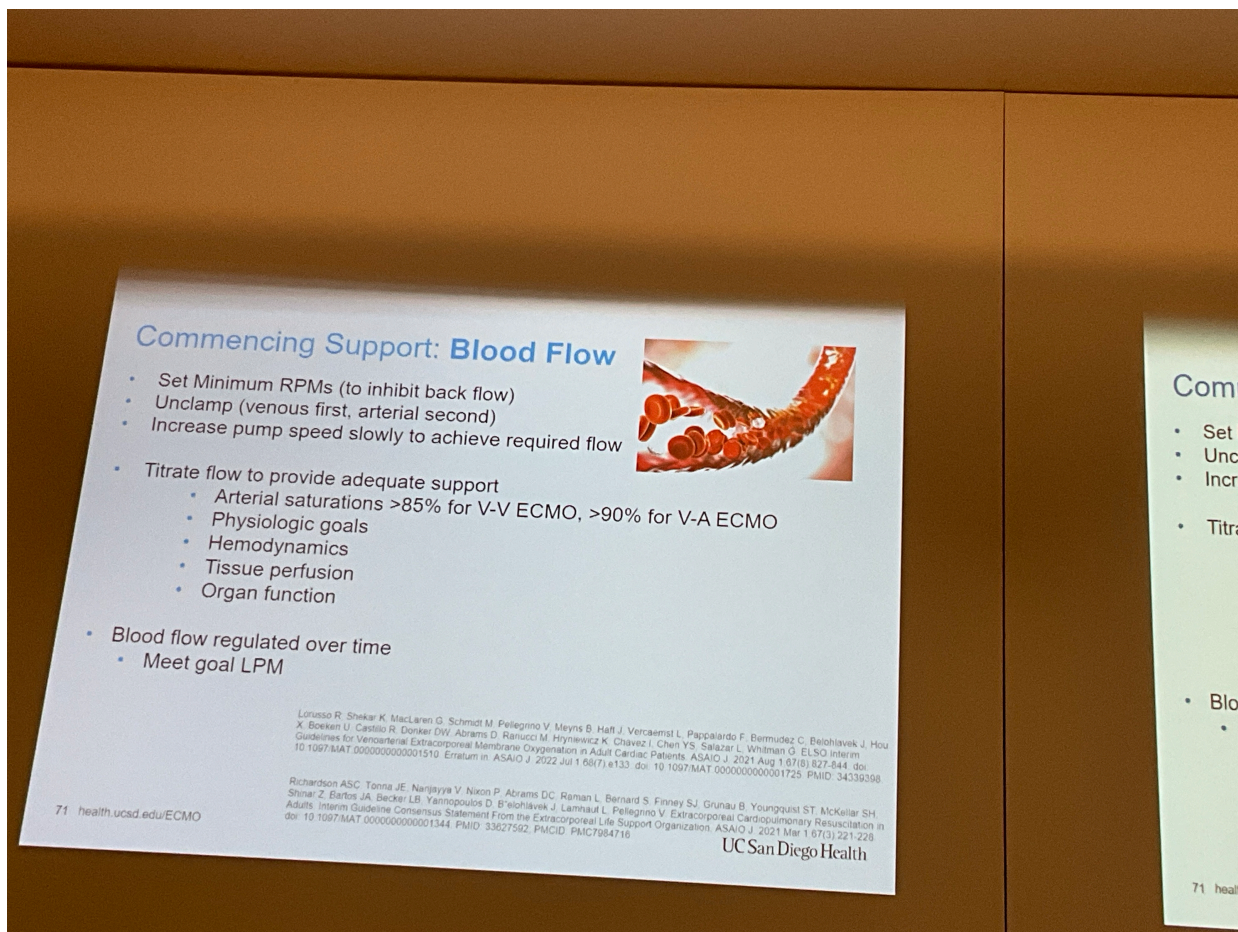




◦ Also risks hyperoxia to brain!, as in super high PO<sub>2</sub>, ~around 500; brain strips higher than 65%

• Therefore not popular

- Central Cannulation
  - Open heart usually in OR
- VAV Cannulation
  - Returns to both vein and artery



• Helpful for Pulmonary hypertension and cardiac insufficiency

- Such as for ARDS VV ECMO and your RV fails
- Con: resistance to venous side is lower so will get more flow there, and arterial cannula will clot off because of



lower flow on arterial side

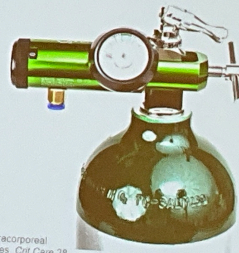
- Hard to manage

## ACUTE CANNULATION COMPLICATIONS

- Bleeding
- Ischemia (VA)
  - Lose limb
- Dissection
- Compartment

### Commencing Support: Sweep and FdO<sub>2</sub>

- Start at 100% (on O<sub>2</sub> tank)
- Start at prescribed sweep
  - Previously 1:1 for V-A ECMO, now more 50% of blood flow
  - 1-2 L/min for V-V ECMO
    - Start lower sweep to prevent large swings in CO<sub>2</sub> for very hypercapnic patients
- Draw ABGs every 15-30 minutes, and slowly titrate sweep to achieve goal CO<sub>2</sub>
- Early changes in CO<sub>2</sub> associated with neurologic complications



The ELSO Red Book, 6th edition, page 93

Cho SM, Heang J, Charro G, et al. Neurological monitoring and management for adult extracorporeal membrane oxygenation patients. Extracorporeal Life Support Organization consensus guidelines. Crit Care 28:296 (2024). <https://doi.org/10.1186/s13054-024-05092-z>

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Calvayias YA, Murehi L, Del Sorbo L, Fan E. The Early Change in Pa<sub>CO2</sub> after Extracorporeal Membrane Oxygenation Initiation is Associated with Neurological Complications. Am J Respir Crit Care Med. 2020 Jun 15;201(12):1525-1535. doi: 10.1164/rccm.202001-0023OC. PMID: 32251608

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SUPPORT



## Hypotension may occur with V-V ECMO initiation

- Common during initiation
  - Especially when priming fluid is cold (pre-warm it!)
- Transient and rarely of clinical significance
- Etiologies:
  - Hypocalcemia
  - pH shifts
  - Temperature changes
  - Shifts in electrolyte concentrations
- Prevention/Intervention
  - Go on support slowly!
  - Almost no advantage to go on fast!
  - Have pressors at bedside and ready to go!

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Tenna JE et al. Management of Adult Patients Supported with Venovenous Extracorporeal Membrane Oxygenation (VV ECMO): Guideline from the Extracorporeal Life Support Organization (ELSO). *ASAIO J*. 2021;Jan 1;67(1):601-610. doi: 10.1097/MAT.0000000000001432. PMID: 33965979. PMCID: PMC8315725.

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- **Set RPM (to inhibit back flow)**
  - If not set, during CP R,

cannulas will act as a shunt!

- That's why start in at least 1,500 - 2000 RPM

◦ VV

- Only care about **saturation**
  - Increase RPM and flow to make
    - PaO<sub>2</sub>
    - > 85% for VV
    - > 90% for VA

◦ VA

- Systemic

## ECMO and Anticoagulation

- Bleeding and clotting are the #1 and #2 complications of ECMO!
- Remember, 600cc of blood is constantly removed and touching plastic!
- The **BEST** way to prevent clotting is to keep blood **MOVING!** (flow)
- The **2<sup>nd</sup>** best way is using anticoagulation...a necessary evil?
  - Almost always in V-A ECMO
  - Sometimes in V-V ECMO

The ELSO Red Book, 6<sup>th</sup> edition, page 97-100

ELSO General Guidelines 8.2017

[https://www.elso.org/portals/0/assets%20guidelines%20general%20a%20v%20version%201\\_4.pdf](https://www.elso.org/portals/0/assets%20guidelines%20general%20a%20v%20version%201_4.pdf)

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McMichael, Ali B V\*, Ryerson, Lindsay M T, Balogh, Carmel J, Fan, Eddy, Faruqi, Davoor, Aronch, Gail M J. 2021 ELSO Adult and Pediatric Anticoagulation Guidelines. *ASAIO Journal* 68(3):p 303-310, March 2022. | DOI: 10.1097/MAT.0000000000001852

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## ECMO an

- Bleeding a
- Remember
- The BEST
- The 2<sup>nd</sup> be
  - Almos
  - Some

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- Arterial pressures
- **Sweep and FdO<sub>2</sub>** (blender?)
  - VA - gas is not the issue
    - 1:1 ratio: flow 5, sweep 5
  - VV
    - High cO<sub>2</sub> levels and CO<sub>2</sub> saturations
    - Take gases to slowly titrate Sweep

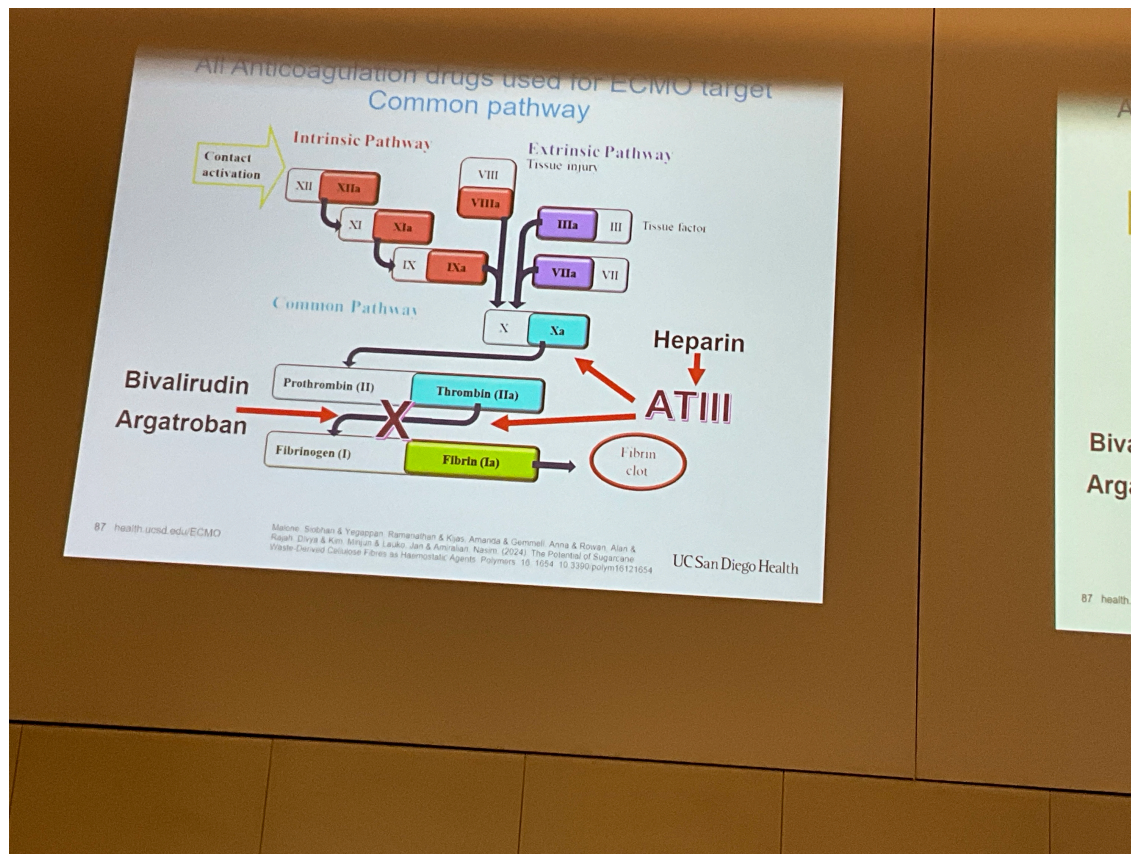


## Hemostasis Platelet plug formation During ECMO

1. High shear stress  
Major activator of platelets – clot formation  
Damaging platelet surface receptors (GP) – bleeding
2. Von Willebrand Factor (VWF) interaction  
Changing shape and binding to platelets and trigger activation  
VWF can break down due to shear stress and effect  
hemostasis - Bleeding

- Hypotension w/ VV
  - Expected, give it time to recover

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AGULATION &  
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MT

- 600 cc outside the body in plastic ECMO machine
  - Clots, so

use flow to keep blood moving!

- Must be anticoagulated
  - VA always
  - VV sometimes
- Goals: **avoid** clots & bleeding
- Hemostasis (coagulation review)



## Heparin

- Heparin works by **boosting the action of ATIII** —
  - It makes ATIII 1000x more effective at shutting down thrombin and Factor Xa.
    - Also weakly inhibits IXa, XIa, XIIa
  - Requires ATIII to work
  - ½ life of 30-60 minutes
  - Metabolized in liver
  - Reversal agent: Protamine Sulfate
- If someone is **resistant to heparin**, we check ATIII levels — because without enough ATIII, **heparin won't work properly**.

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McMichael, A; B. V. Ryerson, Lindsay M. T. Ralano, Daman, S. Fan, Eddy, Farson, David, Anesh, Gail M. 2021 ELSO Adult and Pediatric Anticoagulation Guidelines. ASAIO Journal 68(3) p. 303-310, March 2022 | DOI: 10.1097/MAT.0000000000001652

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▸ Clots to fibrinolysis

- Phase 1: vasospasm

- Reduce blood flow
- ECMO can mimic
- Phase 2: platelet plug
  - Adhesion
    - Sticking to site
  - Activation
    - Recruiting more platelets
  - Aggregation
    - Using fibrinolysis to thicken clot
- Platelet plug formation - How does ECMO change it?
  - High Shear stress activates PLT
  - Von Willebrand Factor interaction activates & changes shape and binding by breaking down PLT
- Clotting cascade (review)
  - Extrinsic and intrinsic pathway to make fibrin
  - Intrinsic is slow, such as infection e.g. COVID, not needing PLT activation from outside vascular
    - Even just ECMO activates it
  - Extrinsic - tissue factor e.g., when it is cut, so it is quicker pathway
  - Common pathway
    - main focus, where fibrin is made
    - Starts in factor X
      - Prothrombin -> Thrombin (IIa) to Fibrinogen -> Fibrin + platelets (mesh)
  - Fibrinolysis
    - Responding to too much clot formation, to stop it
  - ECMO activates intrinsic (extrinsic pathway only during Cannulation insertion)
- Anticoagulant Meds
  - **Preferred**
    - Heparin

- Bivalirudin (angiomax)

### Routine ECMO Labs

- CBC; Platelet count and Hgb/Hct
- Electrolyte Panel: potassium, Ca<sup>+</sup>
- AST, ALT: liver function
  - Most coagulation factors are generated by liver
- Plasma Free Hgb, LDH
  - Lactate and free hemoglobin increase due to cell damage
  - Hint Hemolysis
- Coagulation Labs

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- Argatroban
- Not preferred
  - ASA and Plavix only activates PLT
  - Coumadin takes two weeks, super slow

- Understand common pathway and how it relates to drugs



- Heparin focuses on antithrombin III, but must be already present in body
  - Cheaper, comes in units
- Bivalirudin & Argatroban
  - Direct thrombin inhibitors
  - Useful if no ATIII needed for heparin

## Coagulation Labs: Lots of Options!

- PT/INR: Extrinsic pathway
- PTT: Intrinsic pathway (commonly used in ECMO)
- ACT: Activated clotting time is a rapid point of care test
- Anti-Xa: common pathway (becoming more popular in ECMO)
- Fibrinogen
- Anti-thrombin III levels: Levels below 40 would reduce the effectiveness of Heparin
- D-dimer: signs of over activated fibrinolysis
- TEG: Thromboelastography- Quantitative measurement of the ability of whole blood to form a clot

## ELSO Suggested Anticoagulation Monitoring Schedule

Laboratory Test	Frequency
ACT	Q1h-Q2h
aPTT	Q6h-Q12h (UCSD q12 after stabilization)
Anti-factor Xa assay	Q6h-Q12h (UCSD q12 after stabilization)
Platelets	Q6h-Q12h (UCSD daily)
INR	Q12h-Q24h
Fibrinogen	Q12h-Q24h
CBC	Q12h-Q24h
Antithrombin level	Daily-PRN
Plasma free hemoglobin	Daily
Thromboelastography/thromboelastometry	Daily-PRN for bleeding or thrombotic complications

Note: If Antithrombin levels are low, we switch to direct thrombin inhibitor (cheaper than replacing ATIII)



- Thrombin (IIa)

### Targeted Values depend on ECMO Center

Lab Test	Normal Values	Targeted values on Anticoagulation
PTT	25-35s	
Platelets	150000-450000/mL	50-80 (UCSD 40-60)
Fibrinogen	150-400mg/dL	>50000/mL (we don't transfuse though unless bleeding)
Hgb	35-45%	>100mg/dL (we don't transfuse though unless bleeding)
ACT	70-120s	Goal Hgb >7.0
ATIII	75-120%	180-200s
Anti-Xa	<0.1	>40%
		0.2-0.4 (UCSD 0.11 to 0.3)

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McMichael, Ali B V\*, Ryerson, Lindsay M†, Ratano, Damian‡, Fan, Eddy†, Faraoni, David†, Annich, Gail M‡. 2021 ELSO Adult and Pediatric Anticoagulation Guidelines. ASAIO Journal 68(3) p 303-310, March 2022. | DOI: 10.1097/MAT.0000000000001652

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- Converts fibrinogen -> fibrin
- Argatroban
  - Directly inhibits thrombin
  - Expensive, metabolized by liver
  - *No reversal agent*
- Bivalirudin

### Medical Complications of ECMO

• AKI (55.6%)*
• Bleeding (40.8%)*
• Thrombosis (10-40%)*
• Hemolysis (10-20%)*
• Infection (30.4%)
• Limb ischemia (16.9%)
• Neurologic complication (13.3%)*
• Compartment Syndrome (10.3%)
• Cardiac Arrest

\*Many of these complications are due to anticoagulation, or lack thereof. Will you be a bleeding center, or a clotting center?

The ELSO Red Book, 6th edition, page 97, 346, 449

Torina JE et al. Management of Adult Patients Supported with Venovenous Extracorporeal Membrane Oxygenation (VV ECMO): Guideline from the Extracorporeal Life Support Organization (ELSO). ASAIO J. 2021 Jun 1;67(6):601-619. doi: 10.1097/MAT.0000000000001432. PMID: 33965970. PMCID: PMC8315725.

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- Also direct inhibitor of thrombin
- Does not activate platelets, kidney metabolism



- Also no reversal

### ECMO Complications: Bleeding

- Major bleeding ELSO definition requires 3 units of RBC within a calendar day
- Assess all possible bleeding sites:
  - Head (less likely for large Hgb drops)
  - ENT: tracheostomy, mouth, nose
  - Pulmonary (pleural space or airway)
  - GI Track
  - Hematuria
  - Cannulation sites (retroperitoneal – dx on CT scan)
- Know your options for massive transfusion protocols
  - Consider a standing type and screen q72 hours

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### HIT: Laboratory Testing

#### 1. Immunoassay – detects antibodies to Heparin-PF4

- Example: ELISA for HIT antibodies
- **Sensitive** but not specific → false positives are common
- Quick and widely available
- A **positive** test alone doesn't confirm HIT

#### 2. Functional Assay – confirms whether antibodies are causing platelet activation

- Gold standard: Serotonin Release Assay (SRA)
- Others: Heparin-Induced Platelet Activation (HIPA) assay
- Measures whether patient antibodies **actually activate platelets**
- More **specific**, but slower and often done at specialized labs

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## Acquired von Willebrand's Disease

- **von Willebrand factor (vWF)** — a protein that helps platelets aggregation with collagen and factor 8 and bind to damaged blood vessels to stop bleeding.
- The ECMO pump and oxygenator can causes relative **deficiency** in vWF by unfolding it (proteolytic cleavage by ADAMTS-13)
  - Starts occurring within hours, clinically noticeable around day 5-7
  - May cause bleeding 1-3 weeks into ECMO
- Decreases in vWF = Decreased platelet function
- \*\*\*At UCSDH, this is one of the reasons for early tracheostomy

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Frere C, Mazzeffi M, Maier CL, Helms J, Steiner ME, Sullenger BA, Tanaka KA, Connors JM, Levy JH. Acquired von Willebrand syndrome during extracorporeal membrane oxygenation support: a comprehensive review of current evidence, communication from the ISTH SSC on perioperative and critical care thrombosis and hemostasis. *J Thromb Haemost*. 2024 Sep 22(9):2605-2628. doi: 10.1016/j.jtha.2024.06.007. Epub 2024 Jun 24. PMID: 38925492

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• CB  
pLT  
HG

• CM  
• AS

• Fre  
LD

## DIC - disseminated intravascular coagulation

- Overactive and uncontrolled processes:
  - Coagulation resulting in clot formation in an uncontrolled manner within the micro-vasculature
  - Fibrinolysis
- Etiologies: sepsis, inflammation, malignancy, trauma, pregnancy, etc
- Clinically:
  - Bleeding PIVs & ECMO cannulas, thrombosis, rashes
- Multiorgan Dysfunction:
  - AKI
  - Liver dysfunction
  - Lung injury
  - Shock

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C: huge drop in  
count and  
B/HCT

◦ Watch  
for HIT

P: K and Ca+  
T, ALT

◦ Not  
working  
stops  
making  
coagulat  
ion  
factors

e Plasma HGB,  
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◦ Lactate  
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e HGB - hemolysis

◦ Hint hemolysis

▸ Stressed cells, think about clots in machine

• Coagulation labs

### Diagnosis of DIC

- Clinical (signs and symptoms) and lab diagnosis

#### ✓ Lab Findings

Test	What You See in DIC
Platelets	Low
PT & aPTT	Prolonged
Fibrinogen	Low (consumed)
D-dimer	Very high (due to fibrin breakdown)
Schistocytes	Seen on blood smear (due to microangiopathy)

- Liver failure vs. DIC?
  - Factor VIII is elevated/normal in Liver failure, decreased in DIC.

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### Diagnosis of DIC

- Clinical (signs and symptoms) and lab diagnosis

#### ✓ Lab Findings

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- Liver failure vs. DIC?
  - Factor VIII is elevated/normal in Liver failure, decreased in DIC.

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### Treatment of DIC

#### Treat the underlying cause

#### Supportive care:

- **Platelets** if  $< 10,000$ – $20,000$  or bleeding
- **Fresh Frozen Plasma (FFP)** if bleeding
- **Cryoprecipitate** for low fibrinogen ( $< 100$  mg/dL)
- **Heparin** in select cases (DIC with thrombosis)
- Avoid TXA and prothrombin complex concentrate (PCC) as they may increase thrombotic complications

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- PT/INR extrinsic
- PTT intrinsic (used in ECMO)
- ACT: rapid POCT
- Anti-Xa: common pathway converts prothrombin to thrombin
  - Also indicates heparin efficacy
- D-dimer: chopped particle PLTs, making a lot of clot pieces somewhere
  - Good for initial ECMO, useless after a few days b/c it's natural progress of ECMO
- TEG: thromboelastography - good diagram that measures of ability of whole to form clot, but takes a few hours &

expensive, requiring QC q8h, so not useful for management

○ Every hospital may have different recommendations (see

slide below)

- ACT q2h, QC q8h
- Fibrinogen - checks why some one is bleeding but you don't know why
- TEG - show

## Acquired ATIII Deficiency

- A condition where the body lacks ATIII or the protein doesn't function properly
  - Leading to an increased **risk of thrombosis**
- Diagnosis:
  - ATIII Activity (Function Assay)
  - ATIII Antigen (Quantity of ATIII protein)
- Remember, you must have ATIII for Heparin to work!

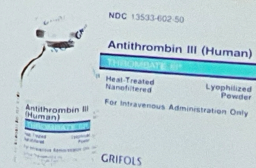
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## Treatment: IV ATIII Concentrate

- Remember, you must have ATIII for Heparin to work!
- A **plasma-derived or recombinant** product that provides **functional Antithrombin III**
- **Brand names** (depending on region): *Thrombate III*, *Kyberlin*, *ATryn* (recombinant)
- Given **intravenously**
- **Onset**: Immediate
- **Peak activity**: ~1-2 hours
- **Half-life**: ~1.5-3 days
- **Expensive**: \$1,500 to \$3,000 per 500 IU vial

Units required (IU) =  
 $120\% - \text{baseline \%} \times \text{body weight (kg)}$   
 1.4%



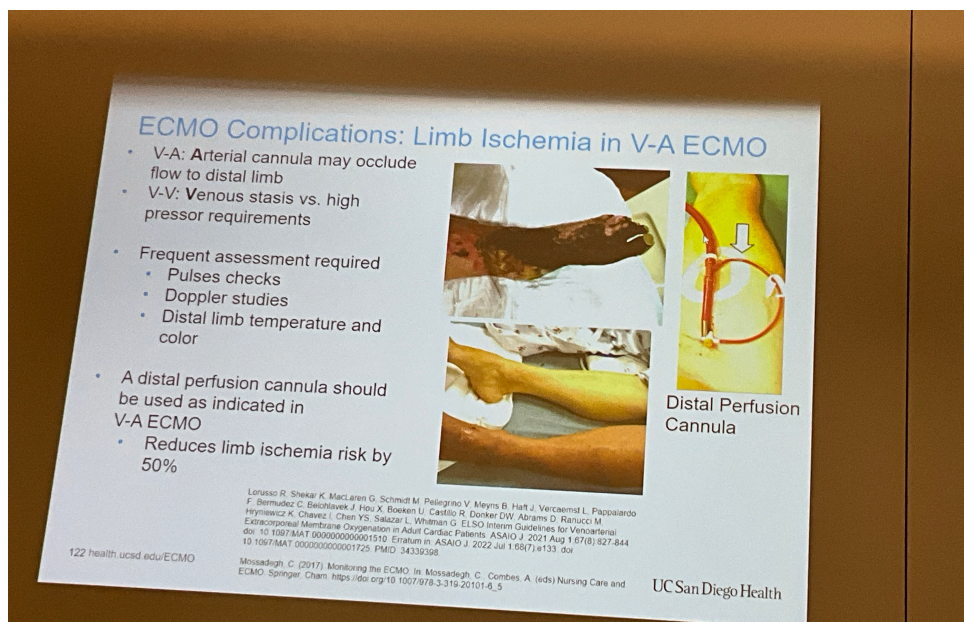
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s where supplemental therapy should be

- Target values might have different protocols, but keep ranges higher than normal





**Etiologies:**

- **Signs and Symptoms**

- **Complications**

- [illegible]

- V-V ECMO

- V-A ECMO

- ECMO

- V-V EC

- Do

- ind

- V-A EQ

- If  $p$

- EC

- En

- Note (MD):
  - Oxygenator
  - Neuro circuits smaller, heparin impregnated
  - Centrifugal instead of roller pumps
  - Vanderbilt trial - anticoagulation goals are decreasing b/c of above changes



## ECMO TIONS

- Medi  
comp  
come  
disea  
ECM
- Bleed

### Mechanical Complications of ECMO

We will spend ALL DAY tomorrow on these!

- Pump Failure
- Membrane Lung Dysfunction
- Air embolism
- Circuit Disruption
- Accidental Decannulation
- Coming off ECMO emergently
- Recirculation
- Drainage insufficiency
- Return obstructions

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The ELSO Red Book, 6th edition, page 113-123 UC San Diego Health

## COMPLICA

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- Assess entire body!
  - GI most common
- Cannulation
  - Must be placed using US
- Know your standing transfusion protocols
  - Most do not have O- on the ready, just T&S
- Coagulation
  - HIT
    - 4T's of HIT

## How to titrate ECMO Flows?

**Increasing pump RPMs increase ECMO blood flow.**

ECMO blood flows depend on:

- Preload
- Drainage cannula sizes/length
- Return cannula size/length and location (vein vs. artery)
  - Afterload (for V-A ECMO due to SVR)

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○ Von Willebrand's disease

- Decrease vWF = decreased PLT
- **GI bleeds happen on LVADs and ECMOs because of ?**
  - Use Desmopressin (DDAVP, IF they're bleeding)
  - Watch sodium
  - Replace vWF
  - TXA
  - RFVIIa (rare)

○ DIC



## Goal V-A ECMO Flows based on $DO_2/VO_2$

### Definitions

- $DO_2$  = Oxygen Delivery  
= Cardiac output (CO) x  $(1.39 \times [Hb] \times SpO_2 + (0.003 \times PaO_2))$
- $VO_2$  = Oxygen Consumption
  - Increases with exercise, catecholamine release, and sepsis/shock

Condition	$DO_2/VO_2$
Normal humans	>5
Shock state	<2
ECMO Goal	>3

Once  $DO_2/VO_2 < 2$ , then aerobic metabolism switches to anaerobic!

The ELSO Red Book, 6th edition, page 73-95

131 health.ucsd.edu/ECMO

Lorusso R, Shekar K, MacLaren G, Schmidt M, Pellegrino V, Meyns B, Haft J, Vercautem L, Pappalardo F, Bermudez C, Belonick J, Hou X, Boeken U, Castillo R, Denker DW, Abrams D, Ranucci M, Hryniewicz K, Chavez I, Chen YS, Salazar L, Vithan G. ELSO interim Guidelines for Venoarterial Extracorporeal Membrane Oxygenation in Adult Cardiac Patients. ASAIO J. 2021 Aug 1;67(8):827-844. doi: 10.1097/MAT.0000000000001510. Erratum in: ASAIO J. 2022 Jul 1;68(7):e133. doi: 10.1097/MAT.0000000000001725. PMID: 34339398

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- Uncontrolled coagulation and fibrolysis
  - Liver failure vs DIC
    - Factor VIII elevated in liver failure



## Goal V-A ECMO Flows based on $DO_2/VO_2$

### Calculating $DO_2/VO_2$ on V-A ECMO

- $DO_2$  = Oxygen Delivery
  - = Cardiac output (CO) x (1.39 x [Hb (in grams/liter)] x  $SpO_2$  + (0.003 x  $PaO_2$ )
  - = **ECMO Blood flow** x (1.39 x [Hb] x  **$SaO_2$  (post-membrane)** + (0.003 x  $PaO_2$ )
  - = ECMO Blood flow x (1.39 x [Hb] x 100 + [0.003 x  $PaO_2$  (post-membrane)])
- $VO_2$  = Oxygen Consumption
  - = ECMO Blood flow x (1.34 x [Hb] x  **$SaO_2$  -  $SvO_2$  from Circuit** + (0.003 x  $PaO_2$ )
- $DO_2/VO_2$  = everything cancels out other than  $\frac{SaO_2 \text{ (post-ECMO Membrane)}}{SaO_2 - SvO_2 \text{ (post-pre ECMO Membrane)}}$

$SvO_2$	50%	66%	75%	80%
$DO_2/VO_2$	$=100/(100-50)$ $=100/50$	$=100/(100-66)$ $=100/33$	$=100/(100-75)$ $=100/25$	$=100/(100-80)$ $=100/20$
$DO_2:VO_2$	2:1	3:1	4:1	5:1

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- Give PLT on PIV lines, away from the Oxygenator
  - PLT can increase thrombosis in Oxygenator
- Acquired AT III deficiency
  - Heparin binds to thrombin, if \_\_\_ is really high



## Goal V-V ECMO Blood Flow based on Oxygen Delivery

- $DO_2$  = Oxygen Delivery
  - = Cardiac output (CO) x (1.39 x [Hb (in grams/liter)] x  $SpO_2$  + (0.003 x  $PaO_2$ )
  - = ECMO Blood flow x (1.39 x [Hb] x  $SaO_2$  (post-membrane) + (0.003 x  $PaO_2$ )
  - = ECMO Blood flow x (1.39 x [Hb] x 100 + [0.003 x  $PaO_2$  (post-membrane)])
- Goal  $DO_2$  = 240 ml/m<sup>2</sup>/min (why 240? Double the resting  $VO_2$  of 120)
  - = ECMO Blood flow x (1.34 x [Hb] x 100 + (0.003 x  $PaO_2$ )
- Goal  $DO_2/VO_2$  = Same as V-A ECMO (>3)

SvO <sub>2</sub>	50%	66%	75%	80%
$DO_2/VO_2$	100/(100-50) 100/50	100/(100-66) 100/33	100/(100-75) 100/25	100/(100-80) 100/20
$DO_2:VO_2$	2:1	3:1	4:1	5:1

## Goal V-V ECMO Blood Flow based on Oxygen Delivery

- V-V ECMO returned blood mixes with venous blood, thus patients  $PaO_2$  and  $PaCO_2$  levels are result of mixed ECMO blood and native venous blood
  - Patient  $SpO_2$  ranges 60-90% depends on ECMO flow, cardiac output, and lung function
  - Goal  $SpO_2$  depends by ECMO center, usually >70, 75, 80, 85, etc
  - Many times,  $PaO_2$  > 50 is acceptable
- Some suggest V-V ECMO flow = 2/3 of the Cardiac Output
  - But how do you calculate the Cardiac Output?

◦ Thrombus



- Blood stasis & low flow

## How to determine CO on V-V ECMO

- **Cardiac Output** = ECMO Flow + Native Venous Flow (not going through ECMO circuit)
- **How to determine native venous blood flow?**
  - *Assumption: no lung function and no recirculation*

$$\frac{C_1 \times \text{Flow 1}}{\text{Total Flow}} + \frac{C_2 \times \text{Flow 2}}{\text{Total Flow}} = C_3$$

$$\text{Total Flow} = \text{Flow 1} \times \frac{C_1 - C_2}{C_3 - C_2}$$

$$\text{Total Flow} = \text{Flow 1} + \text{Flow 2}$$

Variable	Definition
Flow 1	ECMO Blood Flow
C1	Concentration of oxygen or SaO <sub>2</sub> of from ECMO
Flow 2	Native Venous Blood Flow
C2	Venous concentration of oxygen or SvO <sub>2</sub>
Total Flow	Cardiac Output = Flow 1 + Flow 2

**Example:** ECMO flow 4 L, SvO<sub>2</sub> = 64%, SpO<sub>2</sub> = 90

- $\text{Total Flow} = \text{Flow 1} \times \frac{C_1 - C_2}{C_3 - C_2} = 4 \times \frac{100 - 64}{90 - 64} = 6\text{L of Cardiac Output}$
- $\text{Native Venous flow} = 6 - 4 = 2 \text{ L/min}$

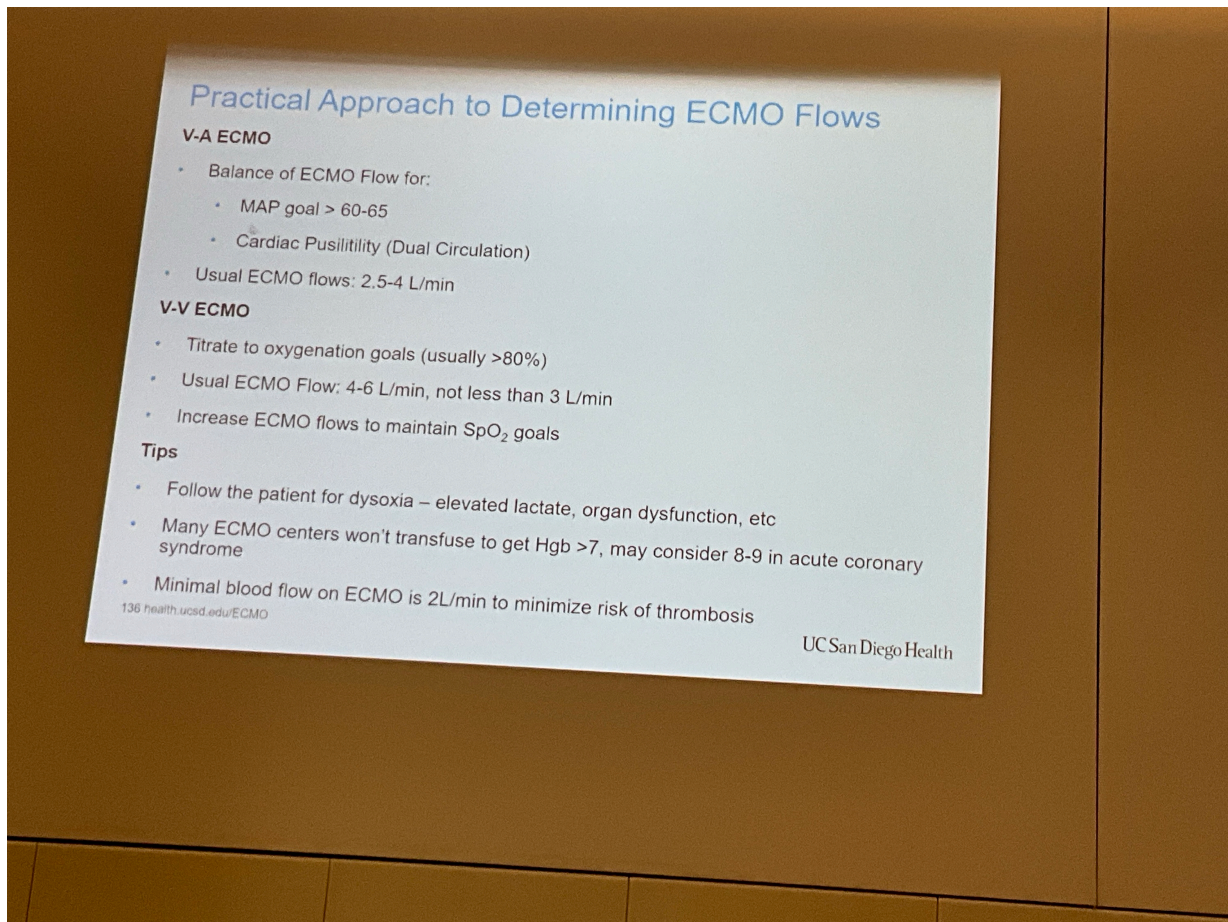
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- Always keep >2k RPM
- Higher flow on VV ECMO
  - VV is higher, 4-6L
- Embolus can get stuck anywhere
  - Stroke
  - Arterial clot more dangerous
  - VV clot back to lungs, less dangerous but still bad



- No perfusion
- Treatment: distal perfusion cannula but not always works
- Prevent: pulse checks, Doppler
  - US only shows flow, but not ischemia (...but what about DVT US scans?)
    - Know saturation, color of limb
- LL ischemia makes you 80% likely to die
  - No longer transplant/LVAD candidate



- Hemolysis!
  - Always expected
  - Free HGB causes AKI esp in ARDS pt



## V-V ECMO with Hypoxemia (lower than goal)

- Worsening native lung function?
- To much recirculation?
- Things that increase cardiac output or  $VO_2$ 
  - Agitation, pain, fevers, sepsis, shivering, etc.
  - Treat underlying cause
  - Do NOT use beta blockers to blunt CO (decreases oxygen delivery)
- **Treatment Options**
  - Increase ECMO Flows
    - May require second drainage cannula
  - Consider using ventilator more
  - Adding a second oxygenator?
  - Tolerate? Is there anaerobic metabolism? Is  $DO_2/VO_2 < 2$ ?

Staudacher DL, Wengenmayer T, Schmidt M. Beta blockers in refractory hypoxemia on venovenous extracorporeal membrane oxygenation: a double-edged sword. Crit Care. 2023 Sep 20;27(1):360. doi: 10.1186/s13054-023-04646-7

137 health.ucsd.edu/ECMO

Tonks JE, Abrams D, Brodie D, Greenwood JC, Rubio Mateo-Sidron JA, Usman A, Fan E. Management of Adult Patients Supported with Venovenous Extracorporeal Membrane Oxygenation (VV ECMO): Guideline from the Extracorporeal Life Support Organization (ELSO). ASAIO J. 2021 Jun 1;67(6):601-610. doi: 10.1089/EAAT.6900000000001432. PMID: 33955970. PMCID: PMC8319726

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## Cardiovascular: V-V ECMO

- Difficult to directly measure patients CO
  - FICK/Thermodilution NOT accurate...why?
  - TTE are generally accurate
- CVP may be elevated
  - Drainage cannula in IVC can impede venous return
  - The negative venous pressure may alter pressures and distort waveform
- Vasopressors
  - Remember that V-V does not support the heart!
  - Maintain MAP >65 mmHg
  - Support the right heart



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- Cardiac Arrest (w/ECMO)
  - Treat like regular ACLS
  - VV
    - Not in CO so must *compress chest in CPR!*
    - Blood already oxygenated
    - But no flow, recirculation begins
    - Coding shows bright red blood for both
    - ECMO flow and FDO<sub>2</sub>
  - VA

### Cardiovascular: V-A ECMO

- CO measurement **NOT** accurate (FICK or Thermo). TREND ONLY
- EF on ECHO only accurate if ECMO flow is reduced to 1-2 L (depending on patient size)
- CVP may not be reliable
  - Elevated with RV failure due to increased afterload (from retrograde flow) or Loss of LV unloading



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### Cardiovascular: V-A ECMO

- Vasopressors
  - Maintain MAP >60-65 mmHg
  - May help to improve LV ejection (inotropy)
    - May not be enough! Consider LV vent
  - Support coronary perfusion
  - Promote aortic valve opening



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Lirio R, Shekar K, McLaren G, Schmidt M, Pellegrino V, Meyns B, Hatt J, Vercaemst L, Pappalardo F, Bermudez C, Bevilacqua J, Hou X, Boeken U, Castello R, Donker DW, Abrams D, Ranucci M, Hryniewicz K, Chavez J, Chen YS, Sakas L, Whitman G. ELSO Interim Guidelines for Venoarterial Extracorporeal Membrane Oxygenation in Adult Cardiac Patients. ASAIO J. 2021 Aug 1;67(8):827-844. doi: 10.1097/MAT.0000000000001510. Erratum in: ASAIO J. 2022 Jul 1;68(7):e133. doi: 10.1097/MAT.0000000000001725. PMID: 34338368

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- No CPR if pump is working
  - Make sure >MAP

### Cardiovascular: V-A ECMO

- As patients heart recovers, more ventilator support will be needed (so that the blood that the heart is now pumping to the lung is well oxygenated)
- ECMO can increase afterload, leading to LV distension (may be vented by IABP or Impella)
  - Remember that the devices are there for off-loading ONLY! **Not** to assist with CO.
- **Pulse checks** in the cannulated extremity.
  - Pulses should be checked every hour for 24 hours, then Q2 and prn. If you lose pulses or they become diminished, **notify the physician immediately**.
  - Pulse checks should continue for 24 hours after decannulation

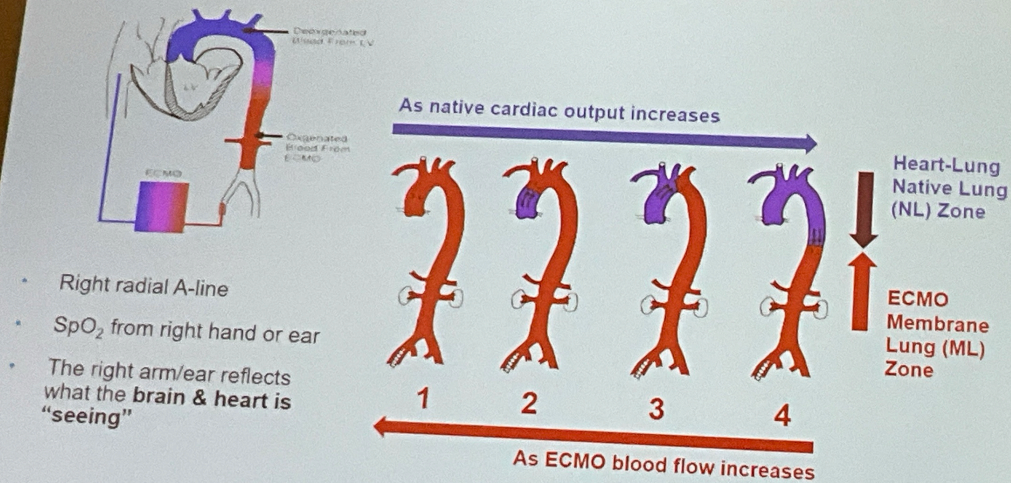
- If not, clamp and do CPR (pump not working)



## MECHANICAL COMPLICATIONS!

- done on Day 2 simulation

### Femoral V-A ECMO has Dual Circulation Always have a right sided A-line and $S_pO_2$



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Badulak J, Abrams D, Luks AM, Zakharov B, Conrad SA, Bartlett R, MacLaren G, Vercaemst L, Lorusso R, Bromian LM, Agerstrand C, Price S, Combes A, Peek G, Fan E, Shekar K, Fraser J, Brodie D. Extracorporeal venoarterial ECMO in adults. Intensive Care Med. 2024 Dec;50(12):1994-2004. doi: 10.1007/s00134-024-07045-8. Epub 2024 Nov 18.

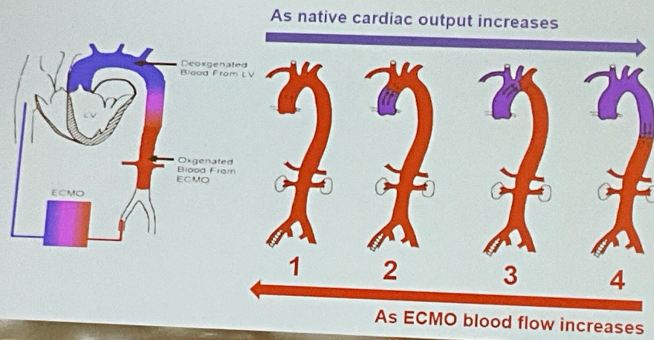
Figure 1.8: Convergence variation for V-A ECMO with femoral A-line  
(continued). Adapted from Rao et al. Crit Care Forum. 2018.

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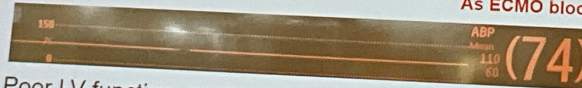
## TITRATE ECMO FLOWS



## What are the Brain/Heart Seeing?



Right A-line



TTE:

Poor LV function, not opening aortic valve

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Badulak J, Abrams D, Luks AM, Zakharov B, Conrad SA, Bartlett R, MacLaren G, Vercaemst L, Lorusso R, Broman LM, Agerstrand C, Price S, Combes A, Peek G, Fan E, Shekar K, Fraser J, Brodie D. Extracorporeal venoarterial ECMO in adults: Position paper on the physiology and nomenclature of dual circulation during 07645-8. Epub 2024 Nov 18.

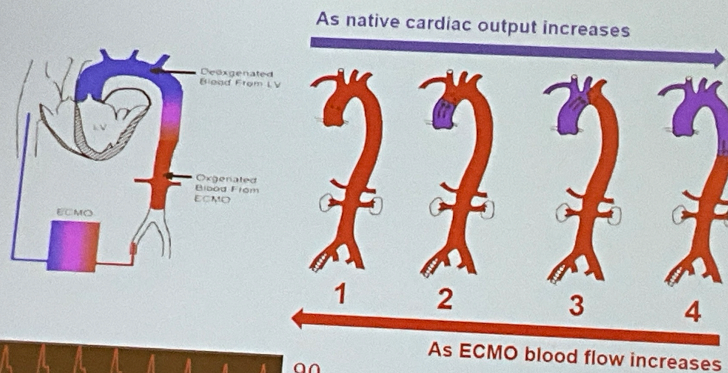
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- preload and afterload dependent
- Venous - low

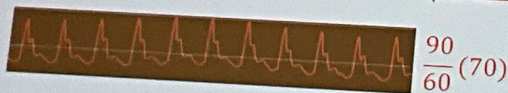
pressure large cannula

- Arterial - high, smaller
- Goal:  $DO_2/VO_2$ 
  - Delivery vs consumption
  - See conditions

## What are the Brain/Heart Seeing?



Right A-line



TTE:

Good LV function, opening aortic valve

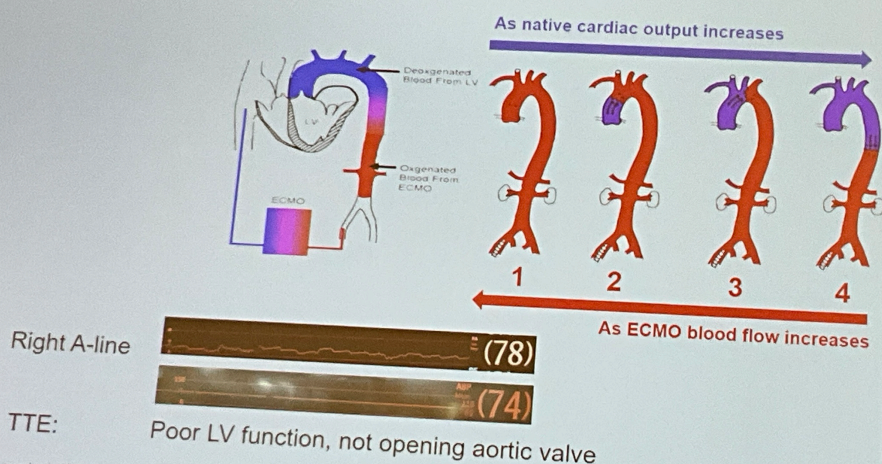
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Badulak J, Abrams D, Luks AM, Zakharov B, Conrad SA, Bartlett R, MacLaren G, Vercaemst L, Lorusso R, Broman LM, Agerstrand C, Price S, Combes A, Peek G, Fan E, Shekar K, Fraser J, Brodie D. Extracorporeal venoarterial ECMO in adults: Position paper on the physiology and nomenclature of dual circulation during 07645-8. Epub 2024 Nov 18.

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## You've lost pulse pressure! What can you do?



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## You've lost pulse pressure! What can you do?

- Is your ECMO flow too high?**
- Decrease ECMO flow by 0.25 L/min
  - No less than 2.5 L/min

### Trial inotropy:

- Dobutamine, dopamine, NE
- Left Ventricular Vent:**
- Impella, IABP, PEEP, etc.

Remember MAP goal >65

Right A-line

TTE:

Poor LV function, not opening aortic valve

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- Anaerobic, lactic acid
- ECMO >3 (DO<sub>2</sub>/VO<sub>2</sub> ratio)



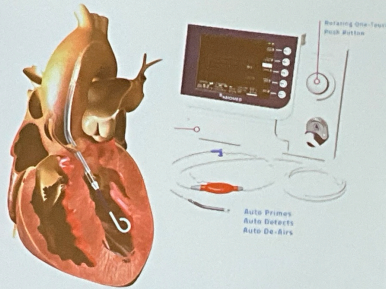
## LV Vents "Unloading" allow the myocardium to recover and prevents LV thrombus

- LV Venting decreases mortality in retrospective ESLO database studies

- IABP was most common
- Impella use increasing
- Ventilator - PEEP

- Allows for myocardial recovery

- Decrease myocardial muscle tension and thus oxygen requirements
- Allows for ejection of blood from LV, minimizing the risk of LV thrombus



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Grandin EW et al. Mechanical Left Ventricular Unloading in Patients Undergoing Venovenous Extracorporeal Membrane Oxygenation. *J Am Coll Cardiol*. 2022 Apr 5;79(13):1239-1250. doi: 10.1016/j.jacc.2022.01.037. PMID: 35361348; PMCID: PMC9187498

Impella Abomed. Accessed 7/25/25. <https://www.heartrecovery.com/en-us/products-and-services/impella>

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## LV Vent recovery

- LV Vent  
retrospe

- IABP
- Imp
- Ven

- Allows

- Dec
- and
- Allo
- min

146 health.ucsd.

○ PO2 normal >80-100

○ Formula DO2

- Saturation matters (100% PaO2 x .003 is 3; other part of formula is negligent)



## ECMO and Echocardiograms

Giving contrast or agitated saline (bubbles) may cause an ECMO issue.

### Is your bubble intervention ON?

- If the ECMO circuit detects air, it can shut off!
- Contrast binds to oxygen molecules, can cause the machine to falsely detect air
- Bedside **ECMO Specialist (you)** can temporarily turn off bubble detection but must monitor patient closely

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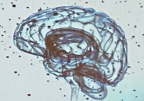
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## What does post-membrane mean?

- Goal VA ECMO flows based on  $DO_2/VO_2$ 
  - Oxygen delivery
    - Oxygenator is always 100%
  - Oxygen consumption
    - Mixed venous subtract from  $SaO_2$ 
      - E.g.  $(100 \text{ spo}_2 - 80 \text{ mixed } VO_2 = 20 = \% = 5:1 \text{ ratio})$ 
        - Note  $SVO_2 = \text{mixed } VO_2$
      - We want 3:1  $DO_2/VO_2$  ratio!
        - $(100 - 66 = 34; 100/33 = 3:1)$
    - Initially  $SVO_2$  is low cuz pts in shock, but I go up as  $O_2$  debt fixed
- Goal VV ECMO (based on number, not ratio)
  - Hard to know CO
  - Some will look at  $DO_2$
  - Goal HGB  $>7$ 
    - Except ACS  $>9$

## Neuro

- **Stroke:**
  - ECMO patients are anti-coagulated due to the pro-thrombotic circuit. Thus, they can clot (circuit) and bleed (anticoagulation)
    - This leaves them at high risk for stroke (embolic and hemorrhagic)
  - Assess frequently
- Over or under oxygenation
  - Frequent ABGs
  - Assess for facial flushing (V-A axillary cannulation)
- Involvement of Neuro Critical Care as needed
- Imaging - CT scan, no MRIs on ECMO, EEG
- Assess anticoagulation
  - Stop if bleeding



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80

wil



## Patient Management by System: **Neuro**

### Each drug is affected differently

- May require higher doses of sedation and opiates (especially propofol and fentanyl)
- Infuse these medications as far away from ECMO as possible (PIV)
- We try not to go over normal dosing of sedation and analgesia medications.

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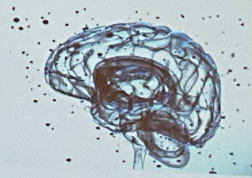
Morales-Castro et al. on behalf of the Extracorporeal Membrane Oxygenation Pharmacology Network (ECMOPharm Net). Pharmacological Research Agenda on Adult Extracorporeal Membrane Oxygenation Using the Drip Method: A Position Article of the Extracorporeal Membrane Oxygenation Pharmacology Network. Critical Care Medicine 10.1097/CCM.0000000000000686. July 30, 2025. | DOI: 10.1097/CCM.0000000000000686

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## Sedation Management on ECMO

- Weaning sedation in V-V ECMO for ARDS patients is challenging!
  - Normal process of CO<sub>2</sub> levels triggering breath is compromised
  - Patients report a drowning feeling
  - May require several attempts before successful
  - Consider rotating agents



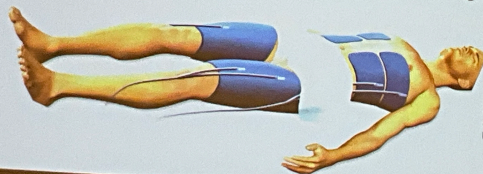
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The ELSO Red Book, 8th edition, page 643-654 UC San Diego Health

- Follow Oxygen delivery
  - Goal PaO<sub>2</sub> can decrease 60-80%, support the body
    - Depends on ECMO flow, CO, lung function
  - How to determine CO on VV ECMO
    - C3 total concentration in arterial
      - SpO<sub>2</sub>
    - Just know total flow formula
    - Some will use C1 = SaO<sub>2</sub> on ECMO
    - C2 from ECMO

## ECMO and Cooling

- All ECMO patients have a **heater** machine that is connected to the ECMO oxygenator
  - The machine can warm patients to a set temperature
  - The machine can also passively cool patients by allowing the blood that is outside the body to cool (and then not re-warming it before it enters the patient)
- ECMO Circuits only passively cool
- They **cannot** bring a patient down to 32 degrees!
- Consider Arctic Sun for Targeted Temperature Management.



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Arctic Sun BD Accessed 8-3-25  
https://www.bd.com/en-us/products-and-solutions/products/product-page/500000000e

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## ◦ Base Goals

- VA - supporting MAP and cardiac pulsatility
  - Lower flow, >2, otherwise clotting
  - CO flow vs native CO



- Increasing arterial CO cause native CO to decrease because it pulls against it!

- VV - supporting goal saturation
  - Higher flow 4-6 Lpm

### Patient Management by System: Labs

- Remember, you have SvO<sub>2</sub> and SaO<sub>2</sub> values on your machine!
  - Calibrate per institution guidelines
- Anticoagulation:
  - Goal aPTT is usually 40-60 (verify your order)
  - Anti-Xa
- Goal fibrinogen: >90mg/dL
- Goal Platelets: >50 x 10<sup>3</sup>/ml
  - **Platelets clog the membrane! Give SLOWLY over 4 hours**
- Goal Hct >21% (or Hgb >7)



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### Drawing Blood Gases with V-V ECMO

#### ABGs:

- V-V ECMO does not contribute to CO!
- Blood continues to be evenly distributed by your heart
- Arterial gases can be drawn from any location

#### VBGs:

- Venous gases drawn from the patient, will **not** be accurate - oxygenated blood is returned to the venous system before it goes through the lungs
- **Only** option for an accurate venous gas is from the **venous pigtail** (pre-membrane) on ECMO
  - *MVO<sub>2</sub> and FICK are also not accurate*

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- VV - Hypoxemia
  - Treat underlying cause
  - Do NOT use beta blockers to blunt CO!
    - Sat goes up because it does not deliver O<sub>2</sub>



## Drawing Blood Gases with V-A ECMO

### ABGs

- Arterial Blood Gases should be drawn farthest from the site of arterial (return) cannula and blood entry:
  - Femoral Cannulation: Right Arm
  - Axillary Cannulation: Femoral line
  - Central cannulation: Right Arm

### VBGs

- Venous gases can be drawn from any venous site

### SvO<sub>2</sub> is a surrogate for MvO<sub>2</sub>

- Should be drawn from venous pigtail of ECMO or PA
- If native CO is **low**, almost all venous return is going into ECMO → your sample might not be representative of systemic oxygen extraction.
- As **native output improves**, venous mixing becomes more natural, and your readings might become more accurate.

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◦ Treatment VV

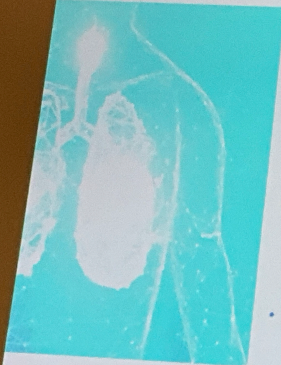
hypoxemia

- Increase ECMO flow
- Up vent settings
- Tolerate it. If DO<sub>2</sub>/VO<sub>2</sub> ratio is >3 it's ok, as long as LA stays low

◦ Cardiovascular support

- VV

## Respiratory: V-A ECMO: LUNG PROTECTIVE!



- **Normal Lung Protective Ventilation**
  - Respiratory Rate (>10)
  - PEEP (5-15 cm H<sub>2</sub>O)
  - V<sub>T</sub> ~ 6 cc/kg, F<sub>I</sub>O<sub>2</sub> < 0.5
  - Pplat < 30 cmH<sub>2</sub>O
- Areas of uneven oxygenation, depending on heart function and cannulation location
- FdO<sub>2</sub> stays at 70-100%. Goal O<sub>2</sub> sat is greater than 95%
  - Sweep MUST stay > 0.5 (depends on membrane)
- **Emergency Ventilator Settings**
  - Ordered in case the patient comes off ECMO for any reason
  - Posted on the ventilator!

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- CO hard to find
- CVP ELEVATED
- Use pressors and inotropes!
  - Inotropes for RVF mostly in VA

▸ VA

- ECHO EF are reduced especially if you overflow on ECMO
- Just support LV



## V-V ECMO Settings

- **FdO<sub>2</sub> Titration?**
  - Maintain O<sub>2</sub> sat >80%? 85%
  - Typical ABG: pH: 7.4, PaCO<sub>2</sub> 60, PO<sub>2</sub> 50-60, SpO<sub>2</sub> 80-90%
- **Sweep** is adjusted according to goal patient CO<sub>2</sub>
  - Start LOW and SLOW
- **Emergency Ventilator Settings**
  - Ordered in case the patient comes off ECMO for any reason
  - Posted on the ventilator

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Do your pulse  
checks  
q1-2hours!

## DUAL CIRCULATION!!!

- Essential to know complication!
- VA ECMO only



## ARDS Management on V-V ECMO

- Weekly bronchoscopy to ensure no big mucus plugs due to low tidal volumes
- Ensure good secretion clearance
- Lung consolidation may get worse before it gets better
- Maintain slight inflation at low pressures to avoid absorption atelectasis
- Coughing – very common
  - Trial precdex
  - Endotracheal lidocaine
- VAPS are very common (up to 80-90% for ARDS patients on ECMO)

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Collado-Lledó E, Mojon Q, Chommeloux J, Pineton de Chambrun M, Hekimian G, Saura O, Lévy D, Schmidt M, Combes A, Luyt CE, Le Fevre L. Recurrent ventilator-associated pneumonia in severe Covid-19 ARDS patients requiring ECMO support. Ann Intensive Care. 2024 Apr 25;14(1):67. doi: 10.1186/s13613-024-01295-1. PMID: 38662274. PMCID: PMC11045714.

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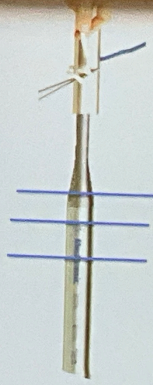
- Always have R sided ART and SpO2 from hand or ear!!
- We don't know where "mixing point" is (see pic)

- membrane vs native lung zone mixing points:
- 1 - all ECMO and CO
  - Flat ART line, want at least 10-15 mmHg
    - Shows O2 delivery and pH to brain and heart
  - Vent is not doing anything
- 3 - 4: mid aorta
- PE: RV failing, LV ok
  - Can create using ECMO flow mismanagement, increasing to 4 -> 1, distending LV, preventing recovery
    - May still need flow based on D/VO2 ratio, lowest being 2
  - Increase vent on 3-4 mixing point



## Cannula Security

- 6 layers of security!!!
- 3-4 sutures
- Canula securement device
- Clamped to bed



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- R side ART & Spo2 & ABG use to titrate ECMO

## Cannula Stability

- Clamp circuit to bed to limit pull on cannula's, watch for things like patient movement (kicking, rolling, etc.)
- Check sutures every circuit check and dressing change. Notify service if they need to be replaced
- V-V Cannulation: a headband? helmet? What can you make?
- Check tubing and circuit integrity every hour

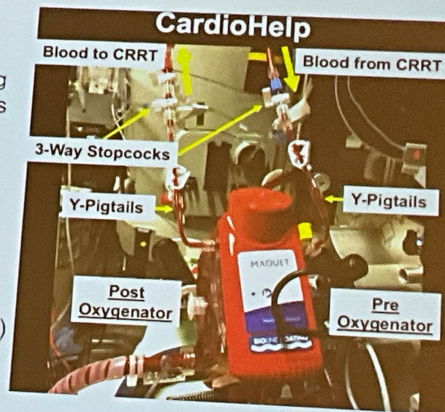
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## CRRT Connection to ECMO

- It is possible!
- Pros
  - Saves you a line (no VasCath)!
  - Reduces changes of infection, bleeding
  - Consistent flow to CRRT machine (less access pressure issues)
- Cons
  - CRRT machines are not designed to receive positive pressure
    - May need to adjust limits
  - Air embolus risk depending on how it is connected to circuit (negative pressure?)
  - Requires training
  - Technically "off label"



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Odian MF, Gammella PS, Crisostomo H, Yi C, Owens RL, Pollema T. Using Cardiohelp, Quadrox, and Nautlius Extracorporeal Membrane Oxygenators as Vascular Access for Hemodialysis. Continuous Renal Replacement Therapy and Plasmapheresis: A Brief Technical Report. ASAIO J. 2023 Nov 1;69(11):e455-e459. doi: 10.1097/MAT.0000000000002005. Epub 2023 Jul 2. PMID: 37399278. PMCID: PMC10602218

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## CRRT Connection to ECMO

- The ECMO Specialist should be at bedside when the HD RN connects the CRRT to the pigtail
  - The ECMO Specialist hands the pigtail end to the HD RN when requested, and ensures a **wet-to-wet** connection (to minimize air)
- CRRT's "venous line" (return) is connected to the ECMO "venous pigtail" (pull, pre-oxygenator)
- CRRT's "arterial line" (pull) is connected to the ECMO "arterial pigtail" (return, post-oxygenator)



Venous to  
Venous & Arterial to  
Arterial

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- pulsating ART
- PO2 80, change vent settings to increase!

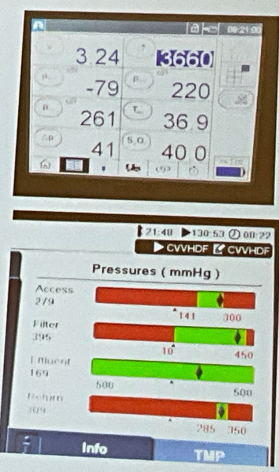


- Support LV
  - Increase PEEP

- Ballo on pump or impella

### How does CRRT effect my pressures?

- **ECMO Pressures:**
  - Should be relatively unchanged
- **CRRT pressures:**
  - You may see an increase (more negative) in your access pressure as the ECMO machine is pushing blood toward the CRRT machine
  - HD RNs can adjust the CRRT blood flow to help with this pressure
  - You may also see an increase in your filter pressure on CRRT
  - Higher ECMO blood flow, may cause higher CRRT pressures
    - CRRT through ECMO may not be possible for patients with very high flows.



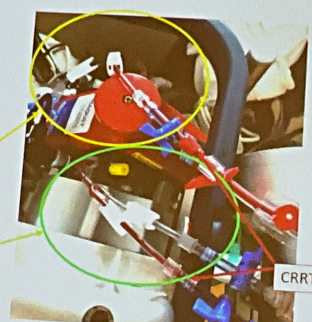
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- LV vents
- Inotropes
- Fem fem ECMO hyperoxygenation
  - Draining from lower extremity
- Unloading devices
  - Impella, balloon, LVAD, LAVA (puncture septum from RV by puncturing through to LV to decrease

### Connecting Cardiohelp oxygenator to CRRT:

- Normally, the Cardiohelp oxygenators have 3 pigtails
  - 1 on the venous (pull) side- Used to draw VBGs, and to zero/initialize the machine
  - 2 on the "arterial" (return) side- Used to draw post-oxygenator ABGs and available for air extraction in emergencies
- Pigtails are now Bifurcated on all of our Cardiohelp oxygenators. The pigtails have 3-ways stop cocks for easy access



View from the top of the Cardiohelp

- This allows us to use one side for ECMO, and one for CRRT access!
- One on the Top arterial/post-oxygenator pig tail (CRRT pull line)
- One on the venous/pre-oxygenator pig tail (CRRT return)

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Odell MF, Girmella PS, Cristoforo H, Yi C, Owens RL, Poltema T. Using Cardiohelp Quadrox and Nafius Extracorporeal Membrane Oxygenators as Vascular Access for Hemodialysis. Continuous Renal Replacement Therapy and Plasmapheresis: A Brief Technical Report. ASAIO J. 2023 Nov 1;69(11):e455-e459. doi: 10.1097/MAT.0000000000002005. Epub 2023 Jul 2. PMID: 37399278. PMCID: PMC10602218

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overload; rare, only in Cath Lab)

- When doing ECHO while on ECMO

- Turn off bubble alarm *temporarily* on ECMO, but WATCH YOUR PATIENT CLOSELY

**ECMO Mobility**

- Gone are the days of log rolls!
- We can walk Patients on ECMO!
  - Start with hip flexion at bedside and monitor pressures
- Assess for candidacy
  - Stable enough?
- Work with PT for first session to determine if assist devices are needed
- ECMO Specialist should be present
- Adjust/increase sweep if needed
  - Increase by 1-2 Liters

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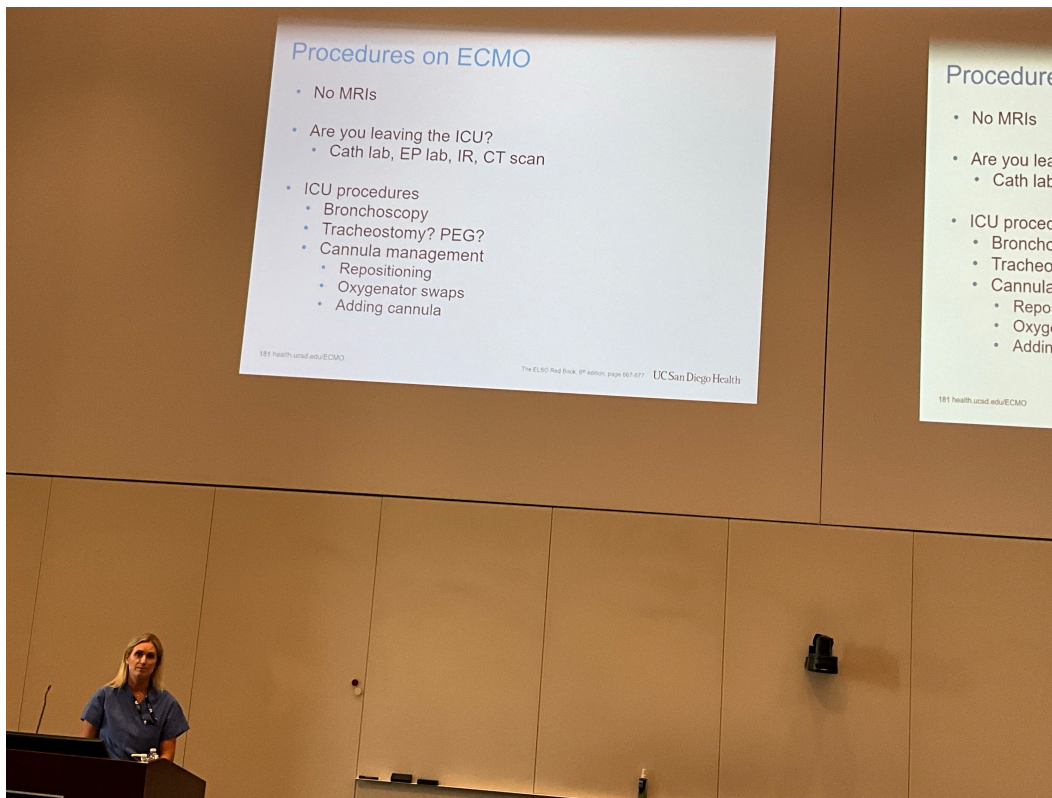
## ECMO & ECHOCARDIOGRAMS

- **bubble interventions**

- Based on facility
  - Don't use bubble studies
  - Bubbles and air causes ECMO to turn OFF!
    - Know this scenario



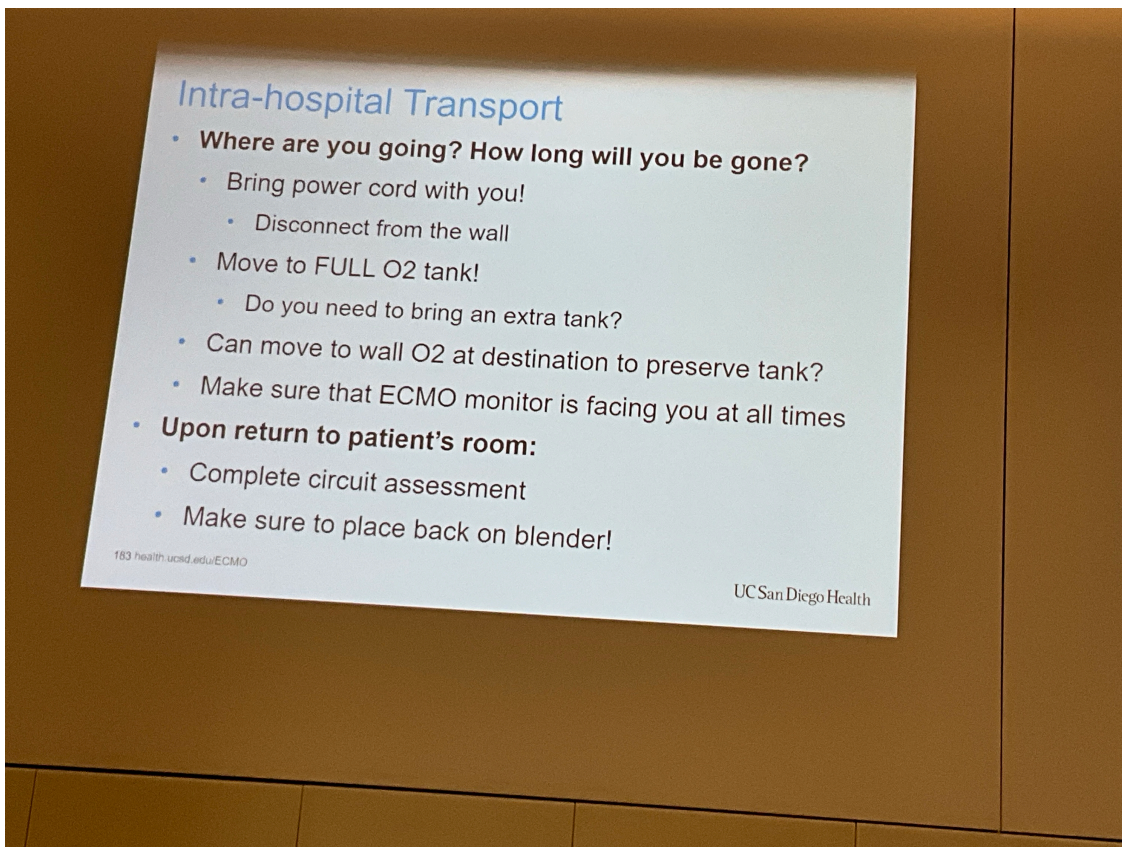
SY



- ECMO affects meds

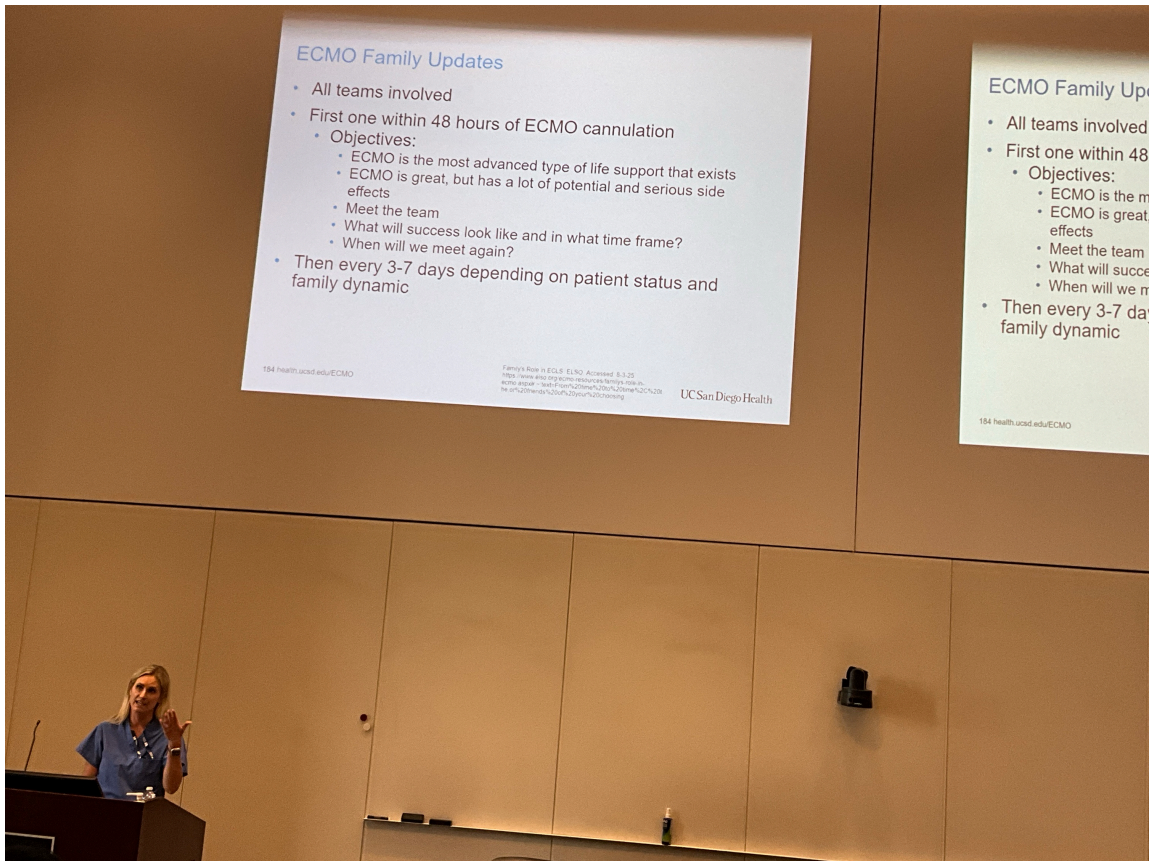
## STEMS

- Neuro
  - Stroke
  - Oxygenation
    - ABGs
    - VA axillary - look for facial flushing
  - Consult neuro team
  - Imaging
    - CT only, no MRI
    - EEG
  - Assess anticoagulant

SED  
MAATION  
NAGEMENT



- Weaning Sedation
  - Pt says feels like drowning
  - Compromised CO2 process system





## Weaning: General Considerations

- Is patient ready?
  - **V-V ECMO**
    - Have chest x-rays improved?
    - Have gases improved during low flow/low oxygen test periods?
    - Vent settings minimal to moderate
  - **V-A ECMO**
    - Has contractility improving (V-A)? A-line?
    - How does EKG look? V-Tachycardia/Arrhythmia?
    - Have dependence on inotropes and vasoconstrictors and other MCS (Impella, IABP, etc.) improved?
- Access configuration
- Keep weaning process simple!
- Don't rush weaning unless necessary
- Team effort!

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- ECMO & cooling
  - Filter heats itself, doesn't cool blood

, pts may have higher temp than programmed

- Use TTM to cool, not the ECMO circuit to hit the goal 32deg F for cooling
  - Temp on ECMO is blood going back to pt



## Weaning from V-V ECMO: **Option 1 - Most Common**

- **Sweep challenge:**
  - In steps, decrease sweep by 0.5L/min increments, maintaining same flows and FdO<sub>2</sub> at 100%
  - If CO<sub>2</sub> remains stable with new setting, challenge again till you reach sweep of 0L/min
  - If SaO<sub>2</sub> >95, PaCO<sub>2</sub> <50 (with normal pH) for 2-3 hours we are ready to come off
  - Needs to tolerate off sweep for at least 2-3 hours for 2 days in a row before we decannulate (2 days is a UCSD criteria)
- Ventilator settings minimal to moderate (able to increase support if needed post decannulation)

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The ELSO Red Book, 6<sup>th</sup> edition, page 336

Tonina JE et al. Management of Adult Patients Supported with Venovenous Extracorporeal Membrane Oxygenation (VV ECMO): Guideline from the Extracorporeal Life Support Organization (ELSO). ASAIO J. 2021 Jun 1;67(6):601-610. doi: 10.1097/MAT.0000000000001432. PMID: 33965970; PMCID: PMC8315725

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## Weaning

- Swe

- Labs

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- calibrate q7 days

## Weaning from V-V ECMO: **Option 2**

- **Decrease FdO<sub>2</sub>**
  - Keeping flows untouched, gradually reduce FdO<sub>2</sub> to 21-40%
  - If patient tolerates these conditions, turn sweep down to 0L/min
  - If SaO<sub>2</sub> >95, PaCO<sub>2</sub> <50 (with a normal pH) x 120 mins we are ready to come off
  - Needs to tolerate off sweep for at least 2-3 hours for 2 days in a row before we decannulate (2 days is a UCSD criteria)
- Ventilator settings minimal to moderate (able to increase support if needed post decannulation)

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The ELSO Red Book, 6<sup>th</sup> edition, page 336

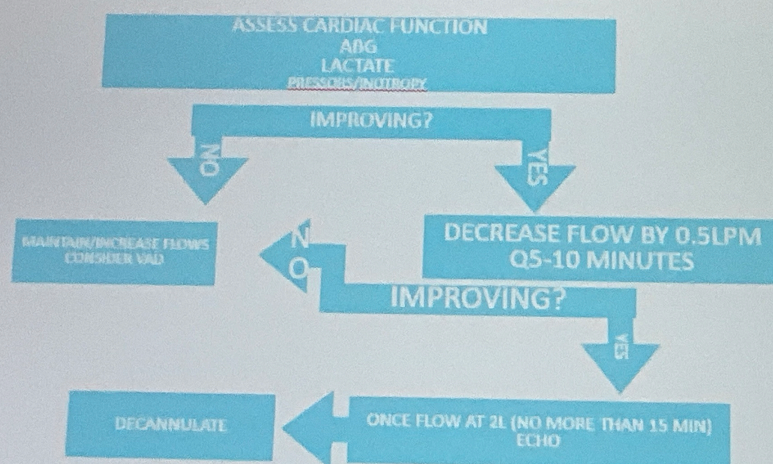
Tonina JE et al. Management of Adult Patients Supported with Venovenous Extracorporeal Membrane Oxygenation (VV ECMO): Guideline from the Extracorporeal Life Support Organization (ELSO). ASAIO J. 2021 Jun 1;67(6):601-610. doi: 10.1097/MAT.0000000000001432. PMID: 33965970; PMCID: PMC8315725

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- Note PLT should be given *slow* over 4 hours to prevent clotting
  - Give through PIV!
- HGB >7; HCT >21%
- VV Blood gas
  - ABG anywhere
  - VBG only from *venous pigtail*

## Weaning from V-A ECMO





1. ECMO Pump RPM was decreased to reduced Blood Flow by 0.5 L/min every 5-10 minutes
2. Anticoagulation was therapeutic
3. ECMO circuit was at 2.0 L/min of blood for no more than 15 minutes
4. Cardiology / Echo Tech was at bedside to perform echocardiogram
5. IABP Settings 100 augmentation at 1:1 (Delete line if no IABP<sup>\*\*\*</sup>)

Time	4 L/min	3.5 L/min	3.0 min	2.5 L/min	2.0 L/min
ECMO Flow					
FiO2					
SpO2					
Ventilator					
FiO2					
SpO2					
Respiratory Rate					
Tidal Volume					
Vitals					
Respiratory Rate					
SpO2					
Heart Rate					
Pulse Pressure					
SBP/DBP/MAAP					
Inotropy/Pressor					
Norepinephrine					
Vasopressin					
Dobutamine					
Dopamine					
Fentanyl					
Morphine					
Nitroglycerine					
Fentanyl					
Propofol (P-level)					
PAC					
CVP					
SvO2					
ImCvO2					
PCWP (mean / V-wave)					
CLiCvO2					
TEE					
EF %					
LVOT VTI					

The ELSO Red Book, 6th edition, page 336 and 401

Lorusso R, Sheker K, McLaren G, Schmidt M, Pellegrino V, Meyns B, Haft J, Vercaemst L, Pappalardo F, Bermudez C, Beshkavet J, Hou K, Boeken U, Castro R, Donker DW, Abrams D, Ranuccio M, Hryniewicz K, Chavez I, Chan YS, Salazar L, Whelan G. ELSO Interim Guidelines for Venoarterial Extracorporeal Membrane Oxygenation in Adult Cardiac Patients. ASAIO J. 2021 Aug 1;67(8):827-844. doi: 10.1097/MAT.0000000000001510

Check ABG and MvO2 at the lowest flow achieved

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## Decannulation

- ECMO provider must be present for decannulation, responsible for decannulation, holding pressure, and suturing, etc.
- Arterial punctures may need cut down for primary repair (usually done in OR)
- Hold heparin for 1 hour prior to decannulation
- Lay flat for 4-6 hours
- Consider keeping sedated
- Keep cannulation site **VISABLE** and assess for bleeding

The ELSO Red Book, 6th edition, page 336 and 401

195 health.ucsd.edu/ECMO

Tonna JE et al. Management of Adult Patients Supported with Venovenous Extracorporeal Membrane Oxygenation (VV ECMO): Guideline from the Extracorporeal Life Support Organization (ELSO). ASAIO J. 2021 Jun 1;67(6):601-610. doi: 10.1097/MAT.0000000000001432. PMID: 3385970. PMCID: PMC8315725

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- VA Blood Gas

### Post-ECMO Management

- Maintain activity, position, nutrition, vent settings
- Continue monitoring in ICU
- Monitor ABG and hemodynamic response
- Avoid increased vent settings
- Check DVT U/S in 24 hours to rule out femoral DVT where drainage cannula was placed

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- ABG Depends on Cannulation
- VBG anywhere
- SVO2

- VA ECMO is lung protective
  - vent settings



- R >10
- PEEP 5-15
- VT ~6, FiO2 <0.5
- Pplat at <30
- Lungs are resting
- FdO2 70-100%
  - 0 sweep technically means no ECMO circulation! ?
    - Always >0.5 Lpm
  - Goal O2sat >95%

### ECMO Specialist Role: What to Ask?

- Veno-Veno or Veno-Arterial?
- Type of Cannulation?
- Do they want a Heparin bolus? How much?
- Goal Flow
- Goal CO2
  - Starting Sweep?
- FdO2

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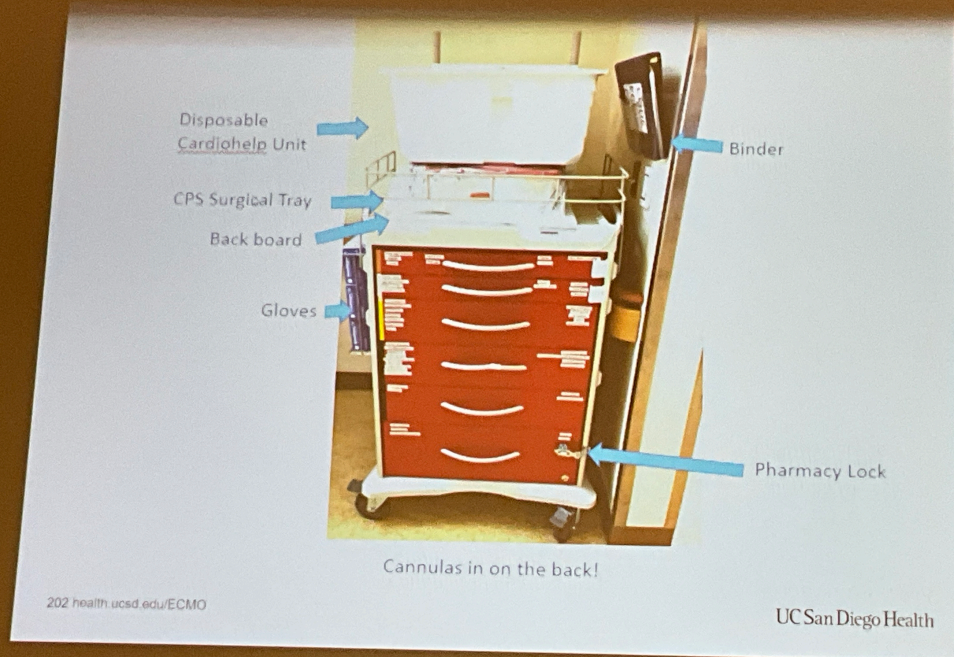
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- Emergency vent settings
  - Should

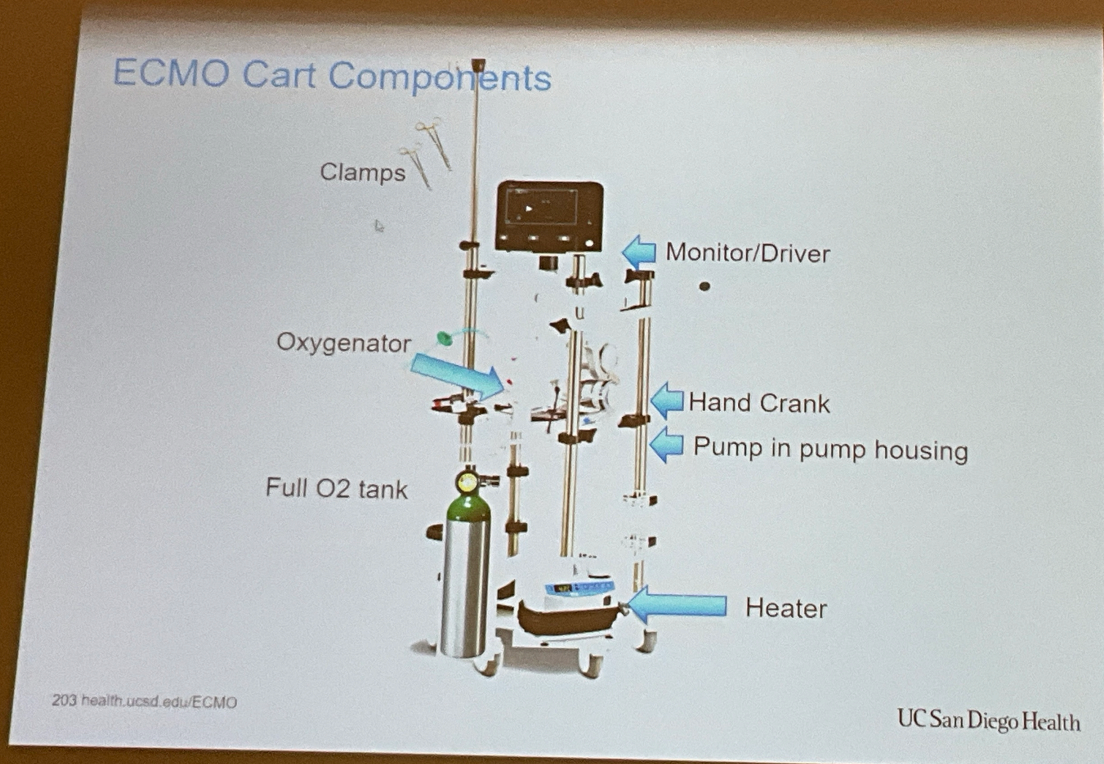
be taped to vent

- Start low and slow on sweep
- ARDS MGMT VV ECMO
  - CXR will look bad at first
  - Do weekly bronchs
  - Coughing common, use Precedex & endotracheal lidocaine





◦ Question on on vent settings: 10-10-10 vent settings

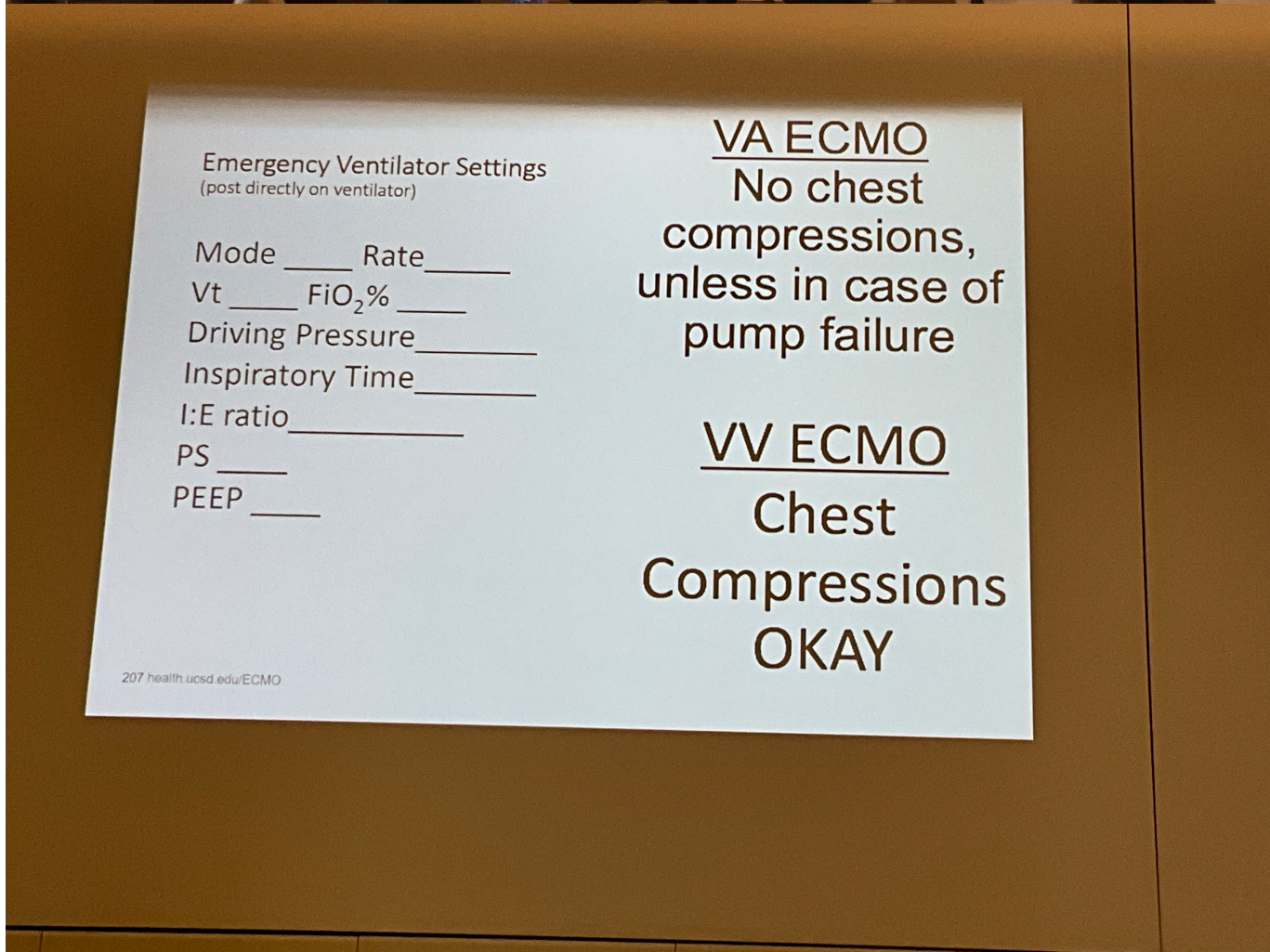
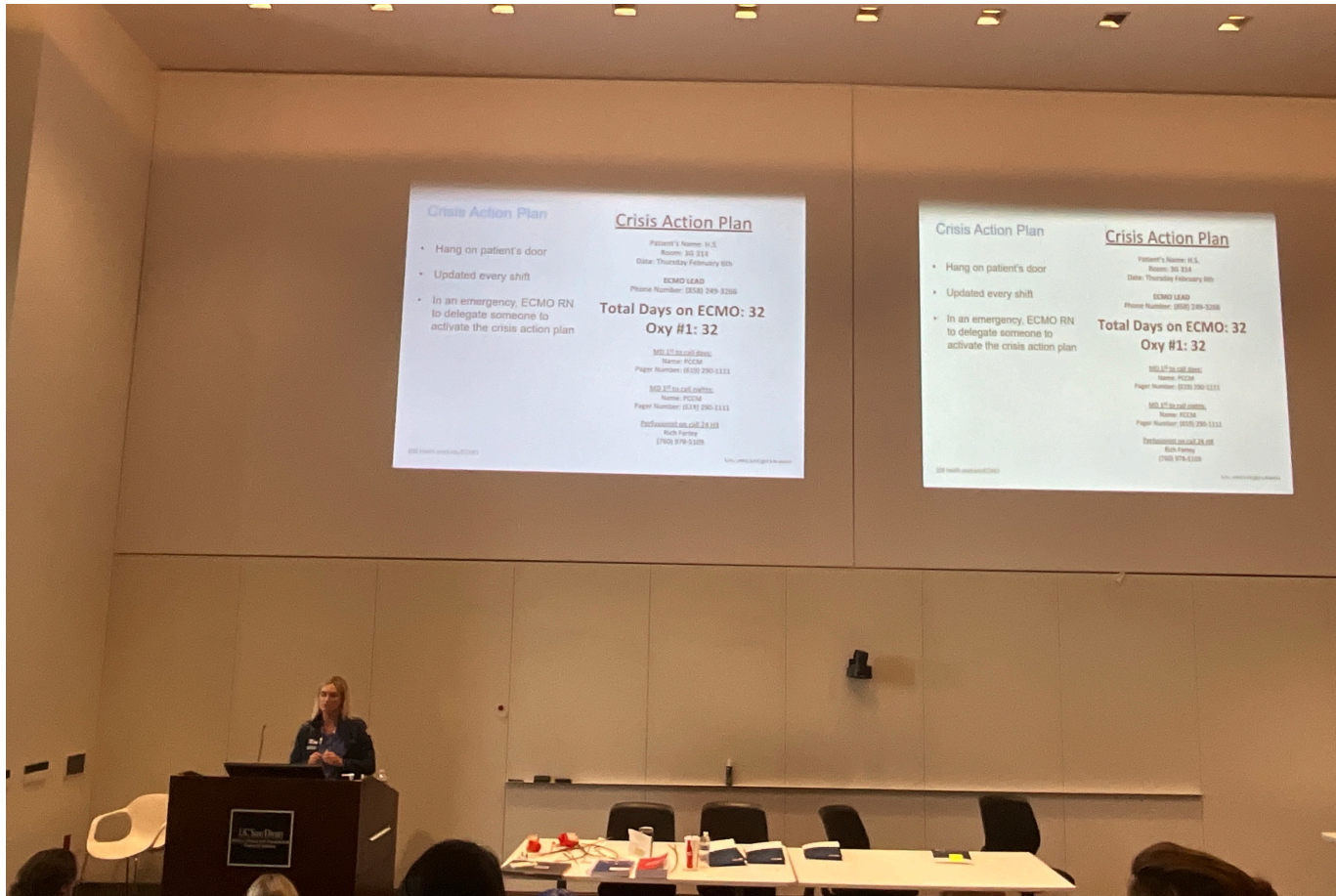


• But no one really knows



- Is proning viable?
  - No survival benefit , controversial
- SKIN
  - Regular assessment & prevention
  - Air mattresses

◦ ECMO dressings



Emergency Ventilator Settings  
(post directly on ventilator)

Mode \_\_\_\_\_ Rate \_\_\_\_\_  
 Vt \_\_\_\_\_ FiO<sub>2</sub>% \_\_\_\_\_  
 Driving Pressure \_\_\_\_\_  
 Inspiratory Time \_\_\_\_\_  
 I:E ratio \_\_\_\_\_  
 PS \_\_\_\_\_  
 PEEP \_\_\_\_\_

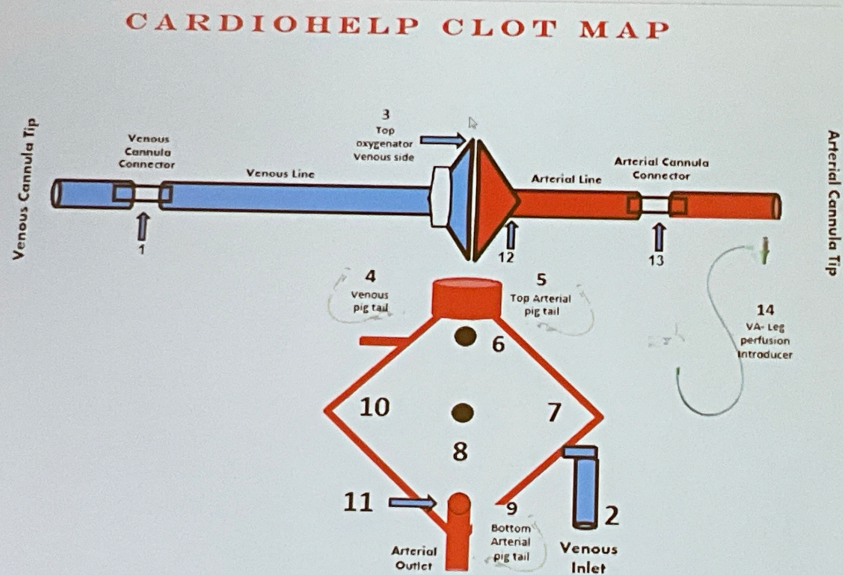
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VA ECMO  
 No chest  
 compressions,  
 unless in case of  
 pump failure

VV ECMO  
 Chest  
 Compressions  
 OKAY



- Treat as central line dressings
- Nothing on market really
  - Large CHG works ok
- Cannula security



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- 6 layers
- 3 sutures after
- Securement device
  - Foley lock device
  - Neck - use strap, like forehead O2 style?



# VV-ECMO Rounding Checklist

After the MD presents, but before the bedside RN presents the "ABCDEFGS" ECMO specialist presents ECMOPLAN Checklist (May be brief if already discussed previously in rounds)

## **E-ECMO flow** are we maximizing or weaning?

- Number of days on ECMO \_\_\_\_\_
- Current ECMO Settings: flow, venous pressure, FiO2, Sweep
- Acute ECMO overnight events (changes in ECMO settings, chatter, albumin bolus, bleeding, etc)
- Sweep Challenge (if patient on ECMO day 4 or more, lung compliance >15 for 2 days, and RR < 25)?
  - Reduce sweep by 1-2
  - Assess for tachypnea, increased work of breathing
  - If patient tolerates send ABG in 20 minutes
  - If pH and CO2 within range on ABG, repeat

## **C-Catheters** placement on Xray? Recirculation? Sites intact?

## **M-Mechanical ventilation**

- Rest: Minimizing vent settings (if not weaning ECMO)
- FiO2
- Tracheostomy Appropriate?
- D-Outcome & Exit Strategy
- Last & next family update
- Bridge to Recovery? Transplant?

## **P-Physical therapies** PT/OT/ST all ordered? Plan for today?

- Can we hold diuretic until after PT?
- Can we put in chair position in bed now?
- What is the goal O2 sat? What is the strategy if our O2 sat drops: maximize flow, give volume, PRNs orders (lidocaine down ETT (coughing), Haldol (agitation), esmolol (tachycardia), opioid (pain))
- If all else fails: low dose paralytic? Under MD supervision, watch for drop in TV, measure pre and post dyspnea and strength

## **L-Lowering Sedation**

- Discontinue neuromuscular Blockade?
- Benzodiazepine/Opioid wean (What is today's goal? 20% per day) Precedex? Consider ketamine wean if tachycardic, Propofol at night to reduce Benzos (triglycerides okay)?
- Add PRNs (haldol, Orals?)

## **A-Anticoagulation?** Bleeding? Clotting?

- Delta P Trend?
- Oxygenator Clot map stable?

## **N-Nutrition?** Need volume (albumin or LR) or diuresis? May we hold diuretic until after PT?

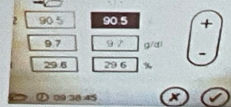
- If chattering or increasing venous pressures, should flow be decreased or fluid challenge?

- Clamp - not all the way, just half way

## CardioHelp Calibration/Initialization

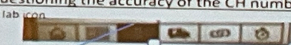
### Steps for VBG Machine Calibration (to be done once a shift and PRN)

- Draw ABG from top venous pig tail
- Press lab icon on CH
- Press the Hg, Hct or SvO2 icon
- Press the file button
- Send VBG and CBC
- Once VBG/CBC resulted. Go back into the lab screen
- Press the lab icon
- Adjust the values on in the right hand column with new lab values and then press green check mark to confirm (use VBG for SvO2 value, and CBC for H+H)



### Steps for Venous Probe Initialization (to be done once upon initiation and PRN if you are questioning the accuracy of the CH numbers)

- From home screen, press the lab icon
- Select SvO2, Hg or Hct
- Press venous probe icon and place the venous probe on safety bar
- Wait for confirmation that venous probe is ok, and then press the green check mark
- Return to home screen



- don't forget to remove when turning patient!



- Stability
  - Check qhour

- Always **clamp** arterial first, then venous
- Always **unclamp** venous first, then arterial
- There are 2 ECMO order sets:
  - Cannulation order set
  - Maintenance order set
- There is a ECLS Anticoagulation Guideline
  - Linked in Epic order set
  - Available on the Medication Resources page
- Infuse Platelets over 4 hours (or as ordered)
- If ECHO contrast is necessary, call ECMO Lead and/or temporarily turn off air bubble intervention
- Consider temporarily turning off arterial air bubble intervention during albumin or other bolus infusions
- To minimize possibility of air, drips should always be on pump and boluses should be given slow (take yellow cap off during bolus)
- Circuit contains approximately 700cc of blood
- For VBG/ABGs: write the ventilator FIO2 on the lab slip if you are drawing from the patient, and the ECMO FdO2 if you are drawing from the ECMO oxygenator pigtails.

#### Transport

**Note:** Perfusion must transport to Cath Lab and OR.  
First assess patient for clinical stability, if you have any concerns, request Lead or provider accompaniment

#### Quantum Checklist:

- ☐ All cart components travels with the patient
- ☐ Move O2 line from ventilation module (under "Y-site") to full oxygen tank (consider taking an extra tank)
- ☐ Bring 2 clamps (clip to your scrubs so they do not get lost)
- ☐ Unplug cart from the wall (bring the power cords with patient). No need to disconnect pt from heater/cooler

#### CardioHelp Checklist:

- ☐ Place ECMO back board between patient's legs
- ☐ Disconnect CardioHelp from heater. (Close valves if applicable or clamp, unhook, turn machine off or connect bridge)
- ☐ Unplug CardioHelp from the wall (bring the power cord with patient)
- ☐ Place CardioHelp on back board facing out (so that you can see the screen)
- ☐ Place hand-crank on CardioHelp
- ☐ Bring 2 clamps with you (clip to your scrubs so they do not get lost)
- ☐ Place full oxygen tank in the bed next to the machine (consider taking an extra tank)
- ☐ Move O2 lines from blender/wall to full oxygen tank

- GI
  - Nutrition
- Nephro
  - AKI common, leads to CRRT



## Primary RN ECMO Emergency Management

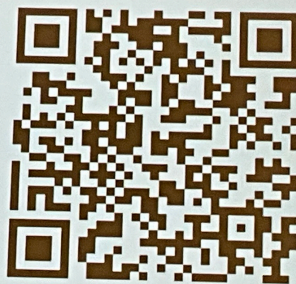
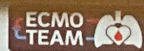
Emergency	What you would see	Interventions
Significant clinical change with patient	<ul style="list-style-type: none"> <li>Change in vitals</li> </ul>	<ol style="list-style-type: none"> <li>Check for cannula color difference (venous-dark red, Return bright red)</li> <li>Check that the console is on, plugged in, and that you have blood flow (L/min)</li> <li><b>ACTIVATE CRISIS ACTION PLAN</b> if you think that the problem has to do with ECMO</li> <li><b>Manage the patient</b></li> </ol>
Loss of ECMO flow (console still on)	<ul style="list-style-type: none"> <li>Flow of 0 on the ECMO machine</li> </ul>	<ol style="list-style-type: none"> <li>Check if air bubble alarm activated.                             <ul style="list-style-type: none"> <li>If activated follow air bubble interventions (below).</li> </ul> </li> <li>Check for kinks/clots, chatter?</li> <li><b>ACTIVATE CRISIS ACTION PLAN</b></li> <li>Reduce PRM to try and regain flow</li> <li>Give volume</li> <li><b>Manage patient</b></li> </ol>
Console failure	<ul style="list-style-type: none"> <li>Blank screen</li> <li>Loss of color change</li> <li>Decline in vitals</li> </ul>	<ol style="list-style-type: none"> <li>Assess patient and cannulas for color change. (**Note that screen can fail/malfunction even when console is still working)                             <ul style="list-style-type: none"> <li>If patient is declining/loss of color change, assume console failure.</li> </ul> </li> <li>Rule out power failure, loss of flow, loss of flow probe, and kinked or clamped ECMO lines.</li> <li>If you need to do CPR- Clamp near patient- (if you don't clamp, CPR will be harder)</li> <li><b>ACTIVATE CRISIS ACTION PLAN</b></li> <li><b>Manage patient</b></li> </ol>
Air Embolus in Circuit (VA only)	<ul style="list-style-type: none"> <li>Pump will stop and alarm</li> <li>You may or may not see visible air in tubing line</li> </ul>	<ol style="list-style-type: none"> <li>Clamp near patient- arterial side first, then venous</li> <li><b>Activate Crisis Action Plan</b></li> <li>Emergency Vent settings</li> <li>Place patient in Trendelenburg position</li> <li><b>Manage patient</b></li> </ol>
Unintentional De-Cannulation	<ul style="list-style-type: none"> <li>Blood</li> <li>Decline in vitals</li> </ul>	<ol style="list-style-type: none"> <li>HOLD PRESSURE at insertion site</li> <li>Clamp ECMO ASAP to avoid continued bleeding</li> <li><b>Activate Crisis Action Plan</b> (including placement on emergency vent settings as patient is now OFF ECMO)</li> <li><b>Get help managing patient:</b> Who is in the hallway? Code blue?</li> </ol>

Where are the pigtails on the Oxygenator? Pre (venous) and post (arterial) Oxygenator?

;fjfffv



Call us anytime!



858-249-3266 (ECMO)

We want to evaluate all patients  
(even patients outside normal ECMO criteria)

Patient/Provider Website:  
ECMO Education Website:  
Email:

health.ucsd.edu/ECMO  
ecmoeducation.ucsd.edu  
ecmo@health.ucsd.edu

UC San Diego Health

- uses dual lumen pigtails
- Affects your pressures



- Connecting CRRT
  - Make sure your pigtails don't clot when drawing ABG/VBGs!
  - You're essentially turning off ECMO and pause CRRT by clamping near it
    - Clots happen fast in pigtails! Flush early and often when drawing ABG
- Disconnecting CRRT
- Returning blood
  - The same CRRT precautions

- ECMO Mobility
  - Needs ECMO specialist, PT/OT initial attempts
  - Can go up in sweep b/c pt is exercising
  - You are directing the exercise and team w/patient
  - Watch for kinking (bending not pretzel)
  - Balloon pump & impella VA pts is harder cuz cannot >30deg in bed



- Procedure considerations: have everything you need



- Transporting!
  - When and how long?
  - Power Cord
  - Full tank O2
  - Can use wall O2
  - Monitor always facing you always
- Returning from transport
  - Complete circuit assessment
  - Go back on blender!!!
    - O2 tank can run out (off ECMO)
      - No FdO2, no Sweep
- Family updates

- Palliative care can be added to treatment, it is not hospice



## WEANING ECMO

- are they improving?
- VA needs fix underlying cardiac problems
- **Can only change 3 things**
  - Blood *Flow* (Lpm)
  - Sweep (CO<sub>2</sub> removal)
  - O<sub>2</sub> delivered (*FdO<sub>2</sub>*)
- Two main ways: wean FDO<sub>2</sub> or Sweep
  - Option 1 - *Sweep challenge*
    - See slide below
    - Follow work of breathing , respiratory vol, respiratory rates
    - Low vent settings
    - Follow respiratory parameters
    - Not removing CO<sub>2</sub> or delivering O<sub>2</sub> (off ECMO)
      - ABG hour later
    - Know how long your facility requires when pt off ECMO
  - Option 2
    - Still turn FdO<sub>2</sub> to zero to see lung oxygenation
  - Both options should be minimal vent settings and not increasing, so don't rush
  - Option 3
    - Decreasing flow
      - No longer used! Decrease flow leads to clots in VV ECMO (only used on VA)







- VA ECMO

- This is a blood flow wean!

- Pressors and inotropes are minimal
  - Extra LV vents also on low settings
  - Use the ELSO ECMO wean guidelines
    - Turn it into a smart phrase
    - Start with the top
    - CVP increasing?
    - PAP decreasing?
    - PCWP not changing
    - If they pass wean, they are stable to come off
      - Decannulate in bedside or OR (preferred b/c of venous cutdown & risk of bleeding)
        - Some ORs will see if they can tolerate all the way down to 1L flow
    - Remove ECMO first before removing LV unloaders
  - VA
    - **Never adjust FdO<sub>2</sub> to <70!** Unless you perform post Oxygenator gas
    - **Never turn Sweep to Zero!**
      - No gas exchange, turns off ECMO
      - Check DVT US on every weaning







- treat ECMO patients like any other patients

Questions:

- cannulas usually last 30 days but can last a year



## PUTTING IT ALL TOGETHER

### CODE ECMO ACTIVATION

- patient selection using SAVE (VA) / RESP (VV)
- Exit plan? Must have a bridge
  - Cath, CABG, transplant, LVAD, etc
- What to ask

- Equipment
  - Cannulation cart
  - ECMO Machine w/O2 tank or wall
  - Ultrasound







- Crisis action plan hung on the pt door



- Emergency ventilator settings (RT)
- CODING
  - VA - no CPR unless pump is not working
  - VV - yes CPR
  - Put this on head of the bed
- Know Cardiohelp and Nautilus clot map
- VV ECMO rounding checklist
- Calibration







- preparing for transfer on ECMO
  - When drawing ABG must put pt temp and ventilator FiO<sub>2</sub>
  - When drawing post Oxygenator gas draw from ECMO which is FdO<sub>2</sub>
- Know Cardiohelp and Nautilus



CZXMm. C. ZCZXZXoisouknjxmmnmjmk,xcvbbvm,

## ECMO EMERGENCIES

- Primary RN handles pt, not you, you stay w/ECMO and handle it
- Order Sets
  - Initiation vs Maintenance
  - Remind MD to place
  - PRN ECMO Order set
    - Lidocaine or heparin etc

## SIMULATION DAY

- can't simulate SVO2 and H/H, both drawn from venous pigtail
- Can't simulate Sweep