Use Of VA-ECMO In The Management Of Cardiogenic Shock

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Outline

- When to consider VA ECMO support
- Basic components of VA ECMO circuit
- Management of VA ECMO hemodynamics

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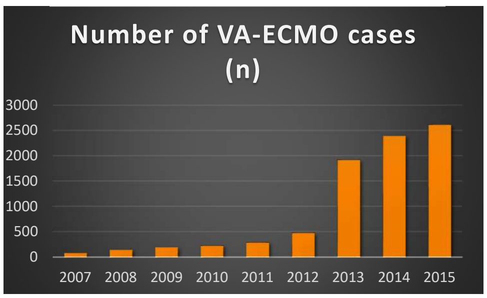
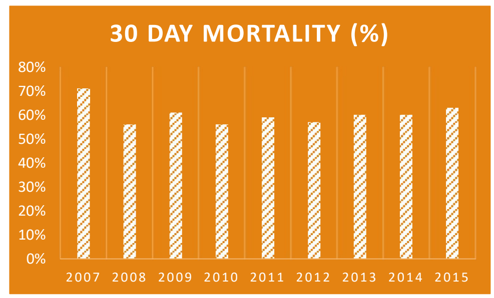
Trends in ECMO utilization





(Becher, Schrage et al. 2018)

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When is VA ECMO considered?

For patients with all the following:

1. Severe cardiogenic shock
2. As a bridge to
   - Recovery
   - Heart Transplantation
   - Durable mechanical support
   - Decision
3. No major contraindication

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Who should not get ECMO?

Advanced age ? (> 70?)

Advanced cancer

Unwitnessed cardiac arrest or downtime > 40 min

Severe irreversible brain injury

Severe aortic incompetence

Severe, irreversible multiorgan failure

Severe peripheral arterial disease (for peripheral cannulation)

Bleeding diathesis

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It’s a team sport

- Timely multidisciplinary assessment is required (including ED providers, cardiac surgery, cardiology, neuro-critical care, and if available, one of the primary physicians)
- Involve social worker, palliative care, and case management early
- If possible, including ECMO in code status discussion for high-risk patients is wise

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Complications

- Hemorrhage (40%)
- Thromboembolism
  - Limb ischemia (16%)
  - Stroke (7%)
- Infection
- Mechanical complications

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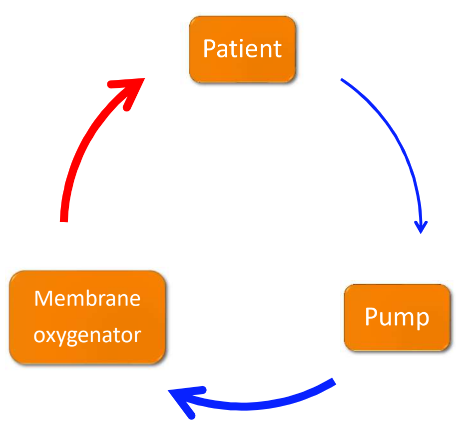
Basic components of VA ECMO circuit



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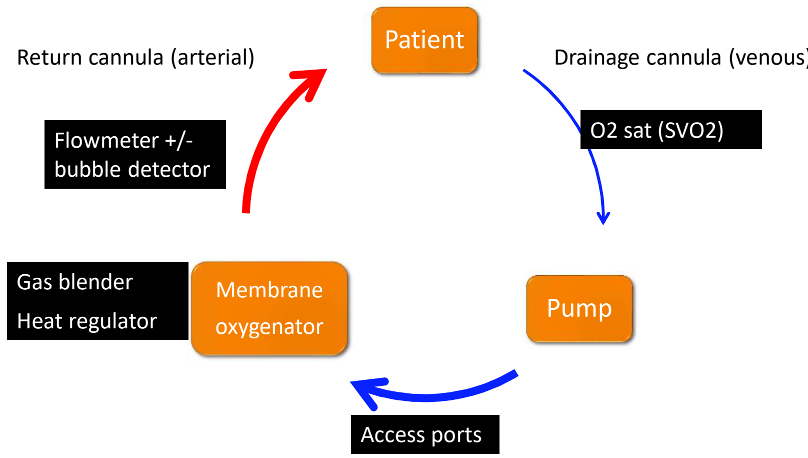
Basic components of VA ECMO circuit



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Access cannula

- Large bore (15-25 Fr generally) access

- Individualized to make it accommodates
  - Vessel size
  - Flow rate . More flow requires larger cannula
  - Type of support required
    - For V-A support, common set ups are
      - Femoral Vein – Femoral artery
      - Internal jugular vein – Axillary artery (via a graft)
      - Right atrium – Aorta (central cannulation)

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Cannula size and resistance

Resistance is proportional to the (diameter)^2

Cannula diameter (Fr)	ECMO Flow (L) 3	4	5
	Pressure drop across the cannula (mmHg)		
15	100	170	>>
17	50	95	145
21	21	36	50
25	16	20	20

Moreover, this is relevant to detecting cannula obstruction / thrombosis

(Shafer and Pittarello 2018)

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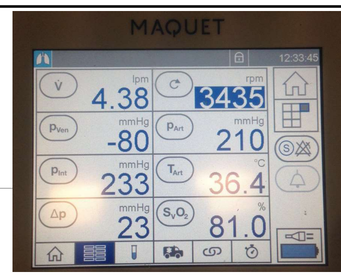
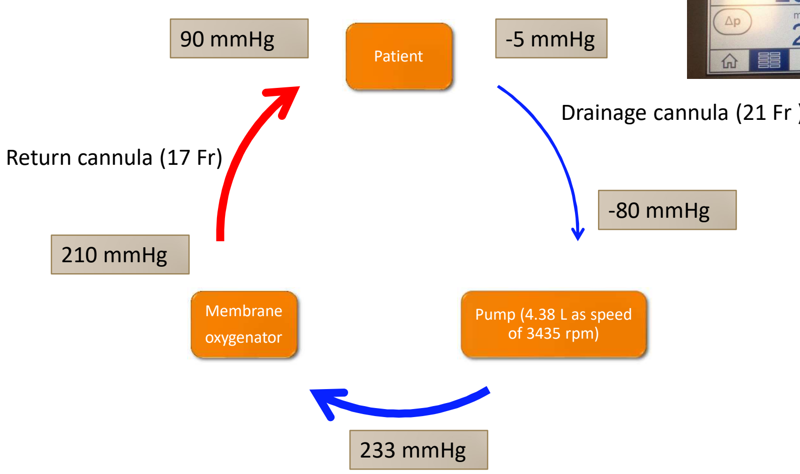
Example of circuit pressures





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Membrane oxygenator (Ventilation)

During VA-ECMO run, there are essentially 2 circuits running simultaneously

- Native lung + intrinsic cardiac output
- Membrane lung + pump flow

What happens if the lungs stop working?

What happens if the membrane clots?

What happens to oxygenation if the pump flow decreases?

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Basics of VA-ECMO management

- Circulatory support
  - Pump flow
  - Mean arterial pressure
- Ventilatory support
  - O_2 delivery: O_2 sat, lactic acid
  - CO_2 washout

If the pump fails to provide either one, the team should be ready to use alternative support (e.g. inotropes, ventilation…)

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How much ECMO flow do I need?

- "Full ECMO flow" = 60 cc / kg / min
  - May increase significantly with activity, and even more so during systemic inflammation
  - Cannulation system in an adult should be large enough to accommodate such flow, usually ~ 4.5-5 L / min

- Ideally, you would want 60-80% via ECMO and rest via the native heart and lung – to prevent thrombosis and maintain pulmonary conditioning

- As the patient becomes more ECMO dependent:
  - Less A line pulsatility
  - More membrane ventilation will be needed – the relationship is not linear. Usually O2 is affected first

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VA ECMO hemodynamic effects

- Perfusing blood pressure : ↑, with decreased pulsatility

- LV afterload: ↑

- LV Preload: ↑ (HF physiology)

- Coronary blood flow: ↓ (increased resistance)

- RV Preload: ↓

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VA-ECMO decreases, but doesn't eliminate cardiac preload

- The LV still fills via
  - Residual pulmonary blood flow
  - Thebesian veins
  - Bronchial circulation

Optimize ECMO support to effectively decrease systemic venous pressure to allow for optimal organ decongestion (CVP should not be > 8 on ECMO)

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Hypotension

MAP = COP X SVR

- Good ECMO flow → low SVR

- Poor ECMO flow
  - Low preload
  - High afterload (Obstruction)
  - Measurement error

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Temperature regulation

- If targeted temperature management (hypothermia post cardiac arrest) is required, ECMO is very effective
- Fever may be masked

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Low flow

- Decreased preload – volume, tamponade, abdominal compartment, cannula thrombosis
- Increased afterload – hypertension, cannula obstruction

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Ventilation

The membrane oxygenators functions similar to a dialysis system, where the dialysate is the gas/air

- Sweep : total amount of gas flowing to the oxygenator → controls both CO_2 wash out and oxygenation
- FiO_2: percentage of O_2 of the sweep gas → oxygenation

Monitor ABGs to make sure we keep physiologic pH (CO_2 hemostasis) and O_2 sat.

E.g. of a common set up is 2L sweep with 30% FiO_2

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Clinical case

A 30 yo male, no known medical history, presented with SOB x 1 week.

- Clinically in acute heart failure (orthopnea, edema, DOE)
- TTE showed biventricular severe dysfunction
- Diuresis was initiated
- On D4 he became more hypotensive (BP 90/70), tachycardic (sinus at 120), cool extremities, rising creatinine, and liver enzymes x 5 normal
- Cardiac catheterization showed no coronary disease, cardiac index 1.3, and severely elevated filling pressures. Both LV and RV stroke work index were severely reduced per invasive hemodynamics
- Myocardial biopsy obtained
- VA-ECMO consult initiated and he was emergently cannulated via bifemoral access
- Endomyocardial biopsy showed lymphocytic myocarditis

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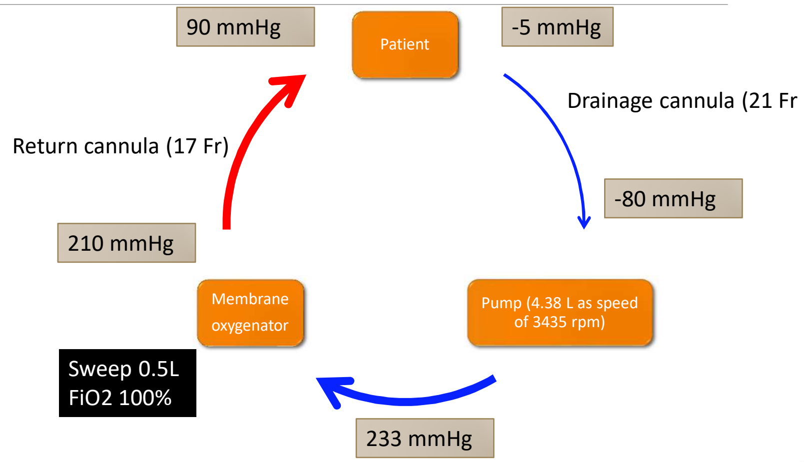
D1

The patient feels well

- HR 95, sinus
- BP 100/60
- CMP showed recovering renal and hepatic indices
- ABG (radial): PH: 7.4 / $PaCO_2$: 38 / PaO_2: 80
- Lactic acid is down to 1.7 from 8 yesterday
- ACT 180, on heparin gtt
- CXR clear
- No drips



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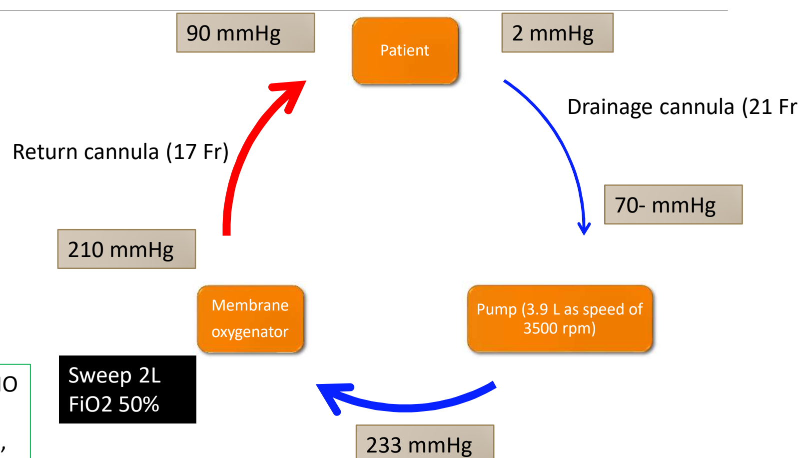
D2

The patient continues to feel well.

- HR 110, sinus
- BP 100/90
- Stable labs
- ABG (radial): PH: 7.32 / $PaCO_2$: 49 / PaO_2: 70
- Lactic acid 1.5
- ACT 180, on heparin gtt
- CXR pulmonary edema
- No drips

The patient is now becoming more “ECMO dependent. Needs troubleshooting of LV unloading – Afterload reduction, diuresis, and LV venting strategy



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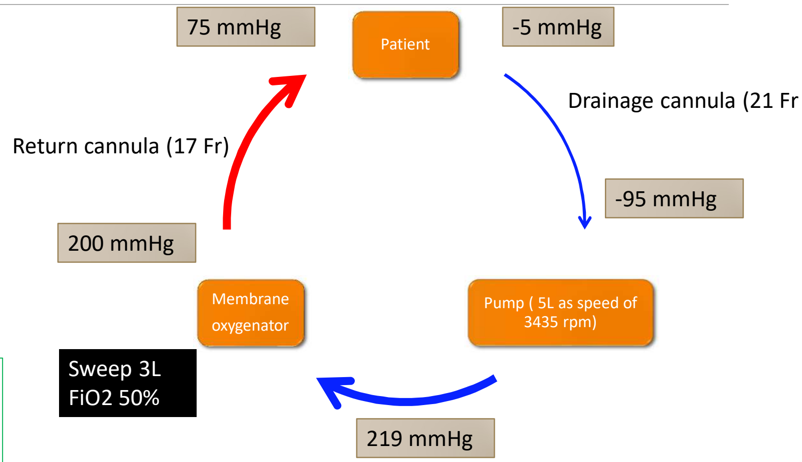
D5

The patient continues to feel ok except for heart fluttering.

- HR 180, VT
- BP 80/75
- Stable labs
- ABG (radial): PH: 7.32 / $PaCO_2$: 49 / PaO_2: 70
- Lactic acid 1.5
- ACT 180, on heparin gtt



The patient can tolerate VT while on ECMO support. Would avoid cardioversion and initiate medical therapy for the arrhythmia and check the impella position

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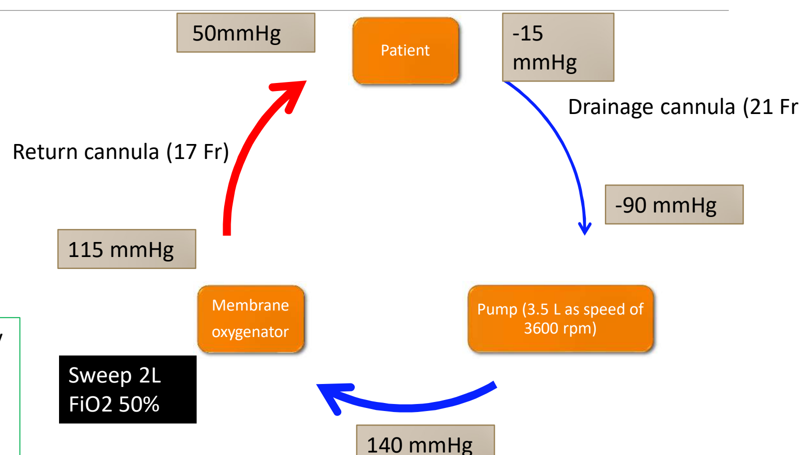
D10

The patient feels tired, has new back pain.

- HR 120, sinus
- BP 60/40
- Hgb dropped from 11 to 9
- Lactic acid 3
- SVO_2 65%
- Cannula chatter



The patient is hypovolemic as evidence by the cannula chatter. Likely bleeding. Check Coags, give volume and transfuse Look for bleeding source (turns out to be retroperitoneal hemorrhage)

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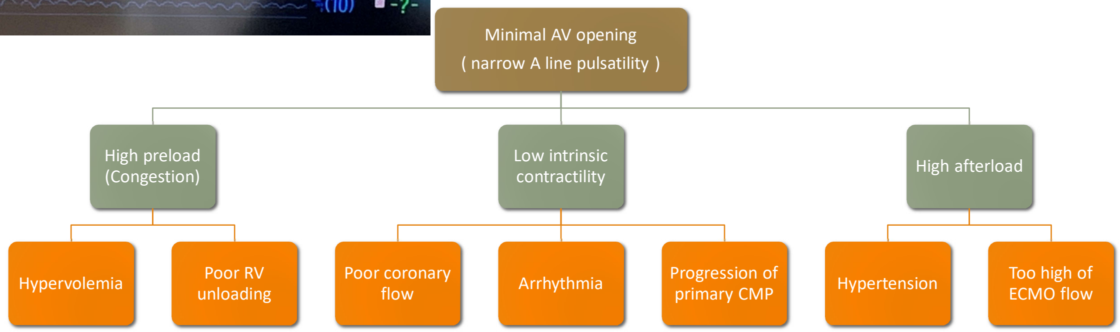

After addressing all the above, if AV still doesn't open well → could lead to thrombus formation in the LV and/or aortic root (VERY high mortality) → Need an LV vent

(Rajagopal 2019)

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What are the LV venting options?

- Inotropes
- Intra-aortic balloon pump
- Impella (need only 1-2 L flow)
- Atrial septostomy (to create a left to right shunt → unload the left side)
- Left atrial cannulation (connected to the ECMO drainage cannula)

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House keeping

- Vasoplegia can occur during the first 24-48 hours of support due to inflammatory surge
- Continuously assess for local cannulation complications / limb ischemia
- Anticoagulation – Follow institutional protocols, usually targeting ACT 160-180. Be watchful for heparin resistance
- If there is systemic bleeding, decreasing ECMO flow temporarily will help with hemostasis (carefully monitor MAP and make sure the patient is anticoagulated before flowing < 3L/min)
- Arrhythmia and respiratory failure can be well tolerated and may not require urgent treatment if the patient is well supported on VA ECMO

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Practical pearls

- Be careful of airlock - specially when manipulating central venous lines
- Try not to move the flow sensors, this can trigger the air-detection “emergency break” and stop the machine
- Definity contrast can be avoided, but if need to be used, let the ECMO tech know to disable the bubble emergency trigger. Also do not inject the contrast in the ECMO system directly
- Be aware of risk of cannula twisting/ rotation

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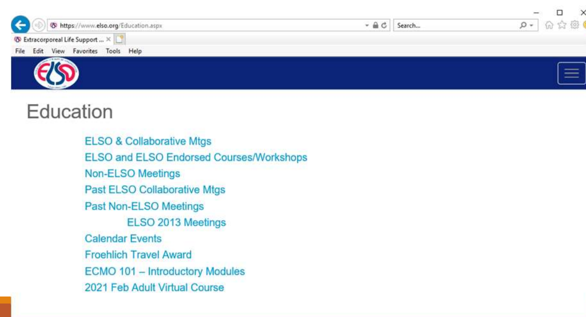
Take home points

- VA- ECMO is a powerful support platform, on the short term
- Always try to keep a balance between Heart Vs pump and lungs vs oxygenator
- Be sure to consult with your ECMO technician, they usually have the answer
- Be sure to engage with ELSO if you are interested in this field



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