# ECMO IN CARDIOGENIC SHOCK

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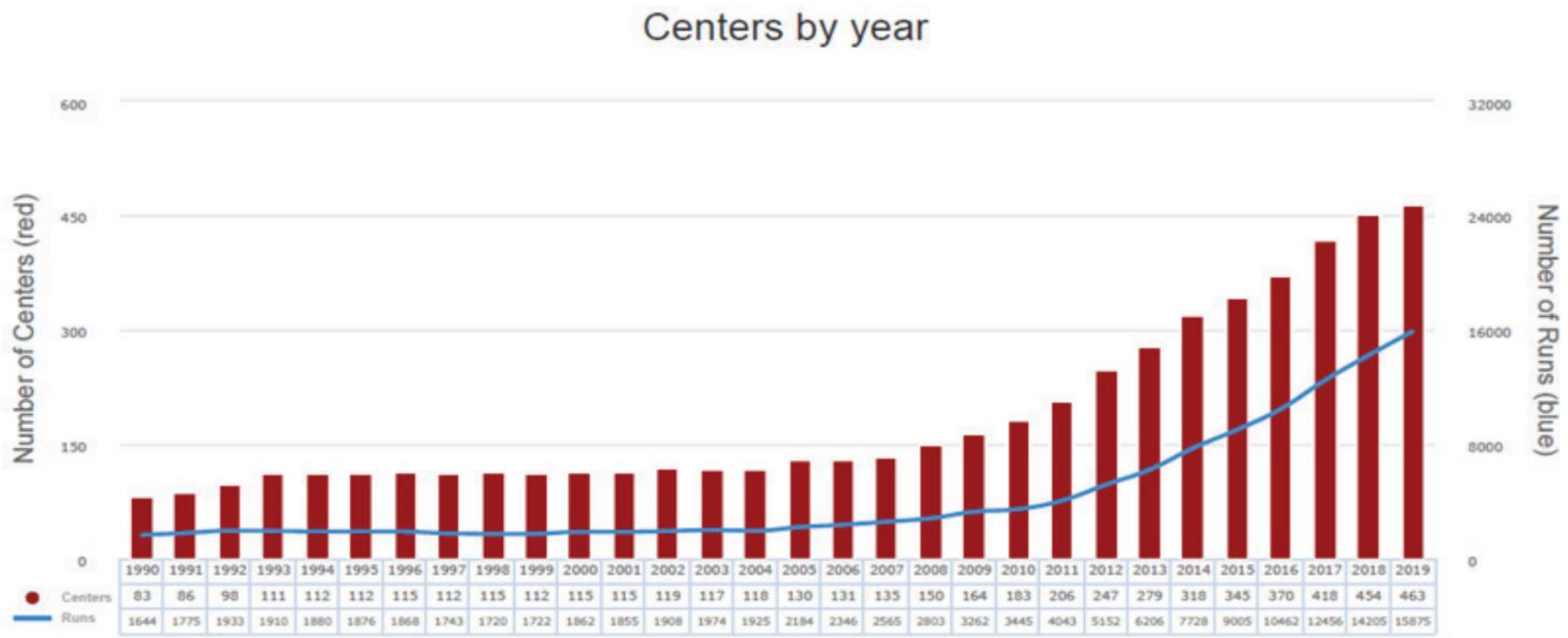
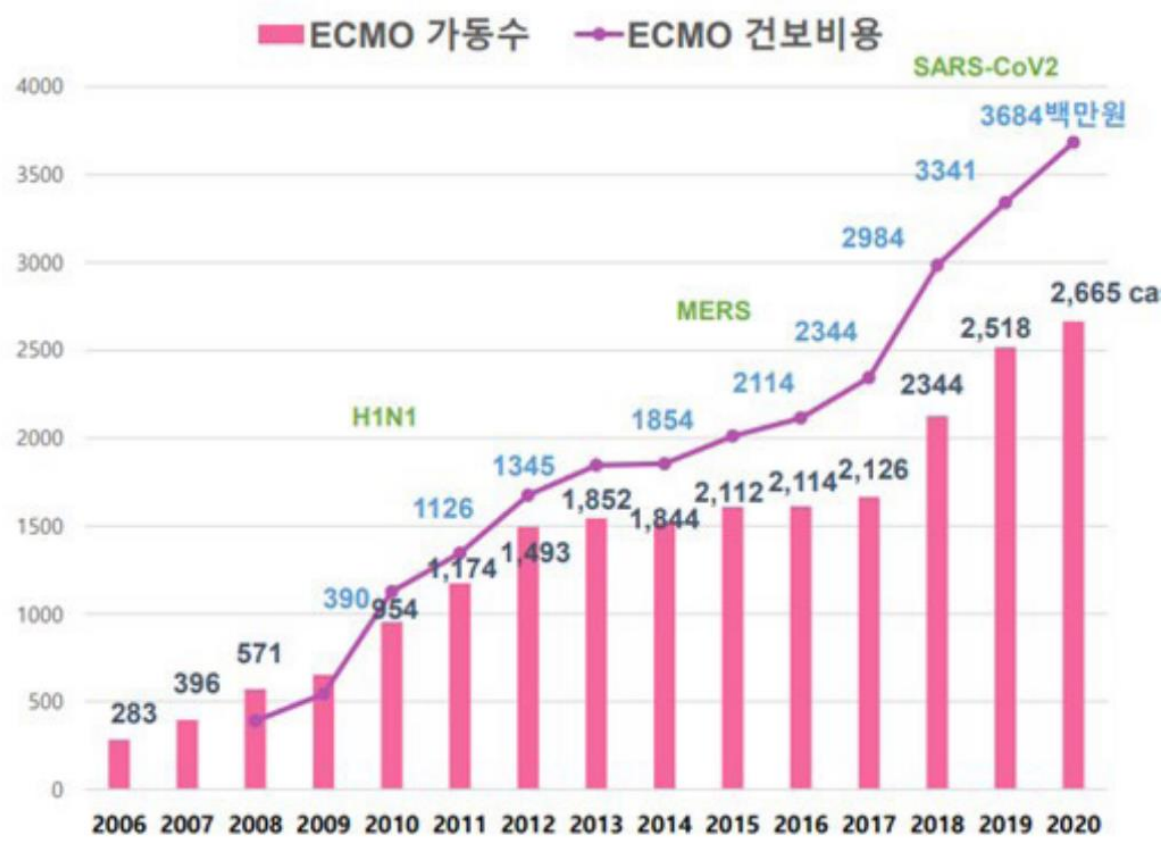
*Seoul National University Hospital*

# ELSO 2020 Annual Report



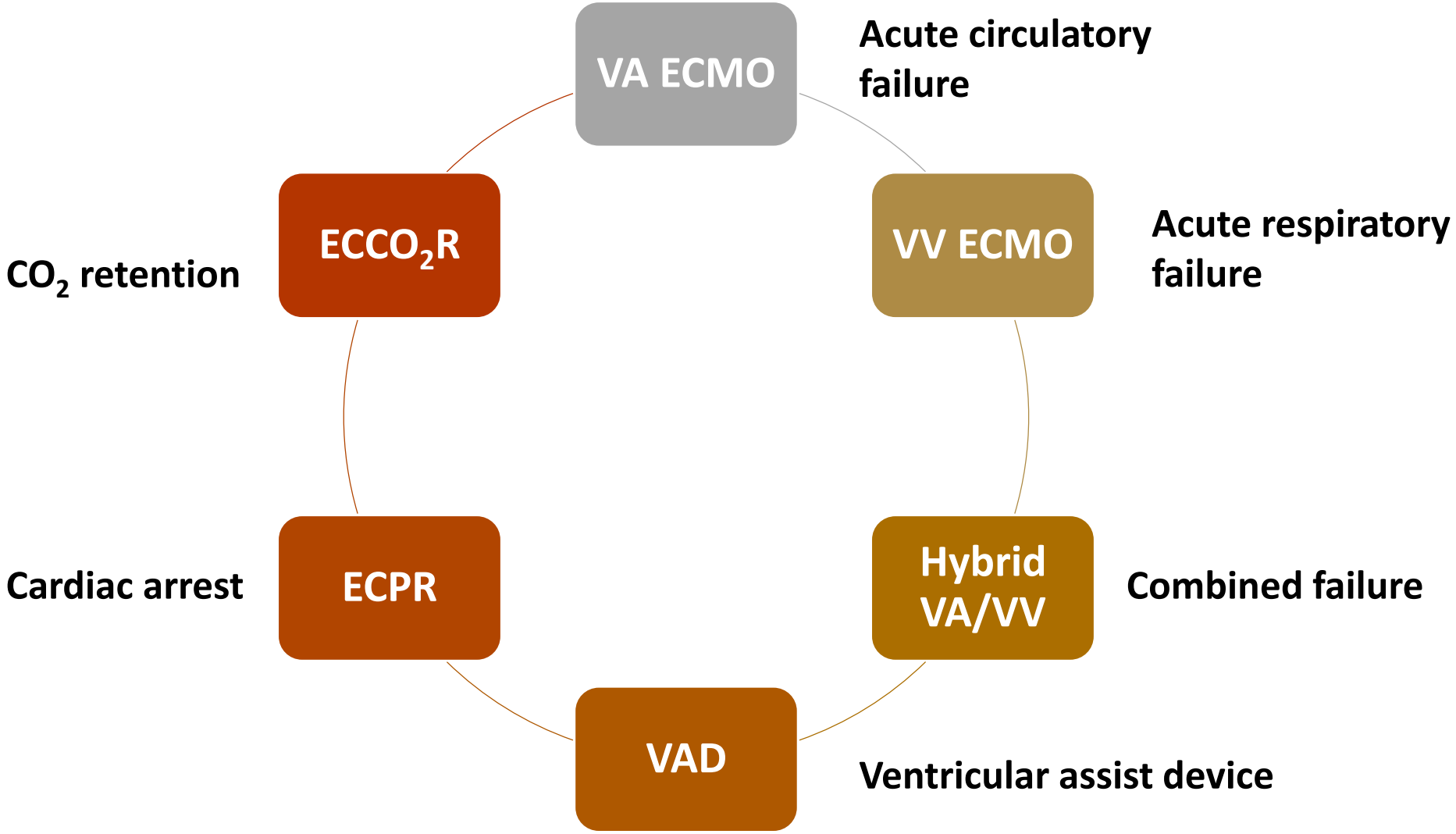
# ECMO Loading in Korea



# Components

- *Introduction*
- Types of ECMO
  - VA vs VV
  - Different configurations
- Physiology of VA-ECMO
- Troubleshooting
  - LV unloading
  - Harlequin syndrome
- Weaning from VA-ECMO

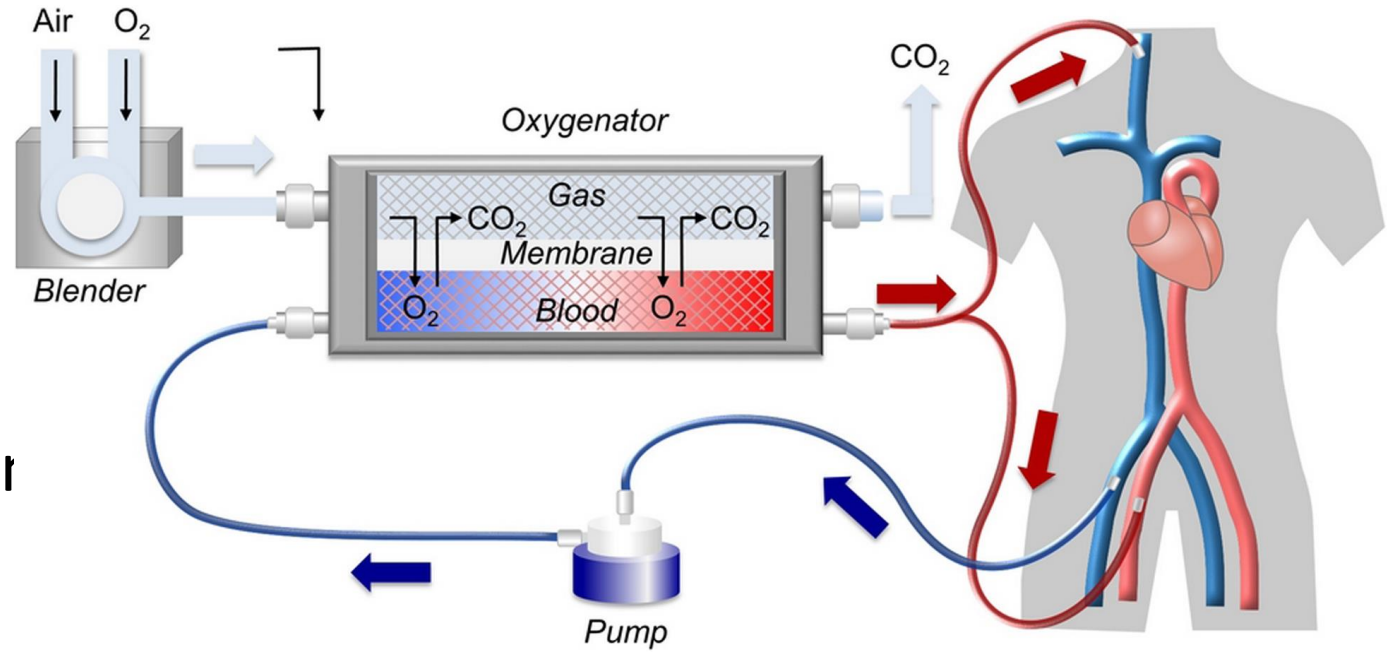
# Extracorporeal Life Support - ECLS

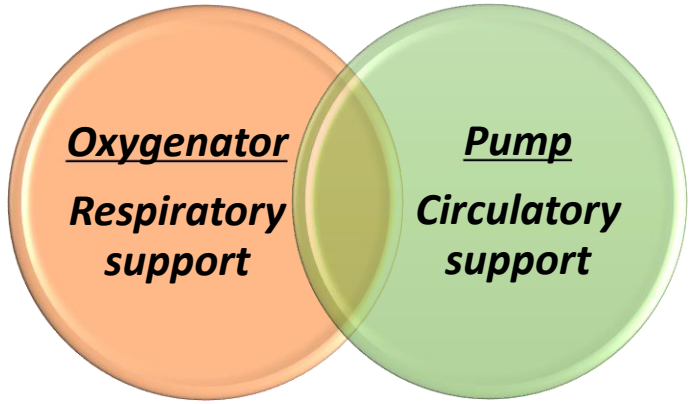


# Extracorporeal Membrane Oxygenation - ECMO

- Draining venous blood
  - Pump
- Gas exchange
  - Oxygenator
- Returning blood to circulatior
  - VV: via vein
  - VA: via artery

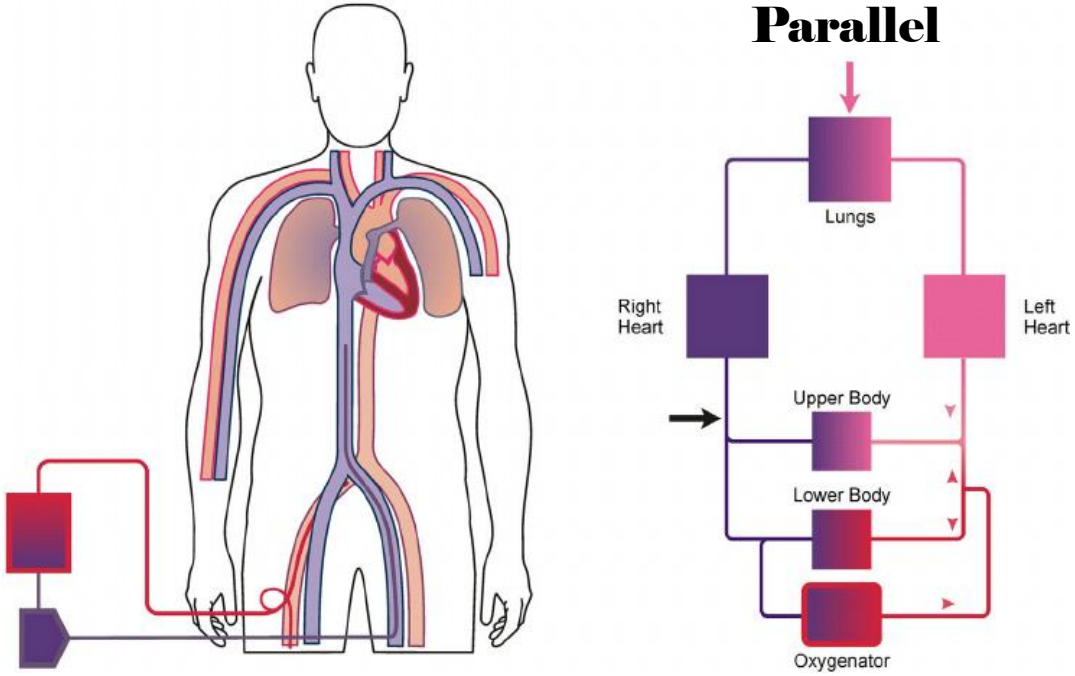
- Extracorporeal Life Support
  - Circulatory support with oxygenation



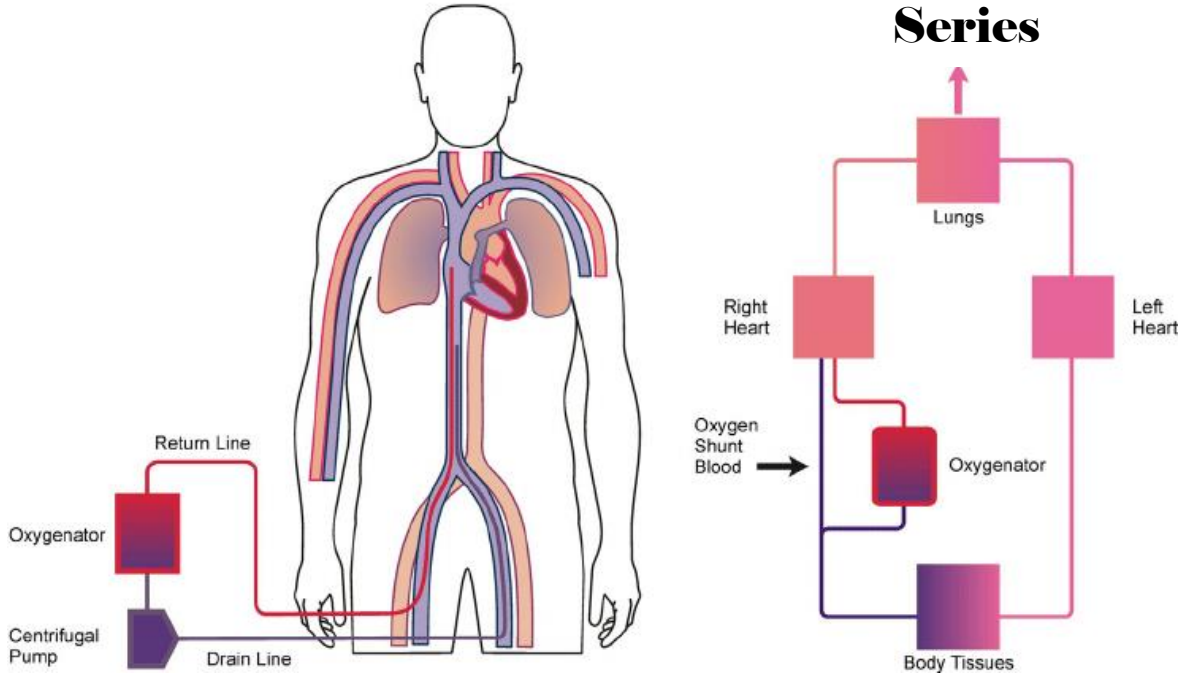
# Types of ECMO

## VENO-ARTERIAL ECMO



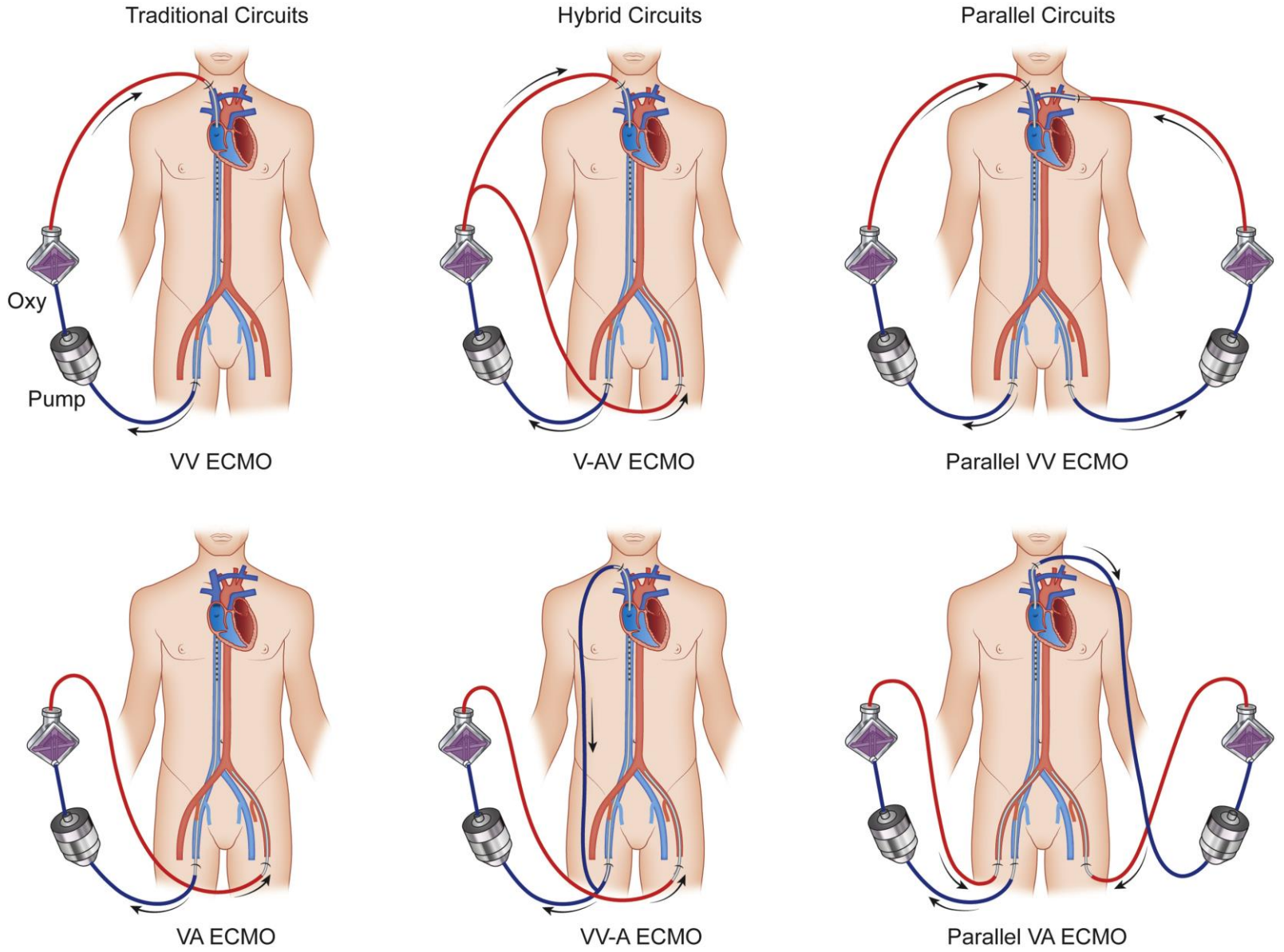

→ Cardiopulmonary support

## VENO-VENOUS ECMO




→ Respiratory support only

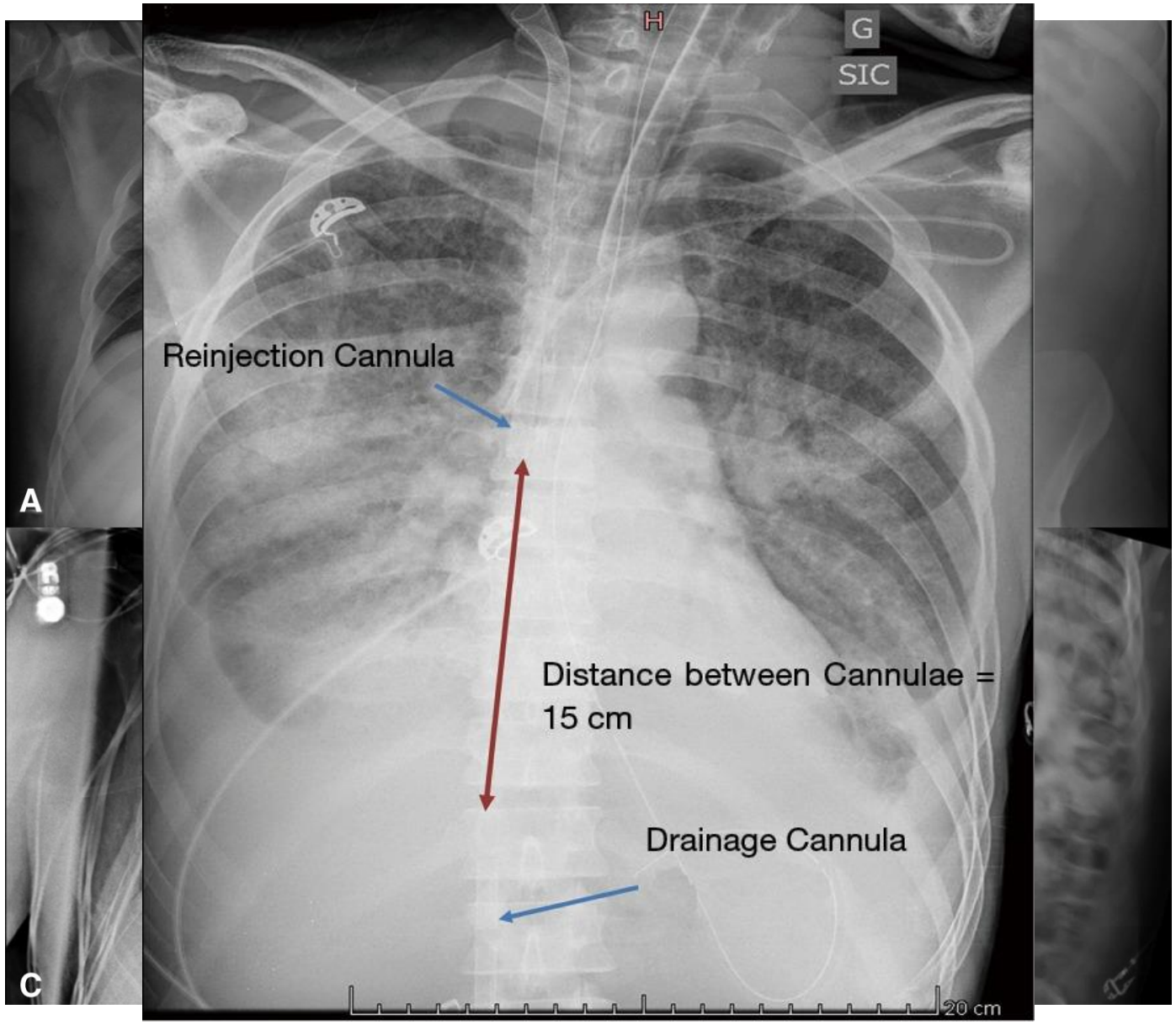
# Different Configurations of ECMO




*JTCVS Tech. 2021 Feb 24;8:77-85.*

# Different Configurations of ECMO

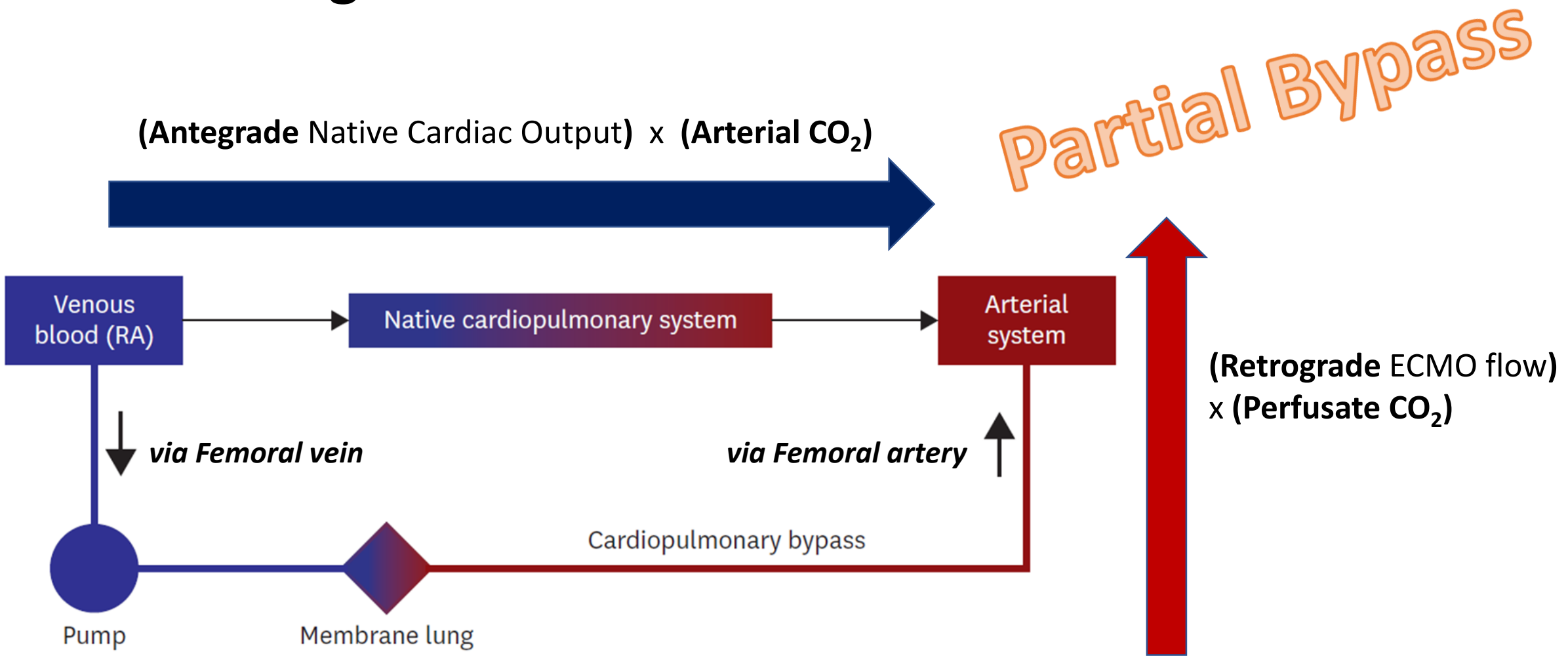
**Position of cannula**
: Routine X-ray
: EchoCG (TEE/TTE)
: Fluoroscopy




*JTCVS Tech. 2021 Feb 24;8:77-85.*

# VA – ECMO

# Basic configuration




Korean Circ J. 2019 Aug;49(8):657-677

# Anticipated Goals of VA-ECMO support

- Adequate end-organ perfusion *(tissue oxygen supply)*
  - Increase systemic flow & MAP
  - Increase $DO_2$
    → *Native CO (x arterial $CO_2$) + ECMO flow (x perfusate $CO_2$)*

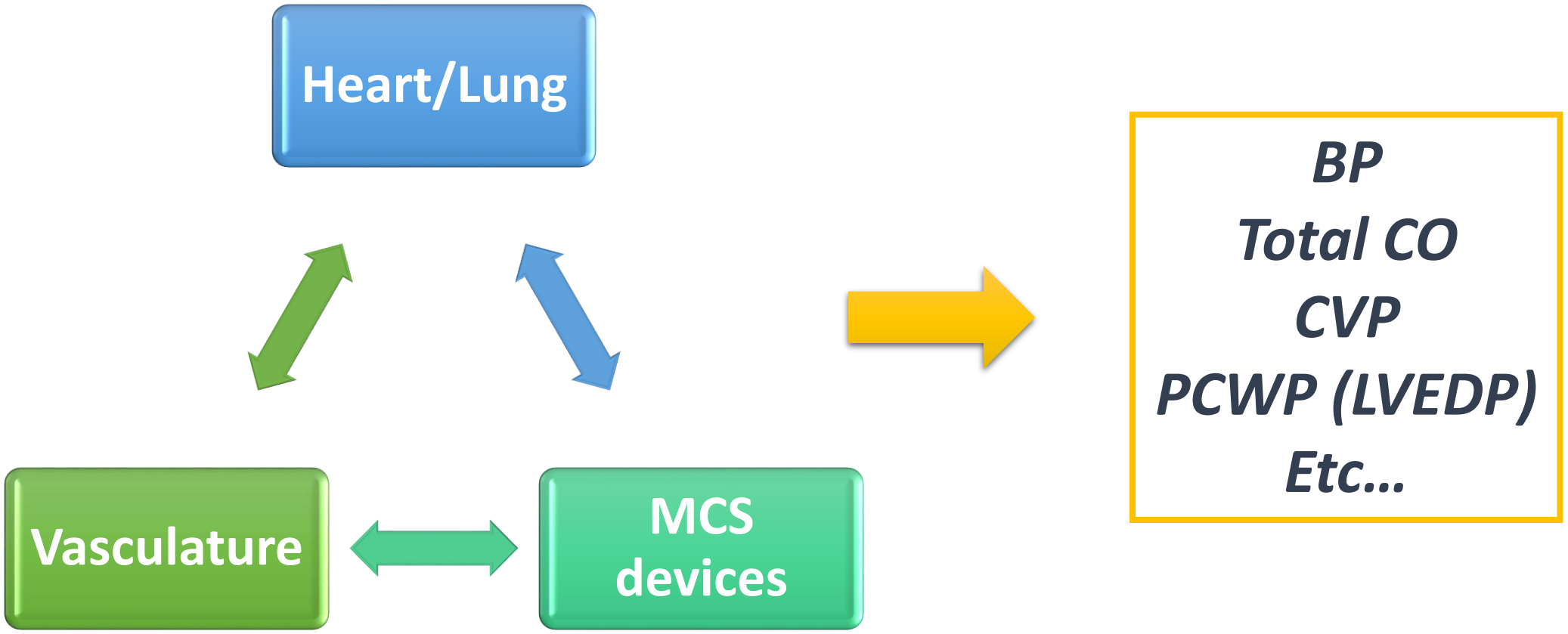
- Promote “Rest & Recovery” of native heart
  - Increase coronary perfusion
  - Decrease $MVO_2$
    - Volume reduction & ventricular unloading ( ↓ LV preload)
    - Minimizing inotropes & vasopressors

# Hemodynamic Effects of VA-ECMO

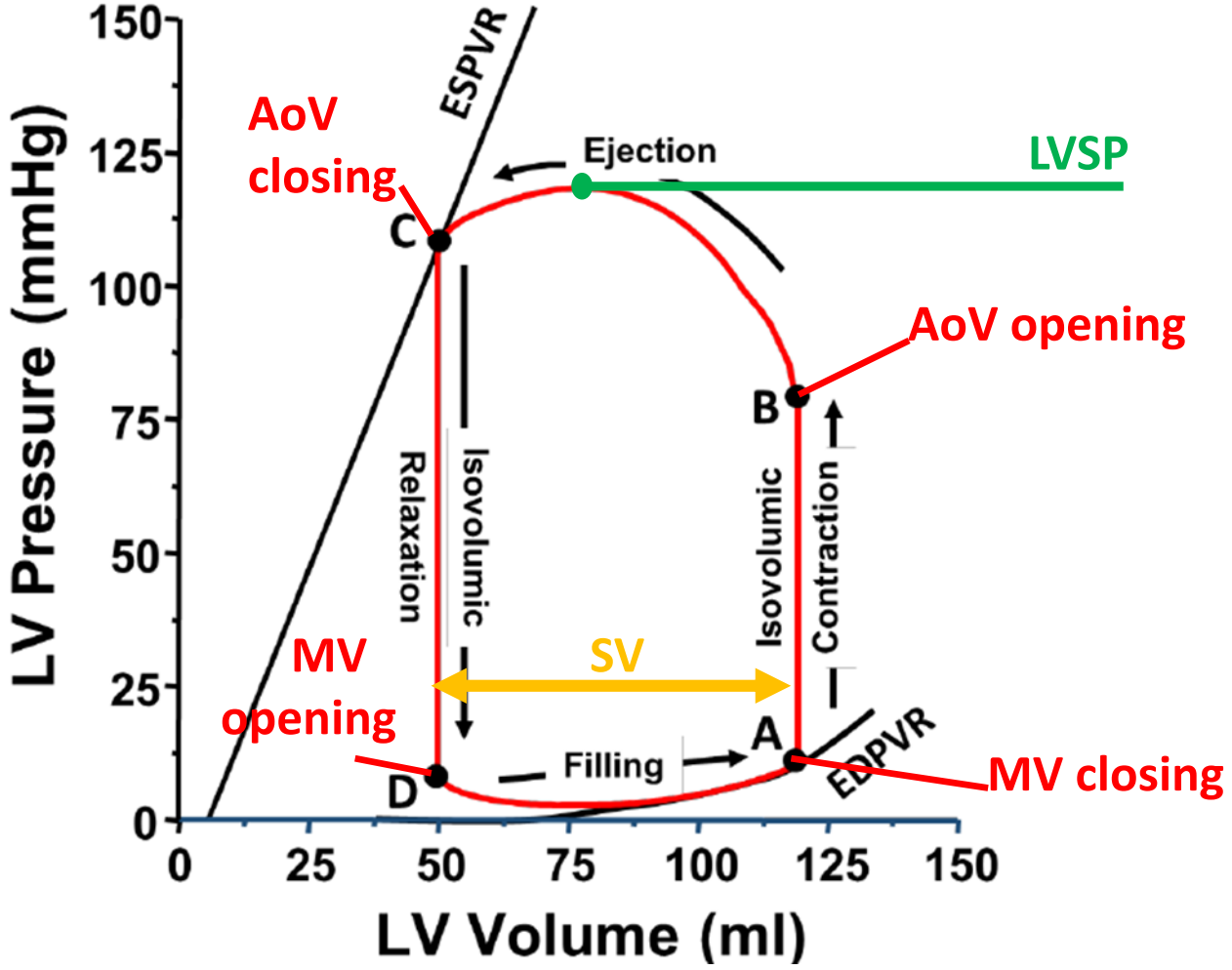
- Afterload Stress

- ***FlowPressor***
  - Afterload = MAP
  - Decreasing RPM = Decreasing SVR

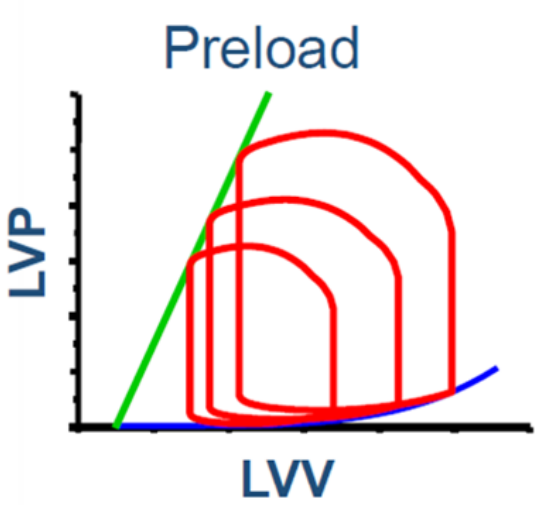
# Understanding Hemodynamics

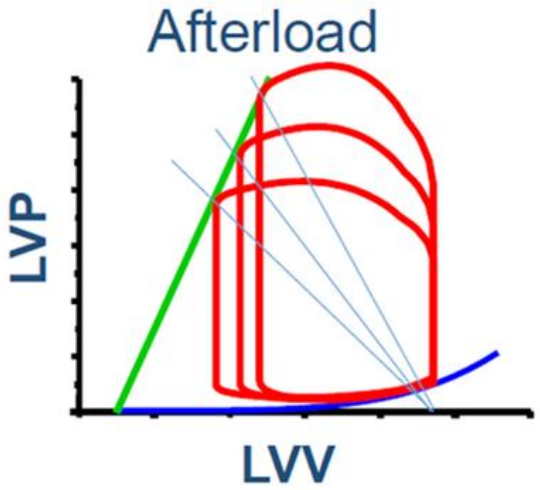


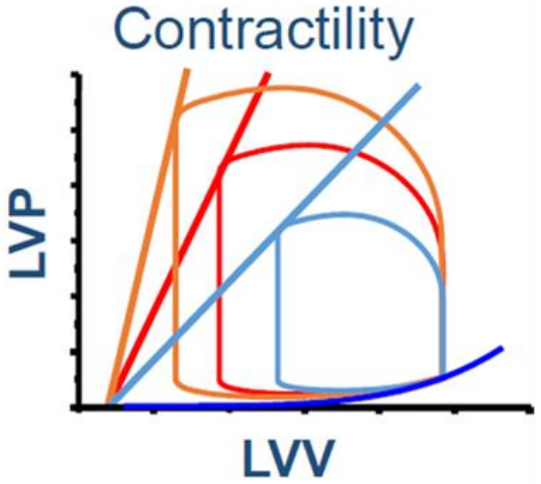
# Pressure-Volume Loop of LV

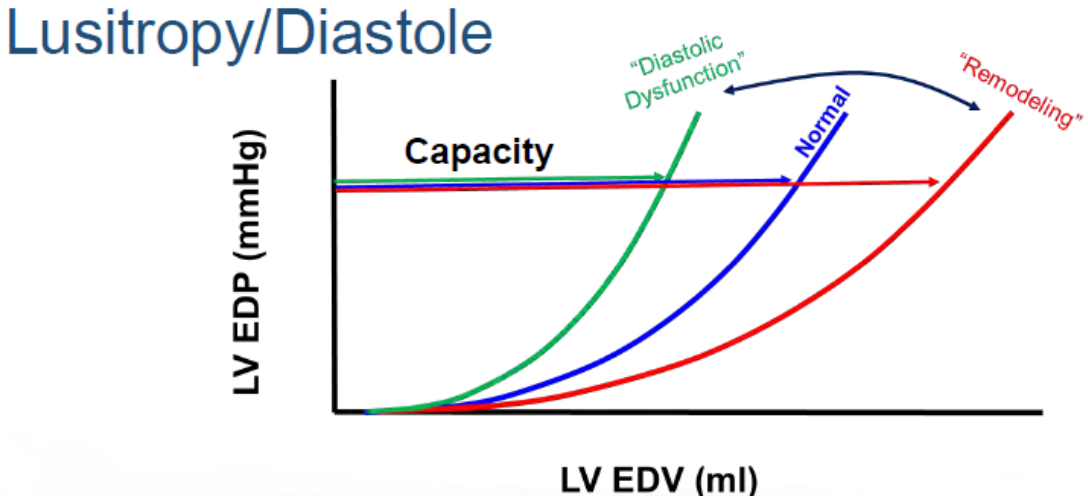


# Ventricular – Vascular Coupling

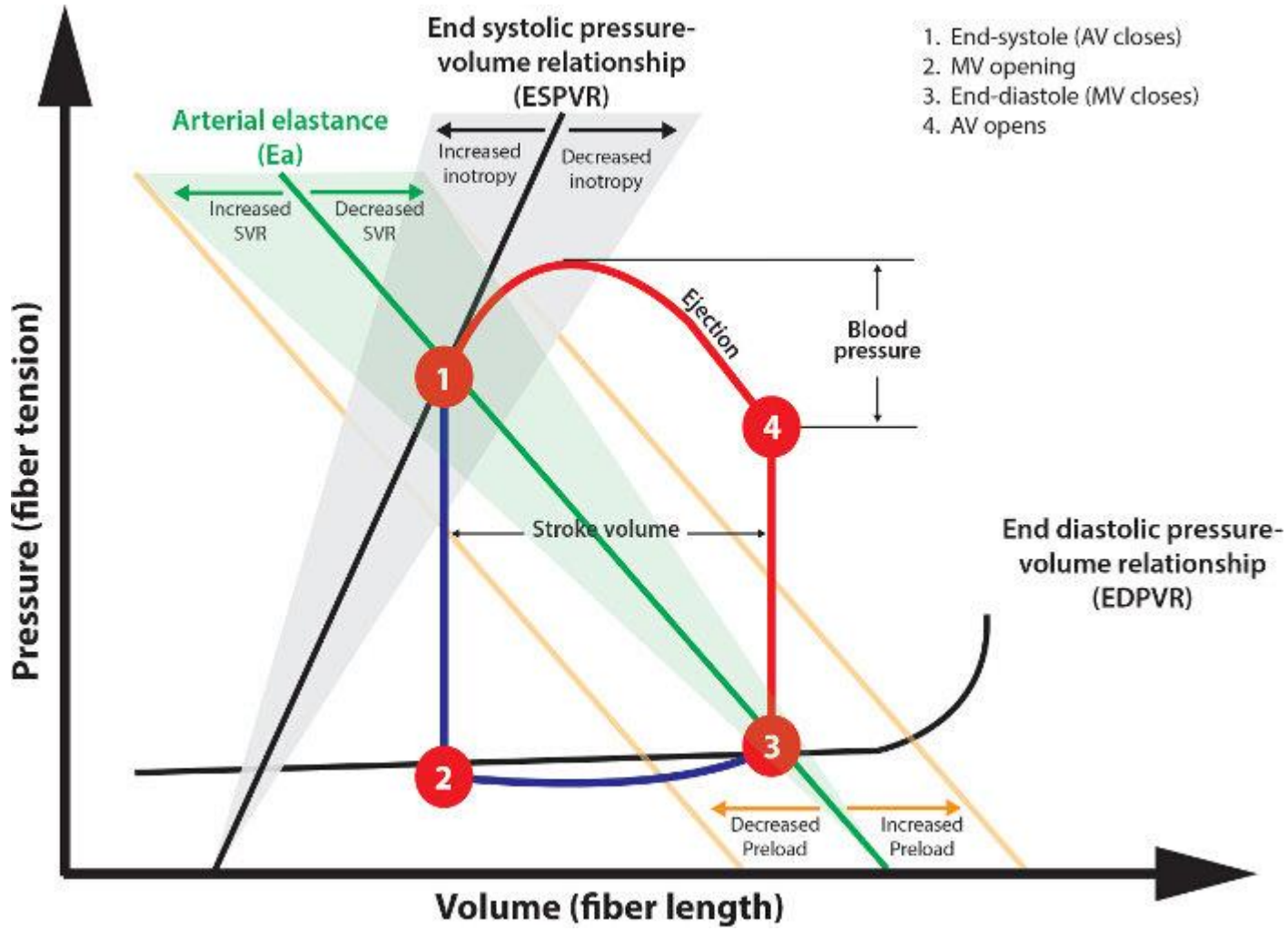


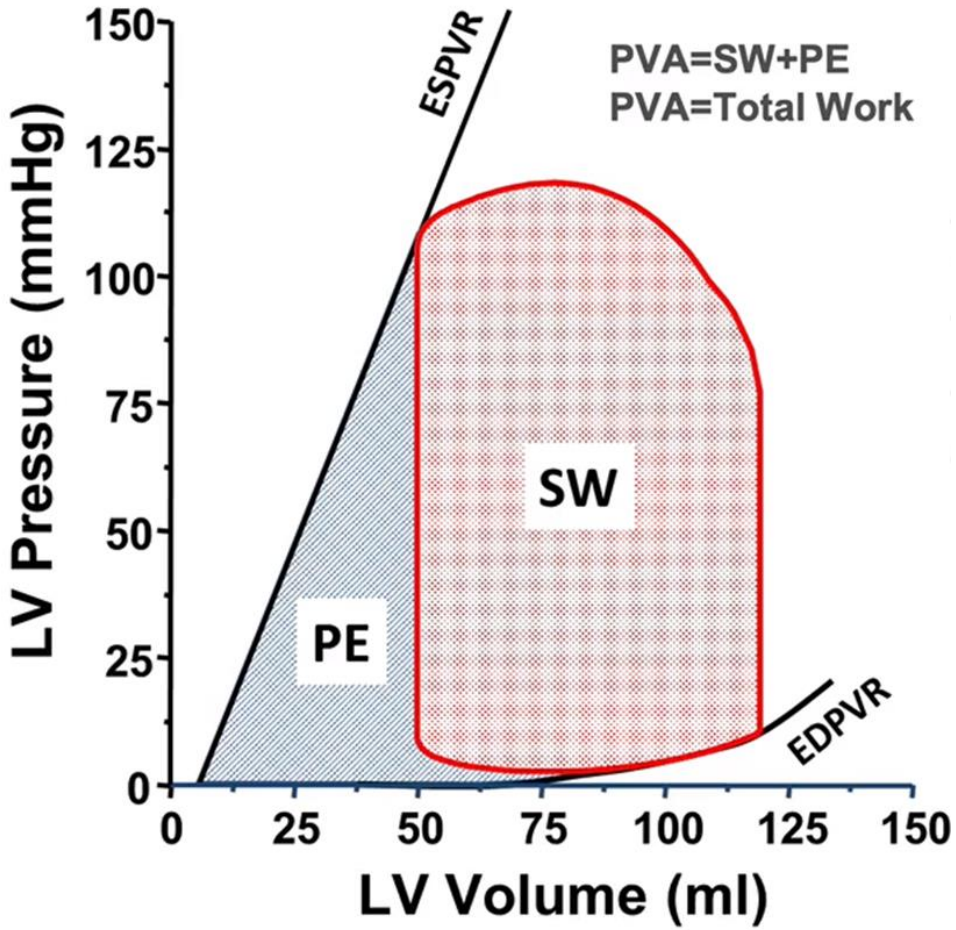



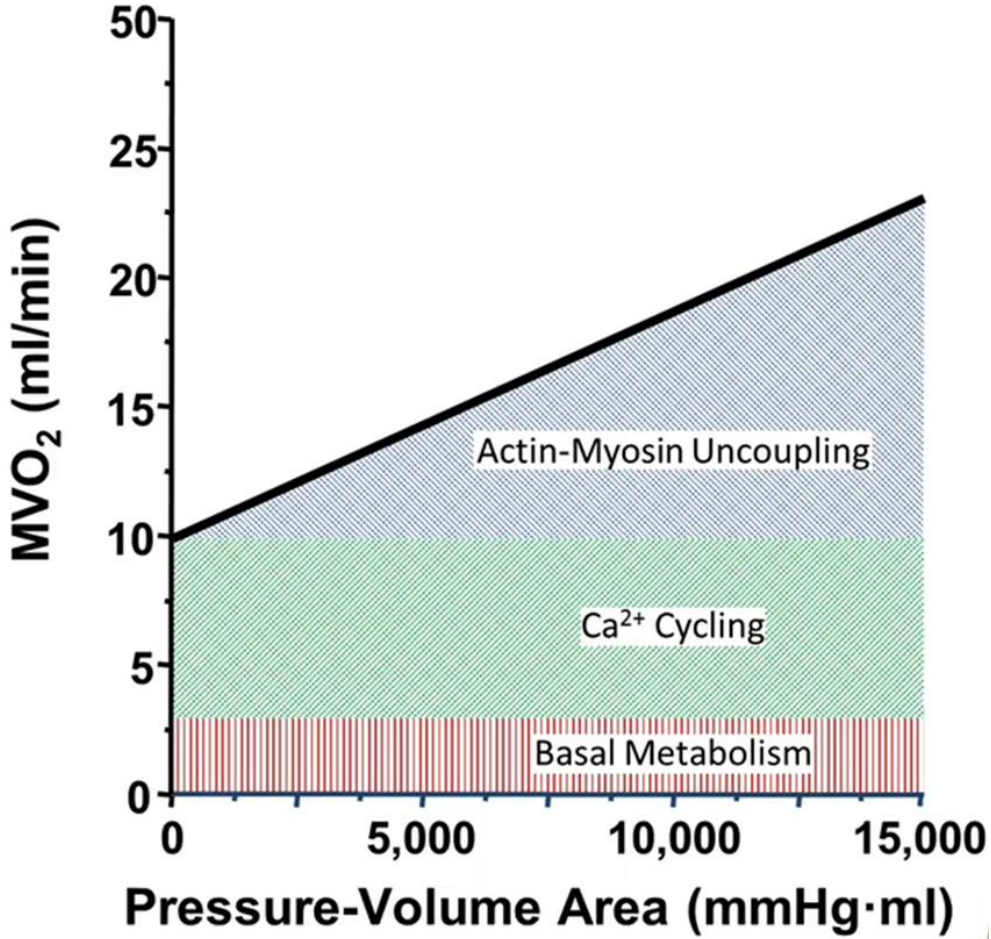



# Ventricular – Vascular Coupling



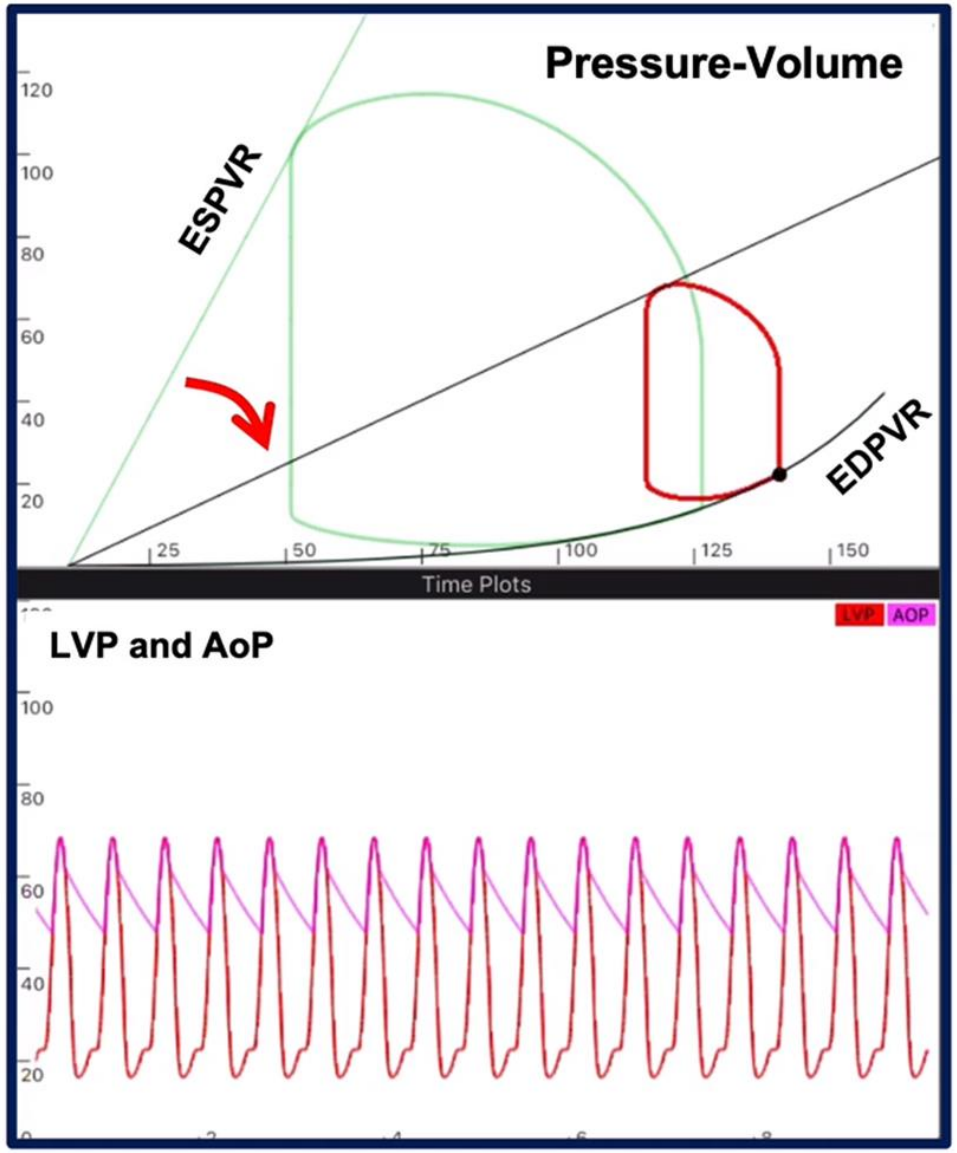
# Ventricular Energetics – $MVO_2$



# Acute Cardiogenic Shock

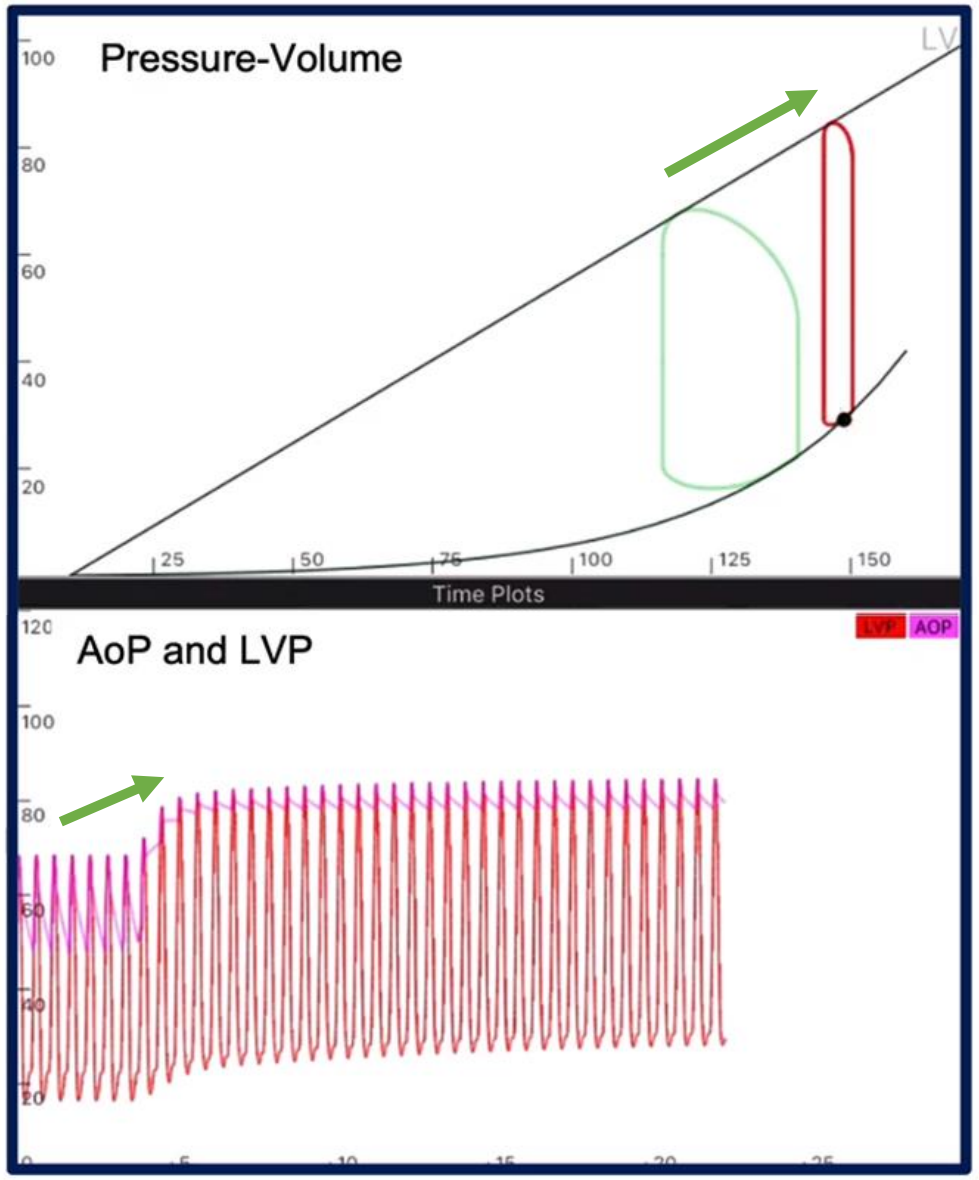
- Caused by
  - ↓ Contractility
- CGS defined by
  - ↓ BP
  - ↓ SV and CO
- Variably associated with
  - ↑ PCWP
  - ↑ CVP



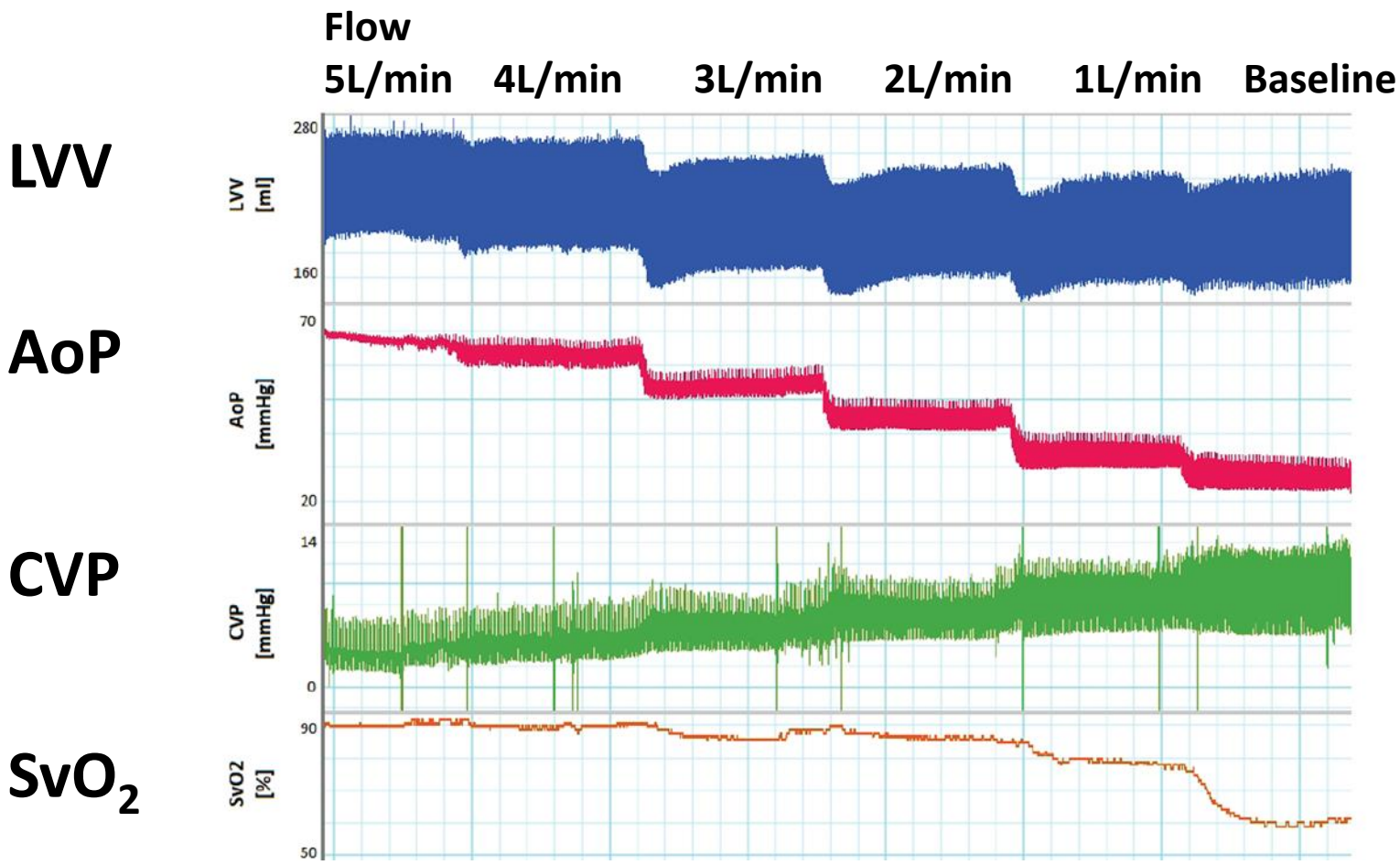
# Impact of VA-ECMO

- ↑ Afterload
- ↑Preload

- ↑AoP
- ↑LVP

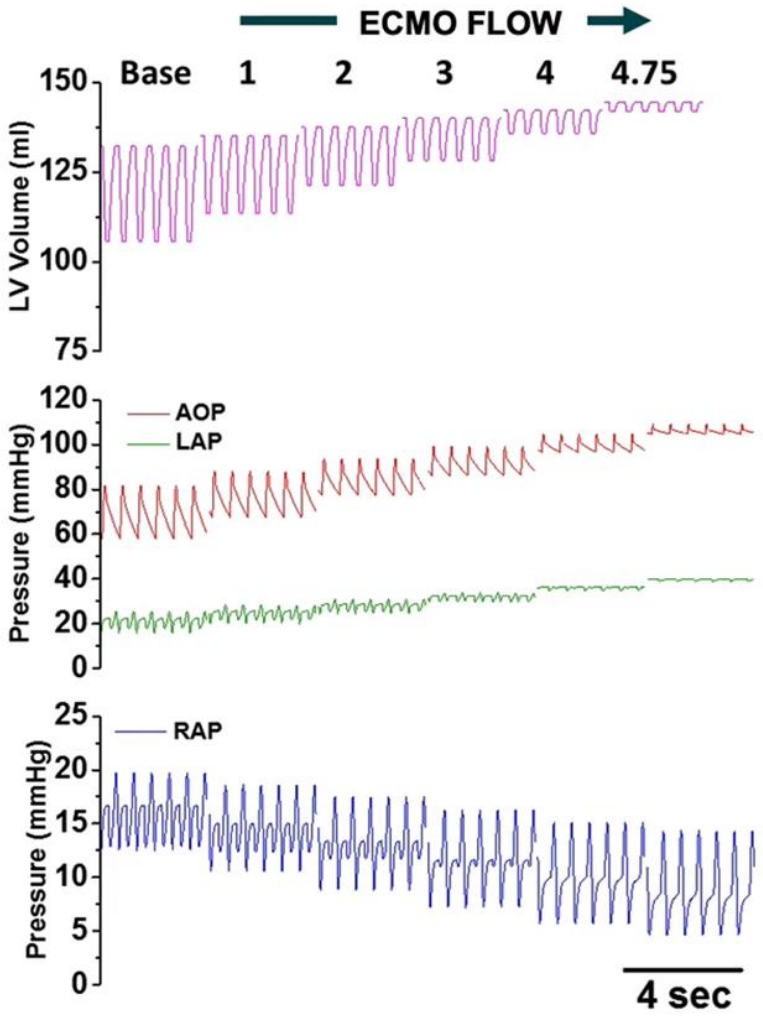


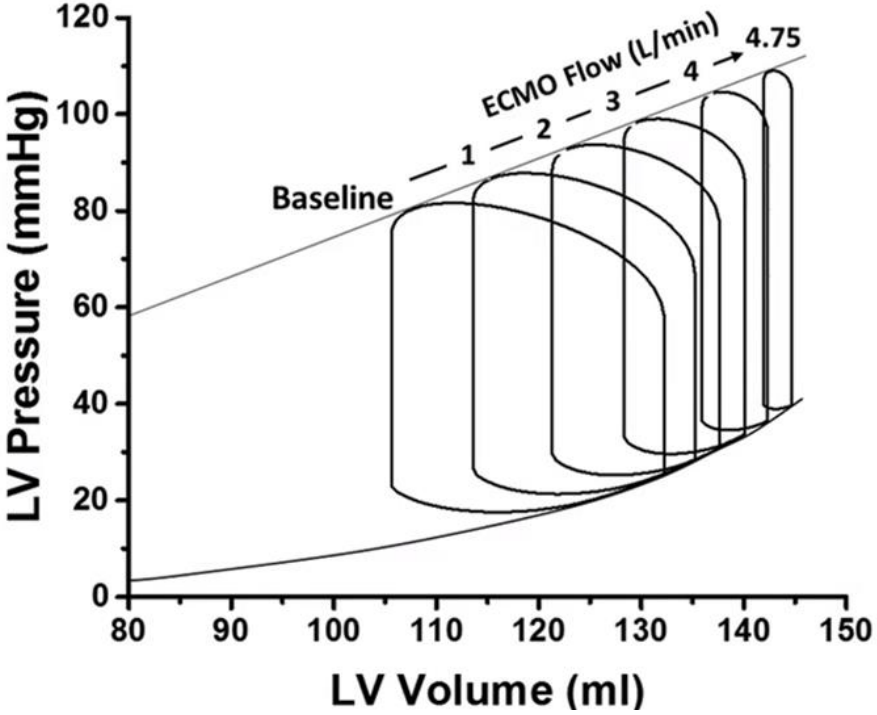
# Regional Tissue Oximetry Reflects Changes in Arterial Flow in Porcine Chronic Heart Failure Treated With Venoarterial Extracorporeal Membrane Oxygenation




*Physiol. Res. 65 (Suppl. 5): S621-S631, 2016*

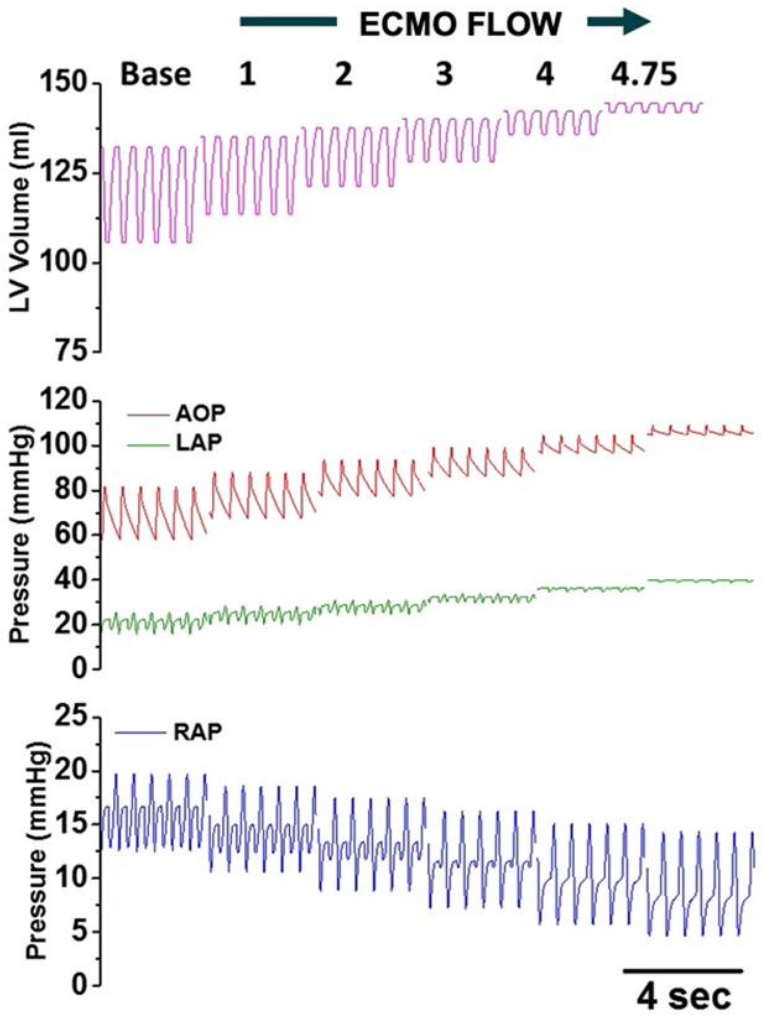
# Impact of Pump Flow on Hemodynamics




*Circ Heart Fail. 2018 Sep;11(9):e004905*

# Impact of Pump Flow on Hemodynamics



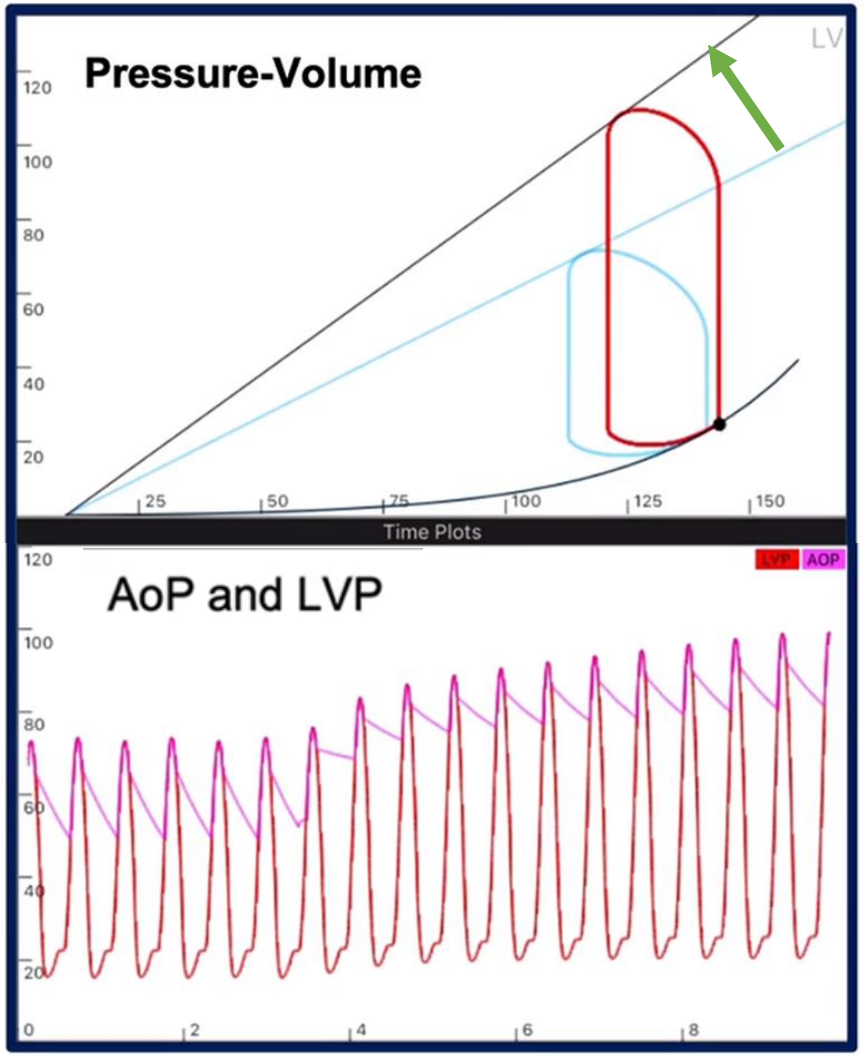

- **With ECMO Flow ↑**
  - **↓ Pulse pressure**
  - **↓ AoV opening**
  - **↑ Competition b/w LV output and ECMO flow**
  - **↑ LVEDP and PCWP**

*Circ Heart Fail. 2018 Sep;11(9):e004905*

# Variability of Hemodynamic Response

- Hemodynamic response to device and drug therapies are variable among patients
  - Degree of LV and/or RV compromise
  - Short term recoverability of LV/RV function
  - SVR and PVR
  - Volume Status
  - Degree of MR and TR
  - Background medical therapy
  - Etc…

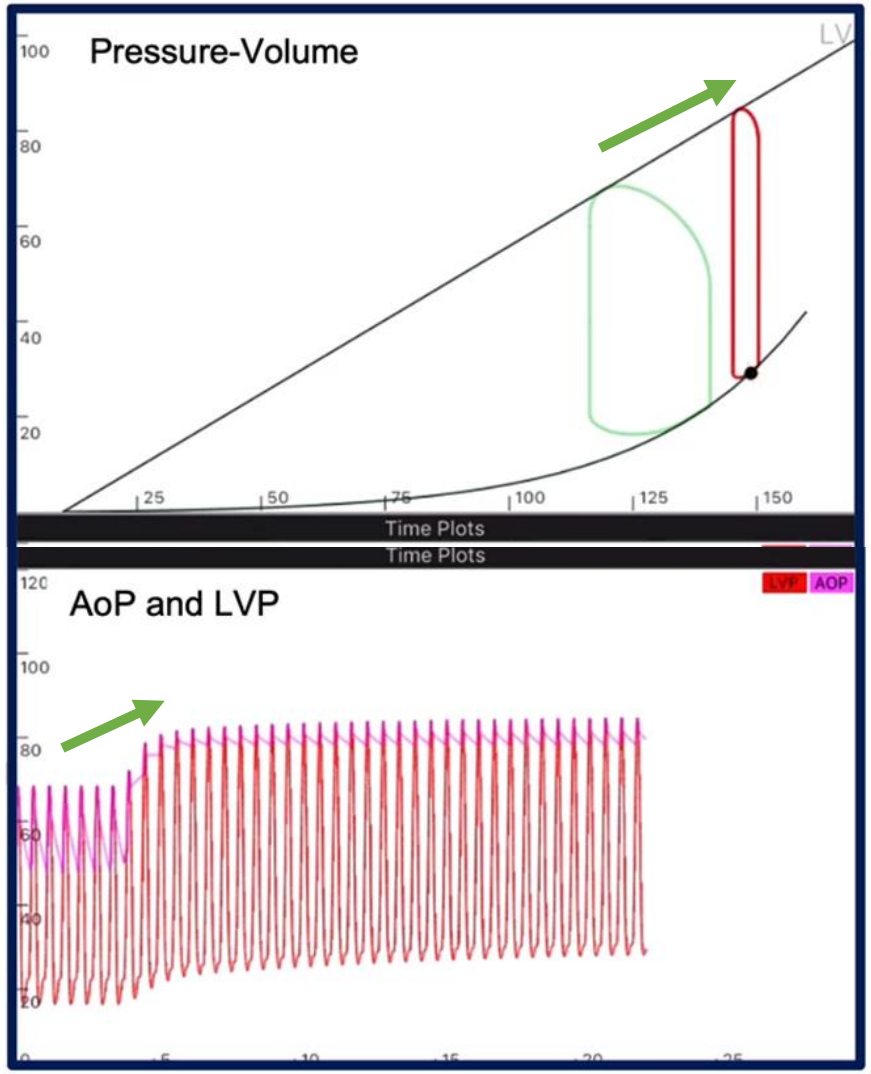
# Impact of VA ECMO – with LV contractile reserve



# Impact of VA ECMO – w/o LV contractile reserve

- ↑ Afterload
- ↑Preload

- ↑AoP
- ↑LVP

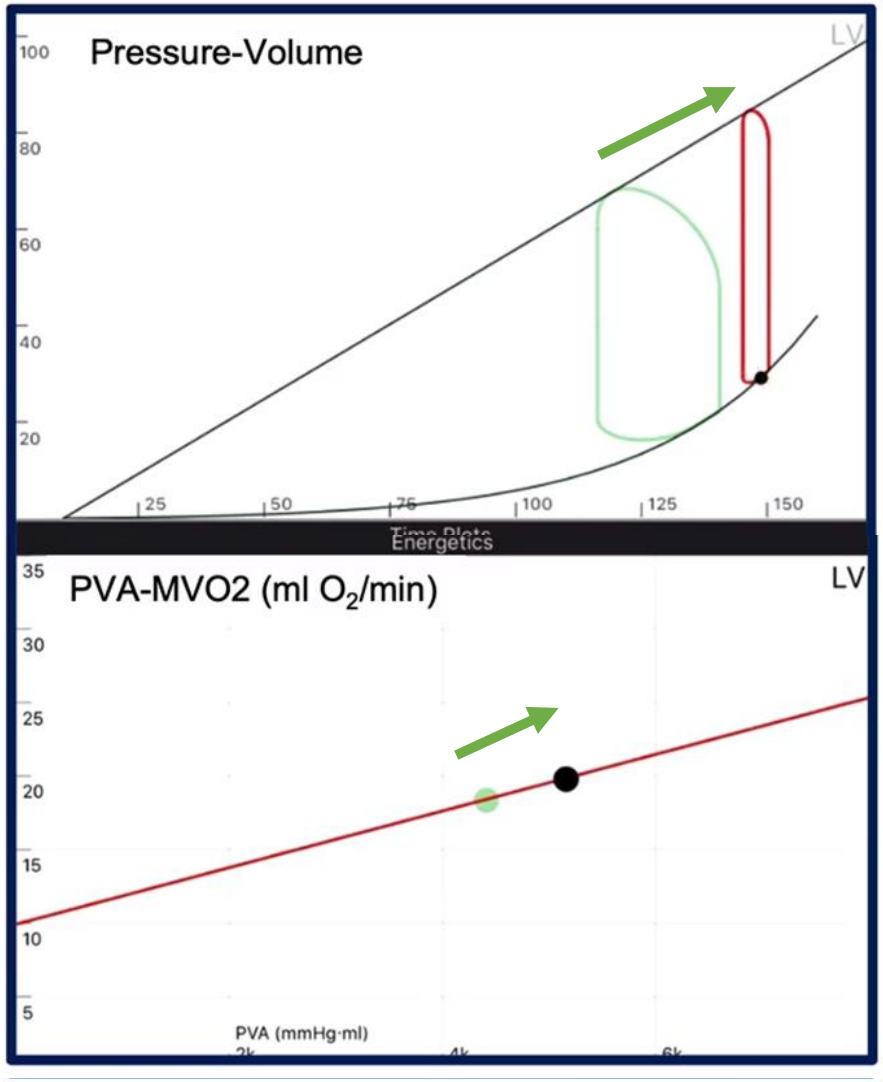


# Impact of VA ECMO – w/o LV contractile reserve

- ↑ Afterload
- ↑Preload

- ↑ PVA
- ↑ $MVO_2$

*Need Venting!*



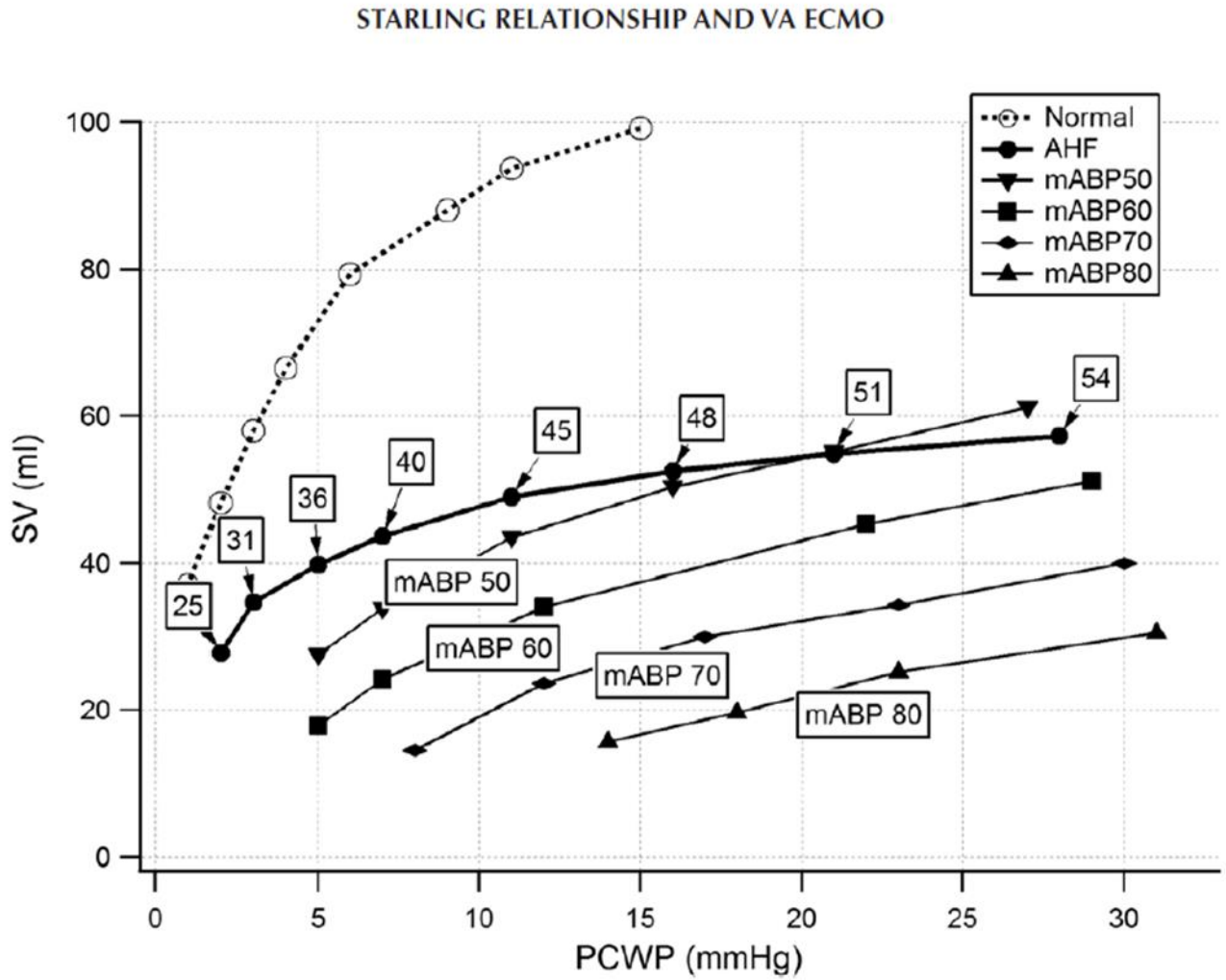
# Hemodynamic Effects of VA-ECMO

- Afterload Stress

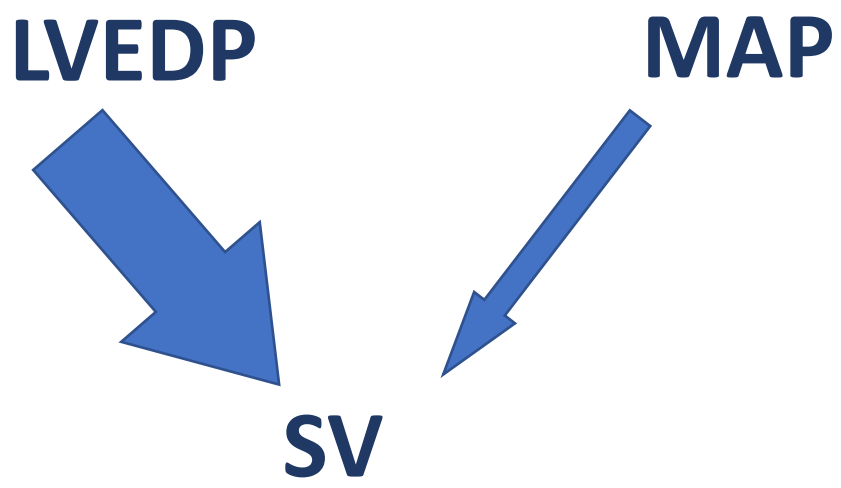
- ***FlowPressor***
  - Afterload = MAP
  - Decreasing RPM = Decreasing SVR

# The Starling Relationship and Veno-Arterial ECMO: Ventricular Distension Explained

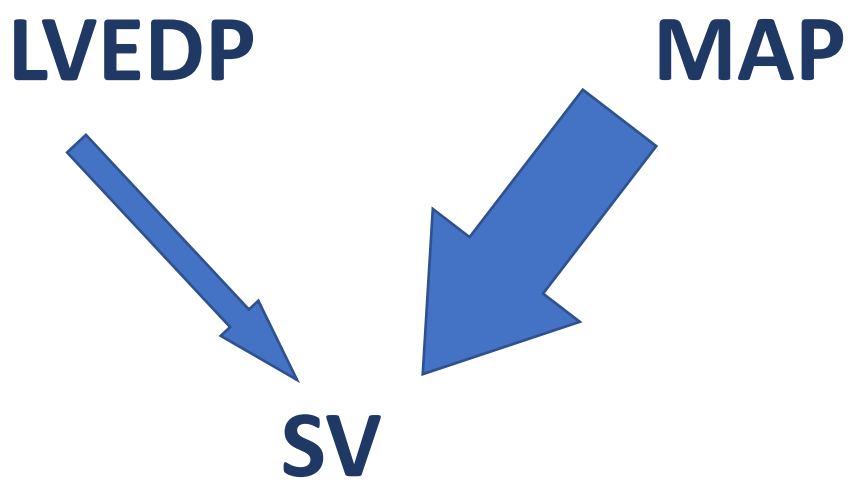
Marc L. Dickstein



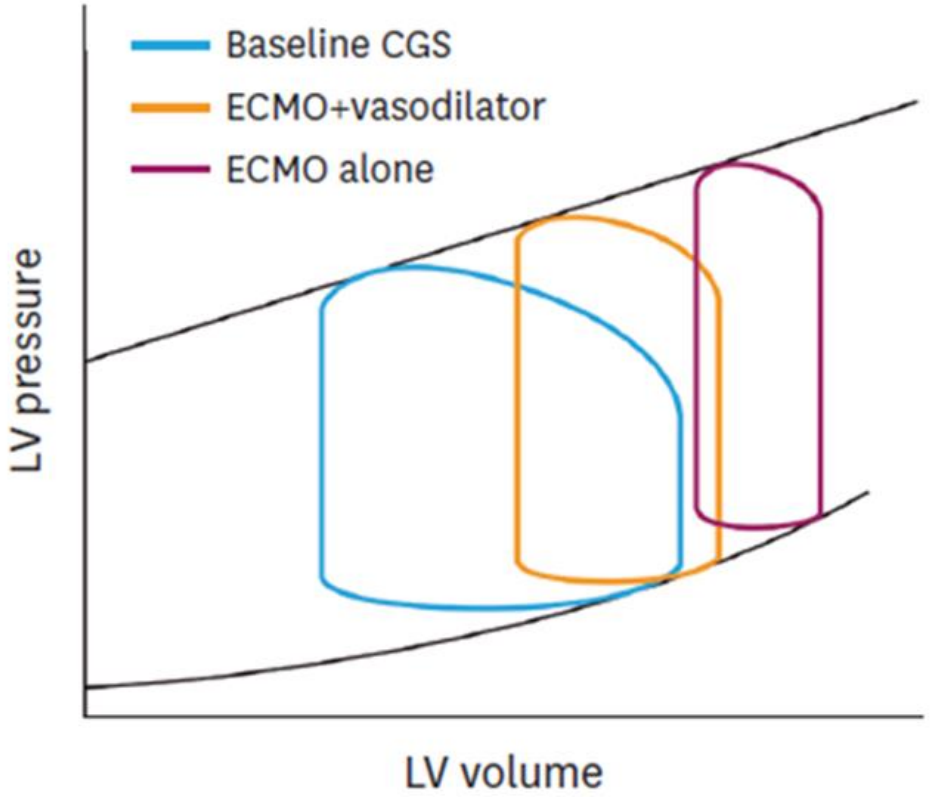
- Normal LV Contractility




- Impaired LV Contractility



# ECMO & Vasodilator

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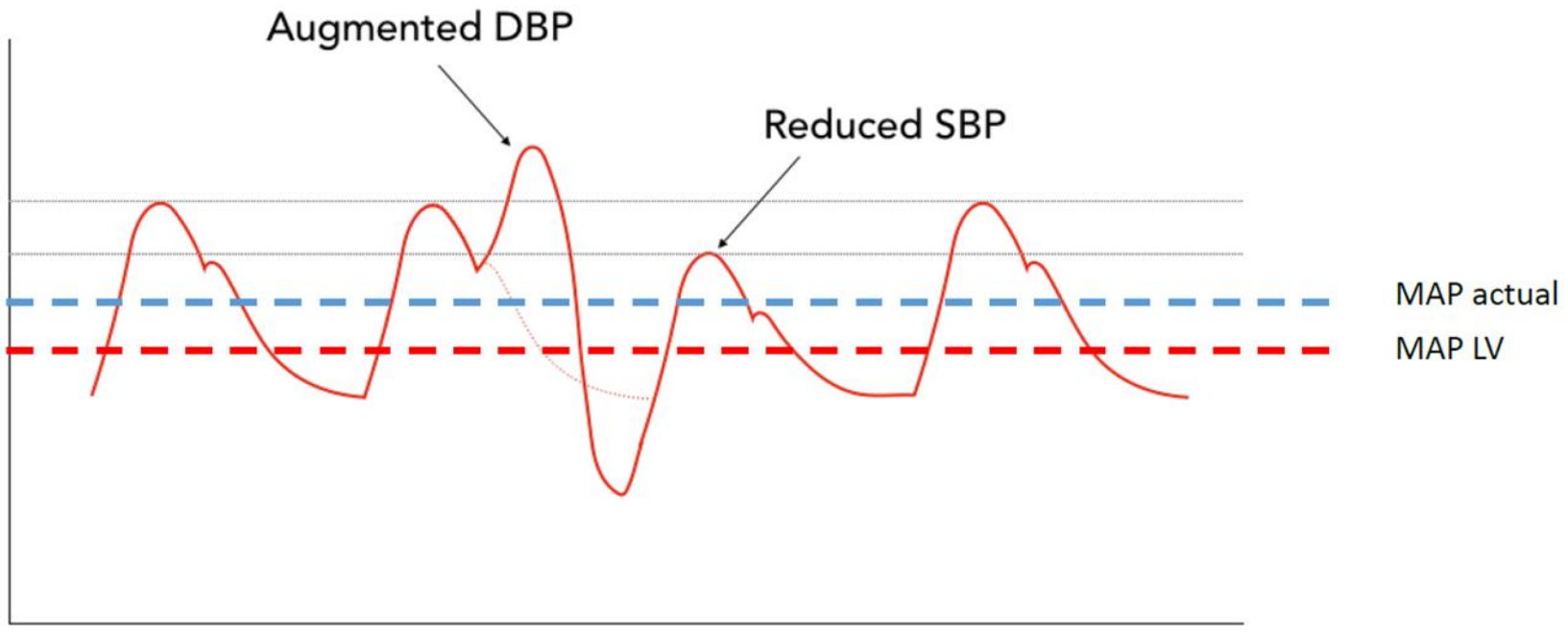
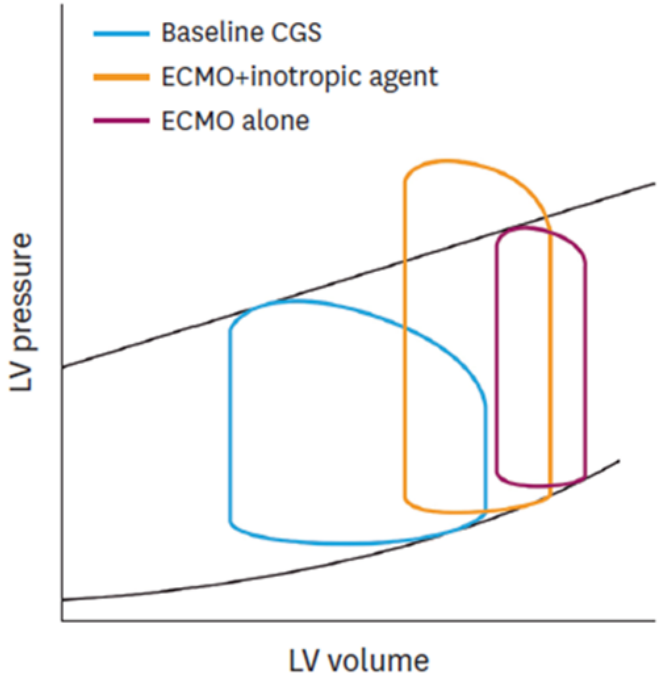
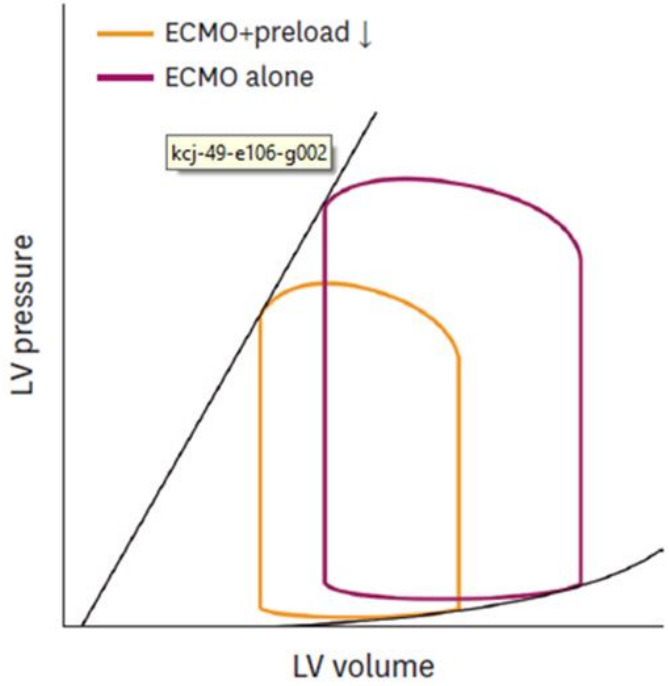
# ECMO & IABP



# Reduce LVEDP by other methods

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# Minimizing Ventricular Load during VA-ECMO

- Minimizing Do of Vasopressors
  - Afterload reduction
- Fluid removal
  - Preload reduction
- Optimizing ECMO flow
  - Adequate tissue oxygenation

*Let the native Heart Rest!*

*Balancing Tissue Oxygen Supply & Demand !*

# LV distention & Pressure overload

- **Loss of AoV opening**
- Pulmonary edema
- Bronchial bleeding
- LV thrombosis

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- **Pulmonary edema**
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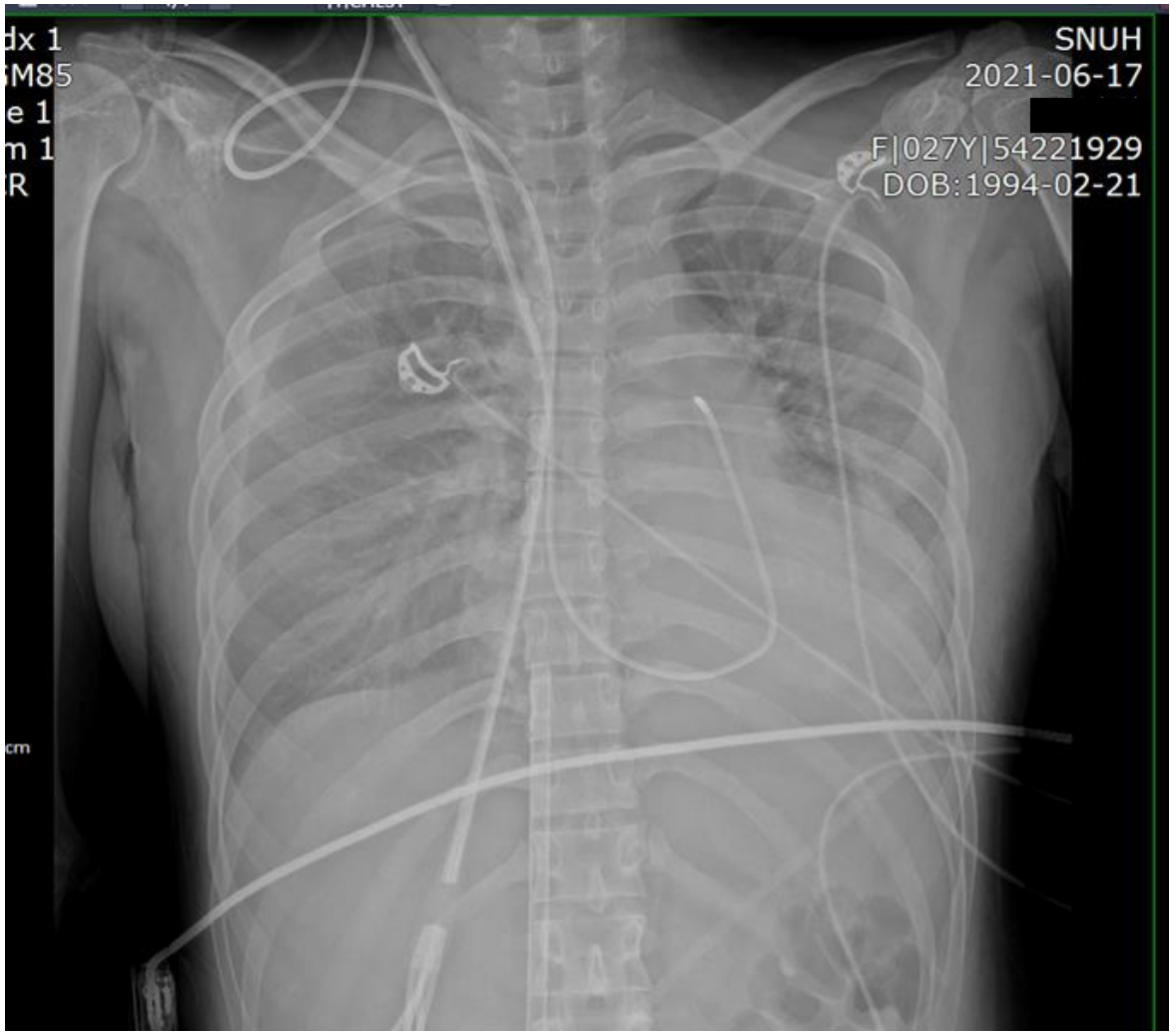

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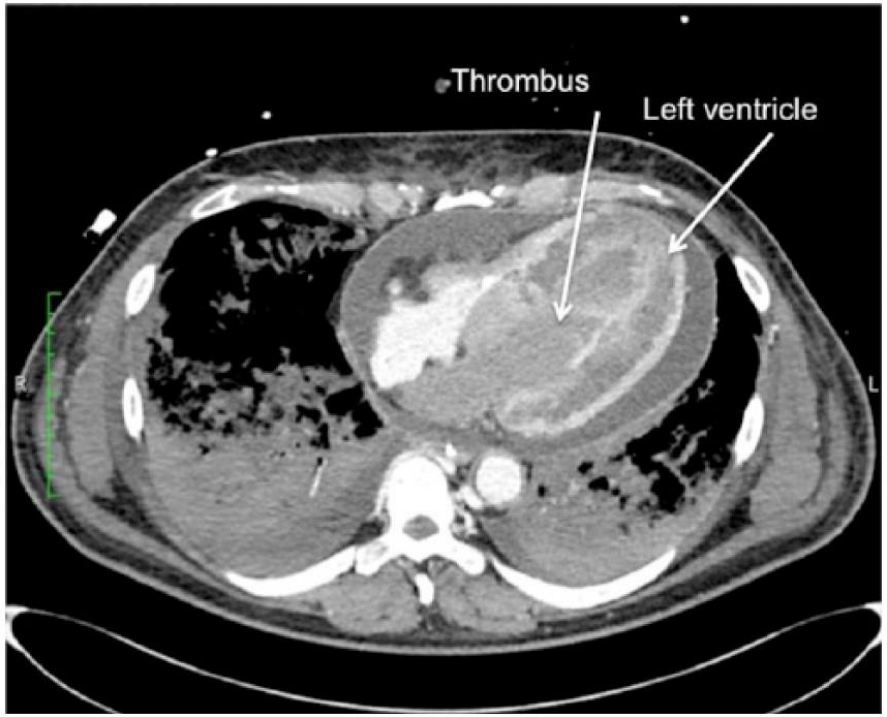
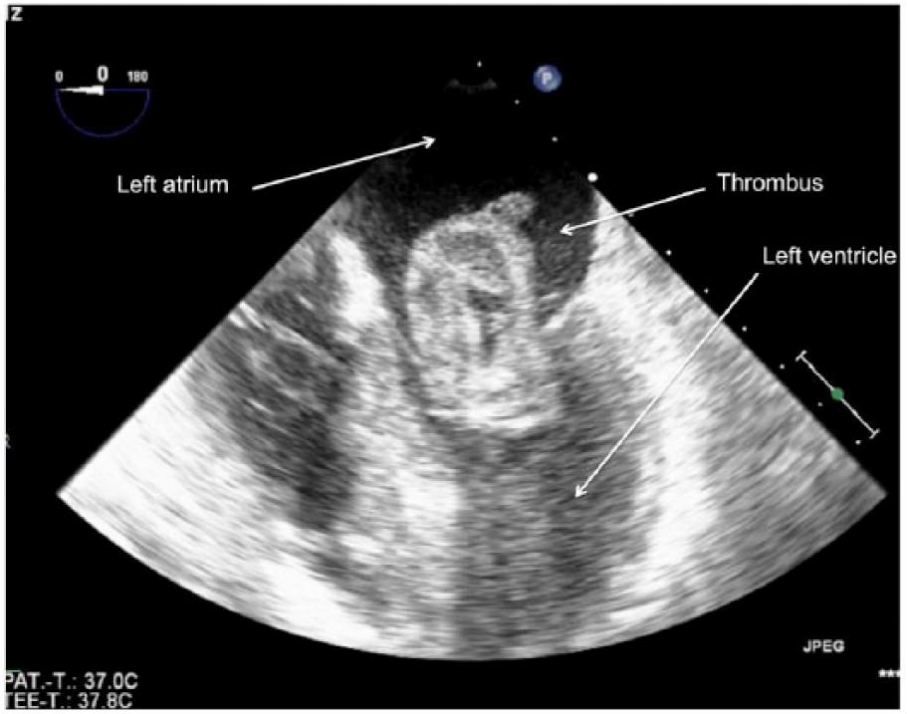



*Perfusion. 2018;33(4):283-288.*

# Indications of LV Decompression

- No obvious ejection & closed AoV
- Refractory pulmonary edema
- Distended LA/LV with ↑ LAP/LVEDP
- Pulmonary hemorrhage
- Significant AR
- LV thrombus d/t stasis
- Impaired RV function
- Insufficient LV unloading by ECMO circuit
- Elevated LV wall stress
- Severe or persistent LV dysfunction

# LV Decompression during VA-ECMO

- Reduce ECMO speed
- Inotropes
- Afterload reduction
  - Vasodilators (e.g., nitroprusside)
  - IABP

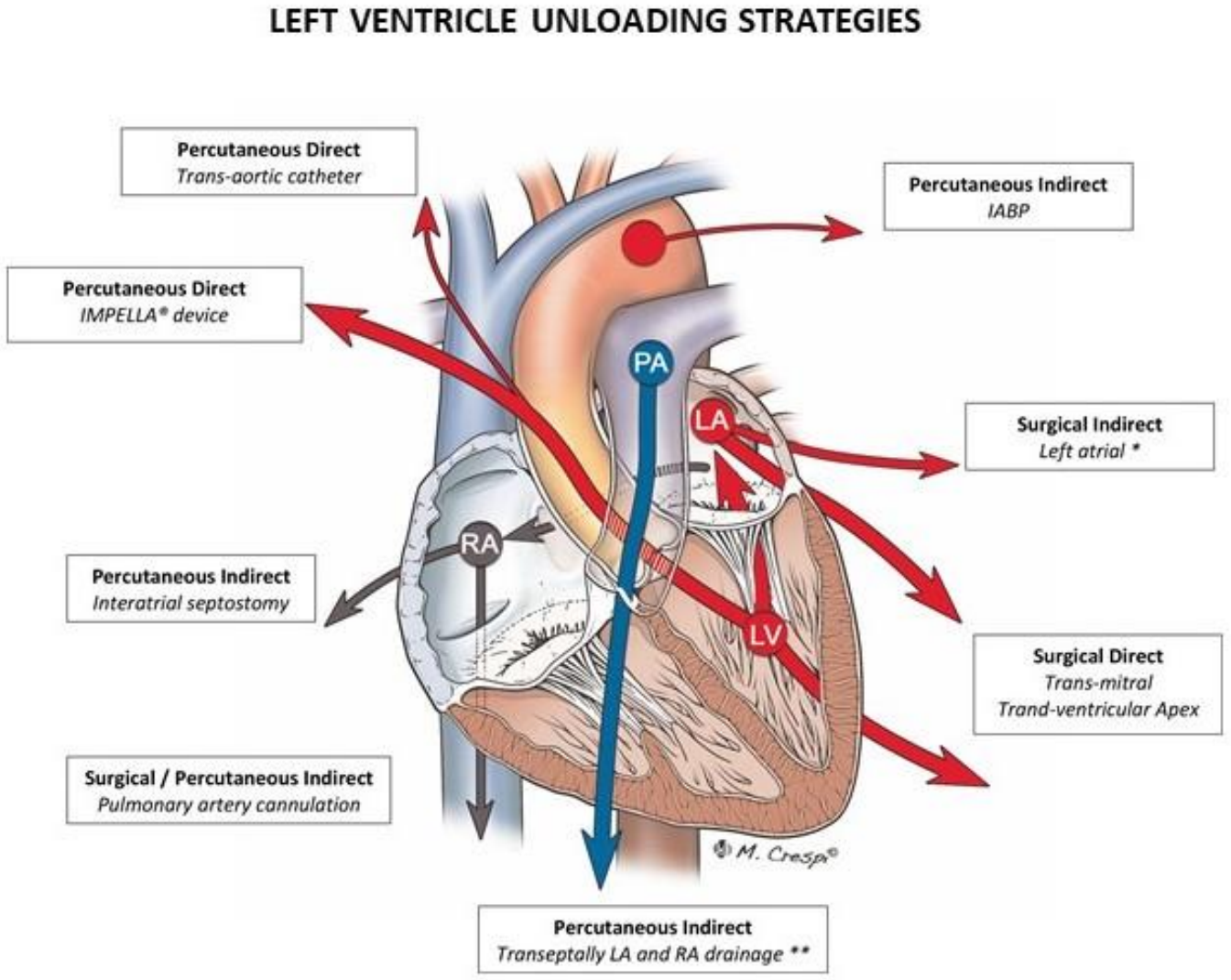
- ***Mechanical LV decompression***

# LV Decompression during VA-ECMO

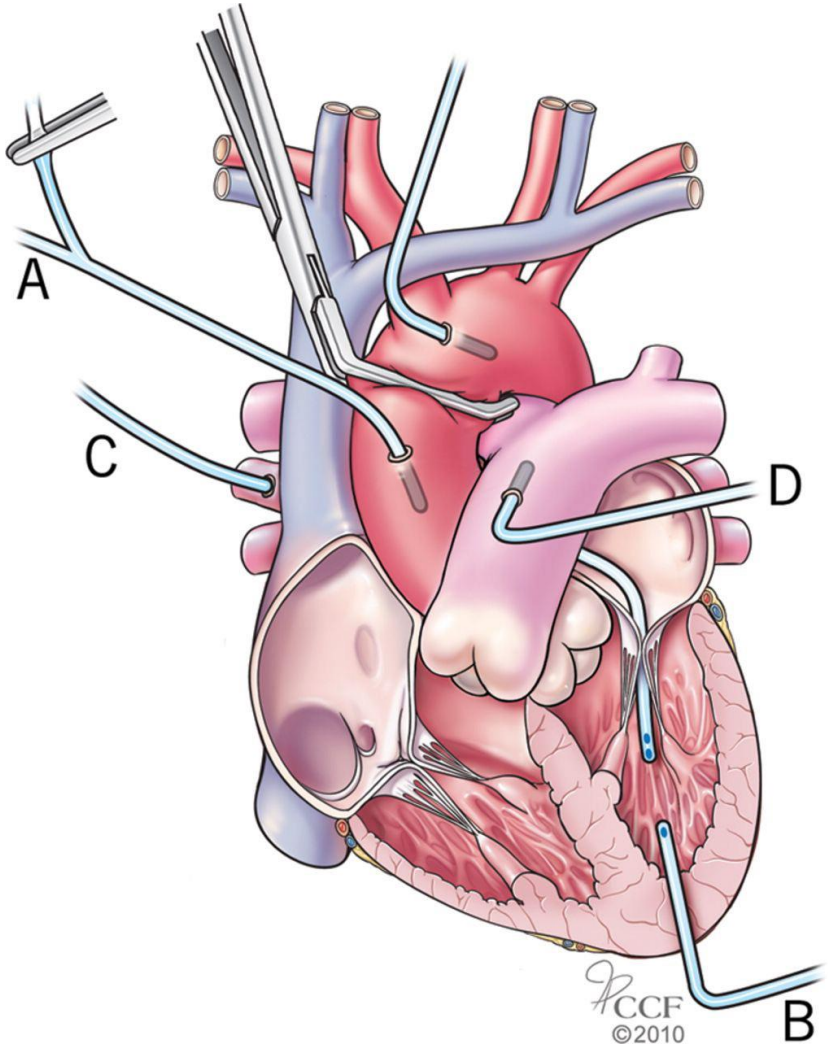
- **Mechanical LV decompression**

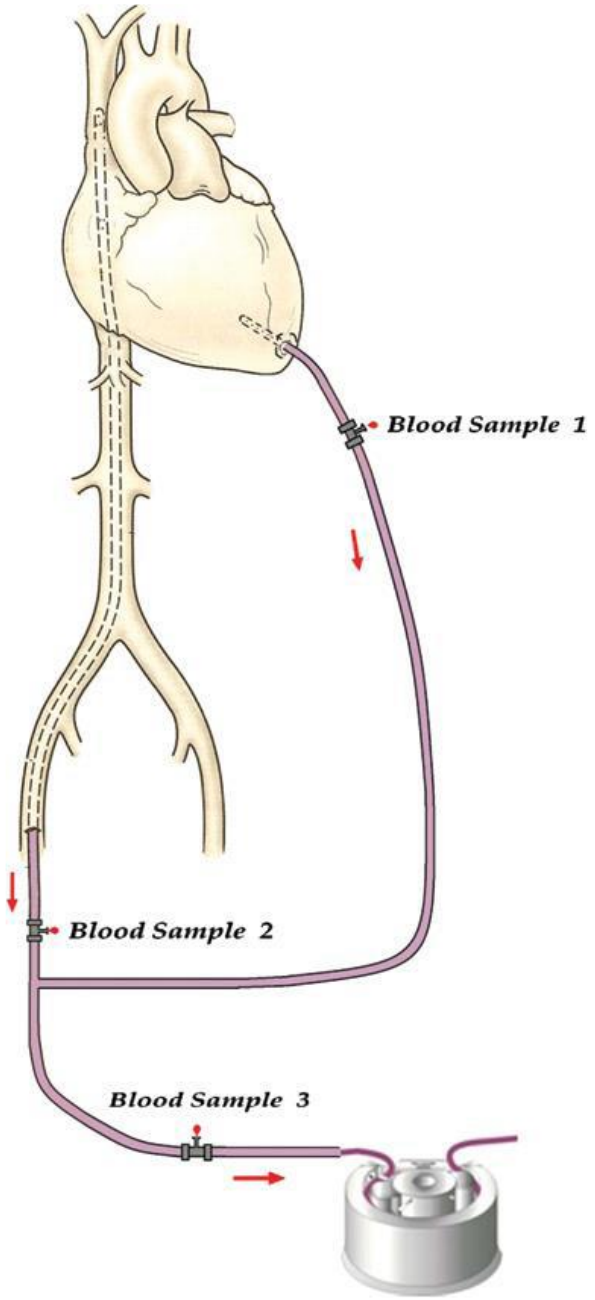
- *Surgical*
  - LA or LV venting
  - Pulmonary a. or v. venting

- *Percutaneous*
  - Trans-septal venting
  - LA or LV venting
  - Trans-aortic venting: Impella

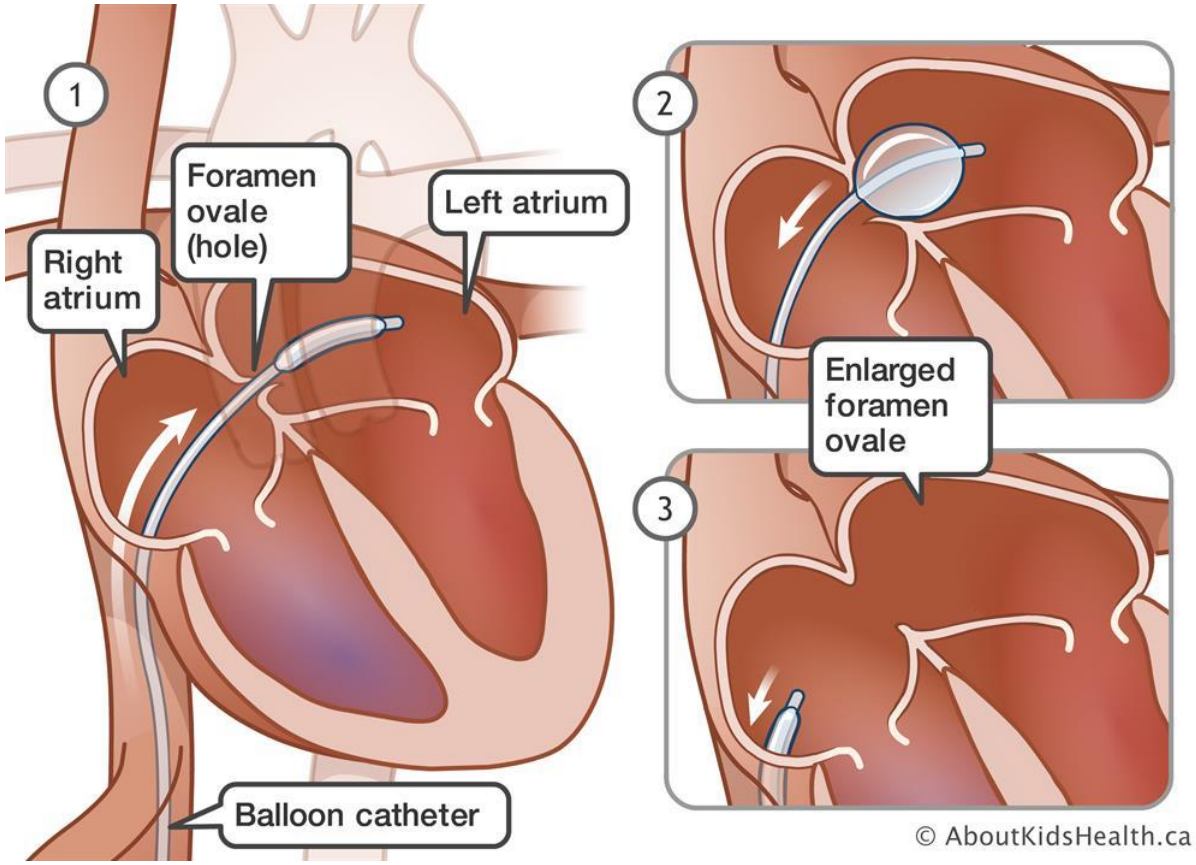


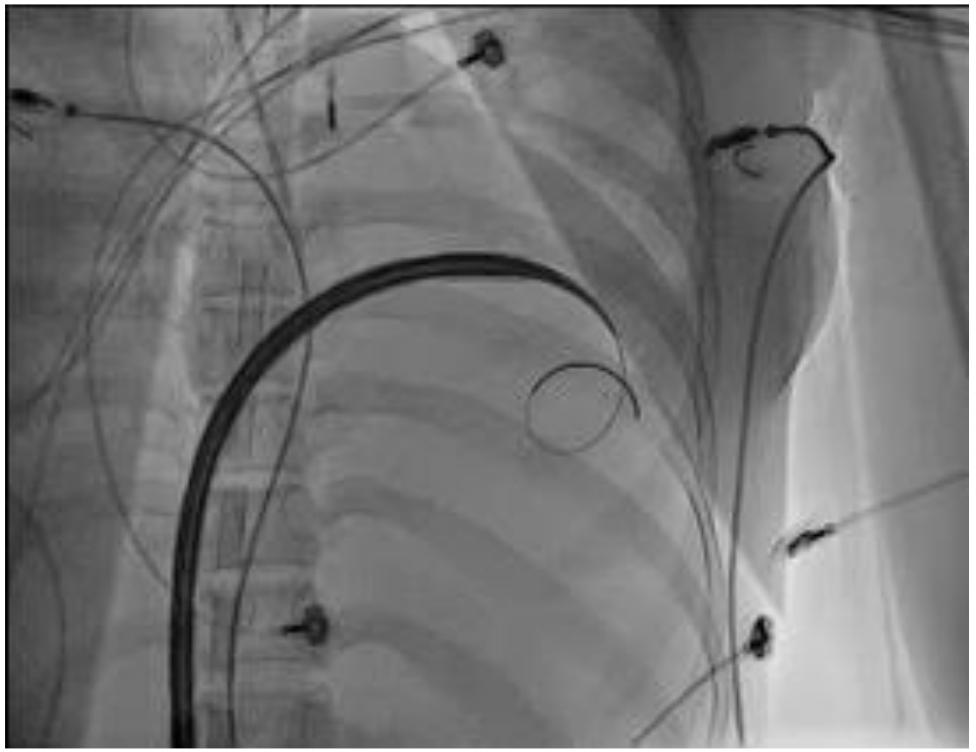
# Surgical Venting



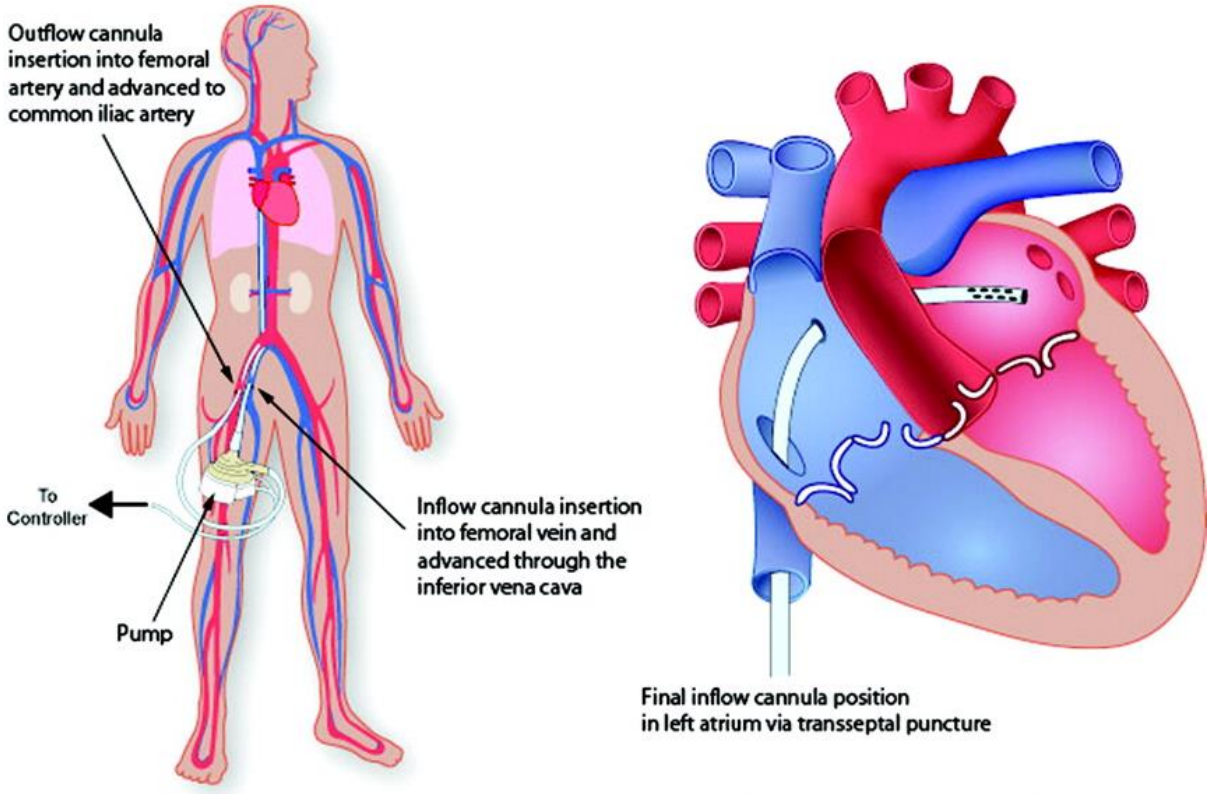



# Percutaneous Venting

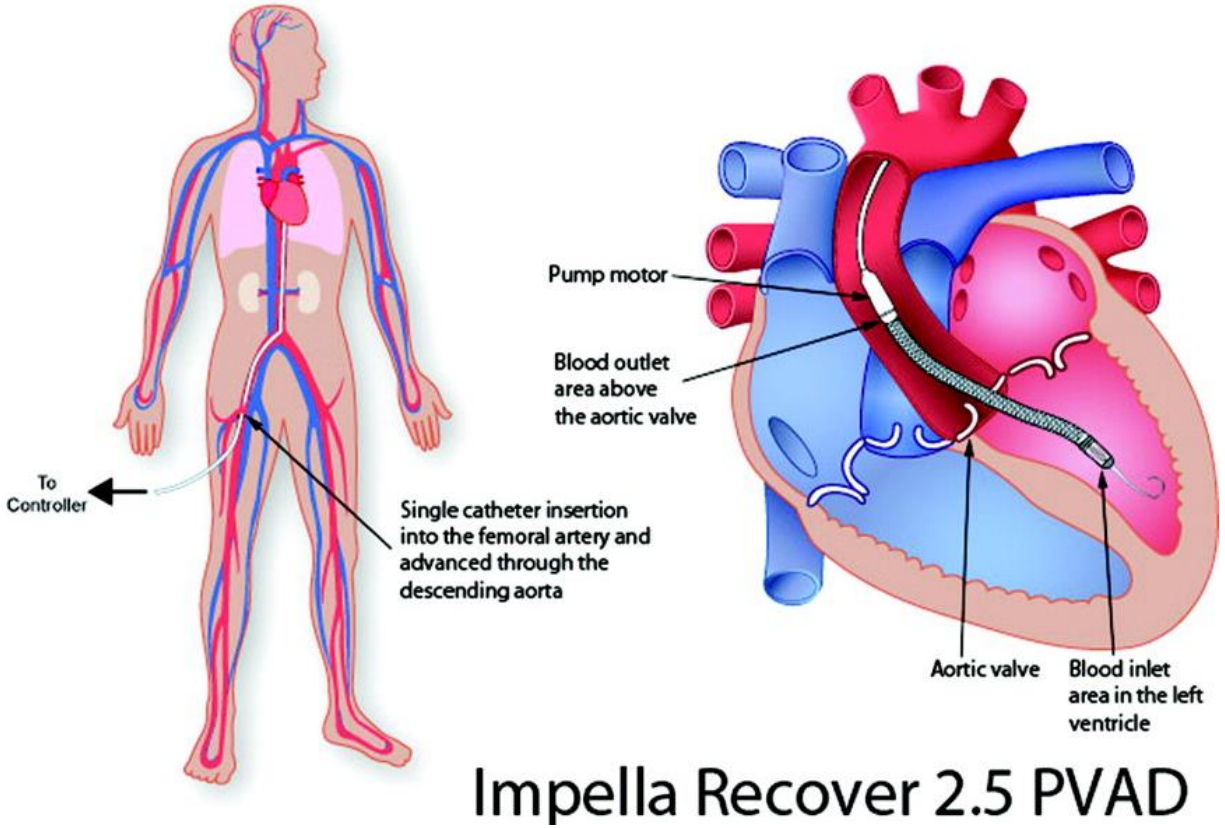


# Percutaneous Venting



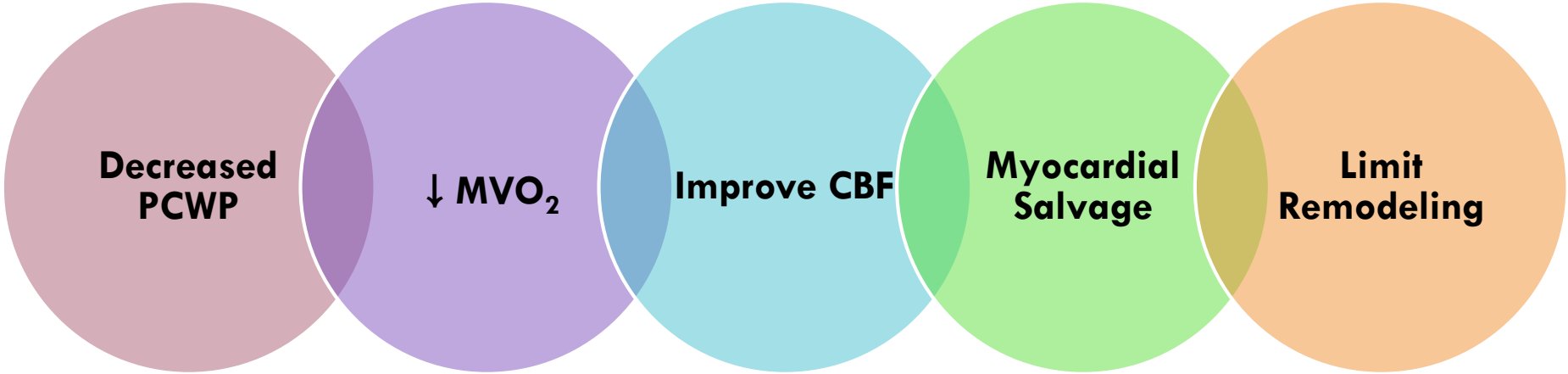

TandemHeart PVAD

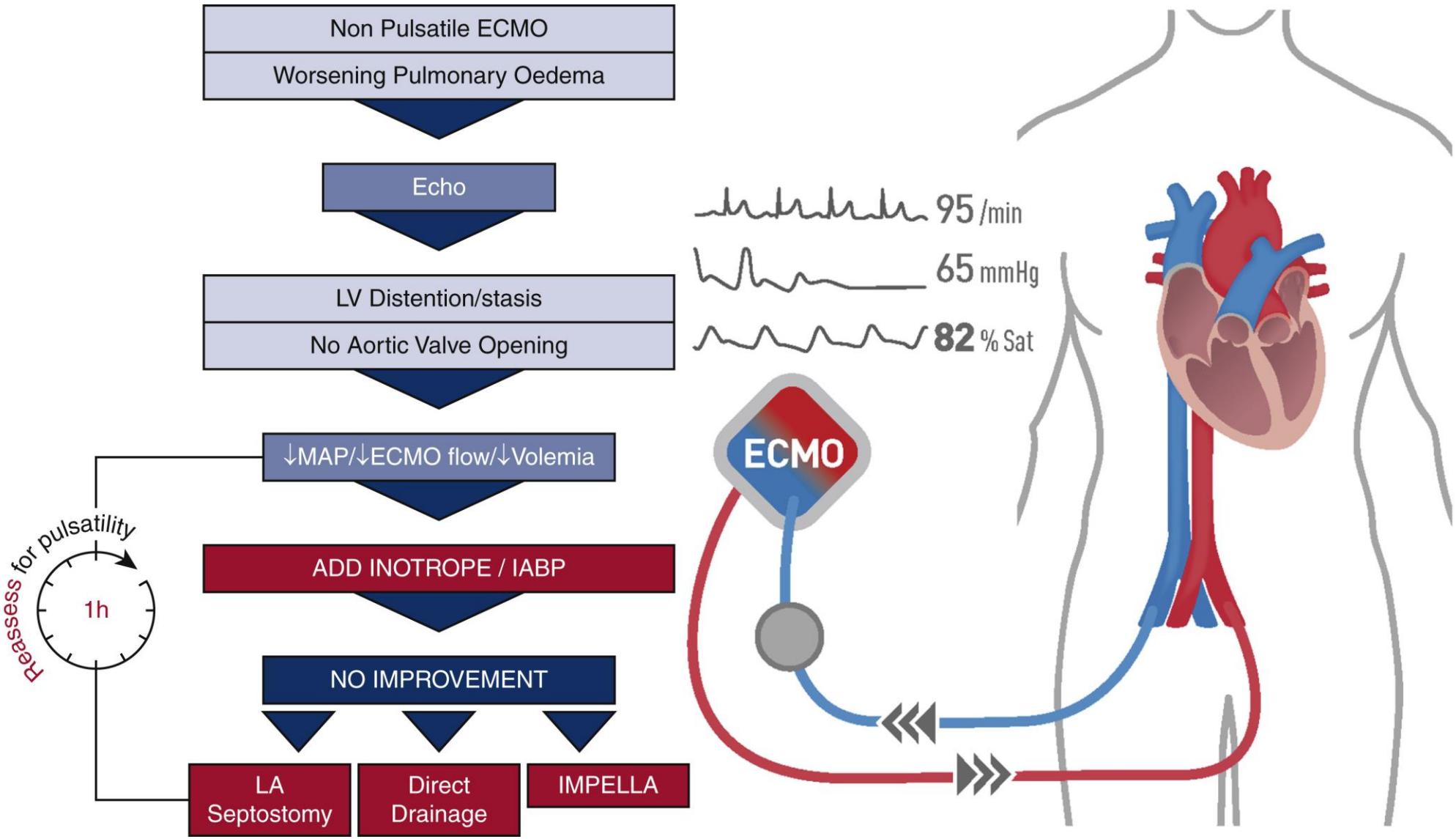



Impella Recover 2.5 PVAD

# LV “Unloading”

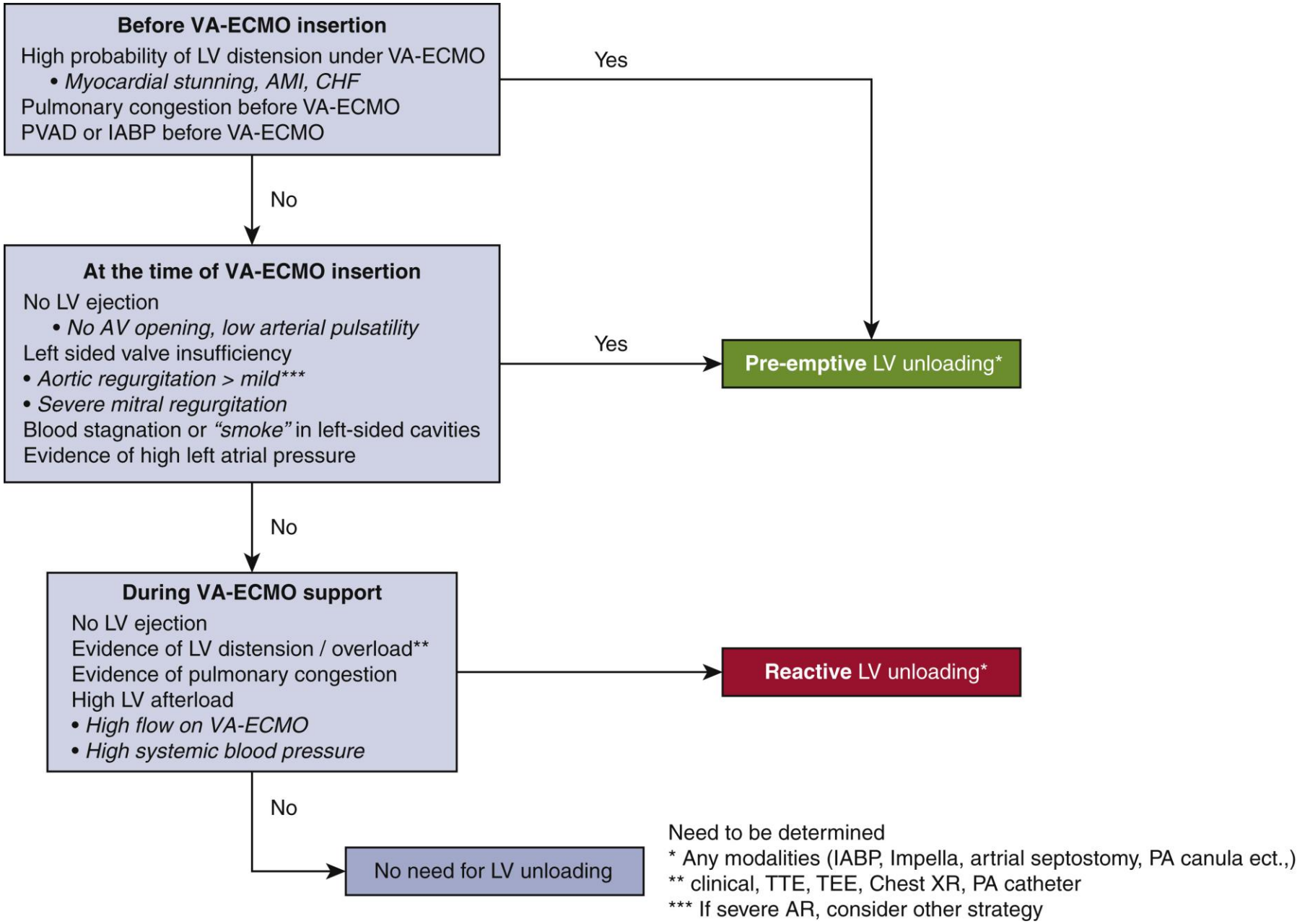
- Reduction of total mechanical power expenditure of the ventricle
  - ↓ $MVO_2$
  - ↓Hemodynamic forces that lead to ventricular remodeling



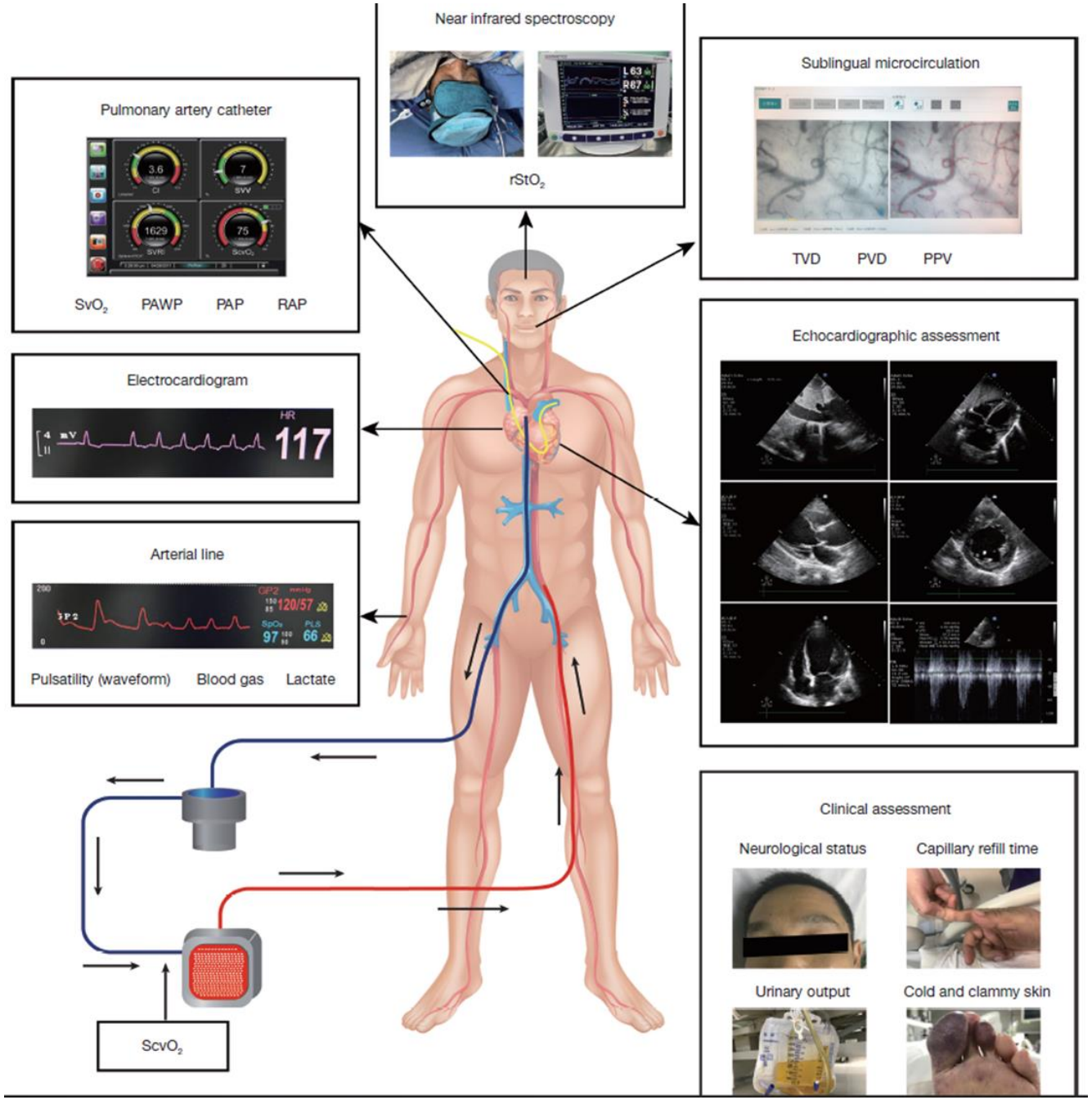



*JTCVS Open. 2021 Oct 19;8:70-76*

JTCVS Open. 2021 Oct 19;8:70-76

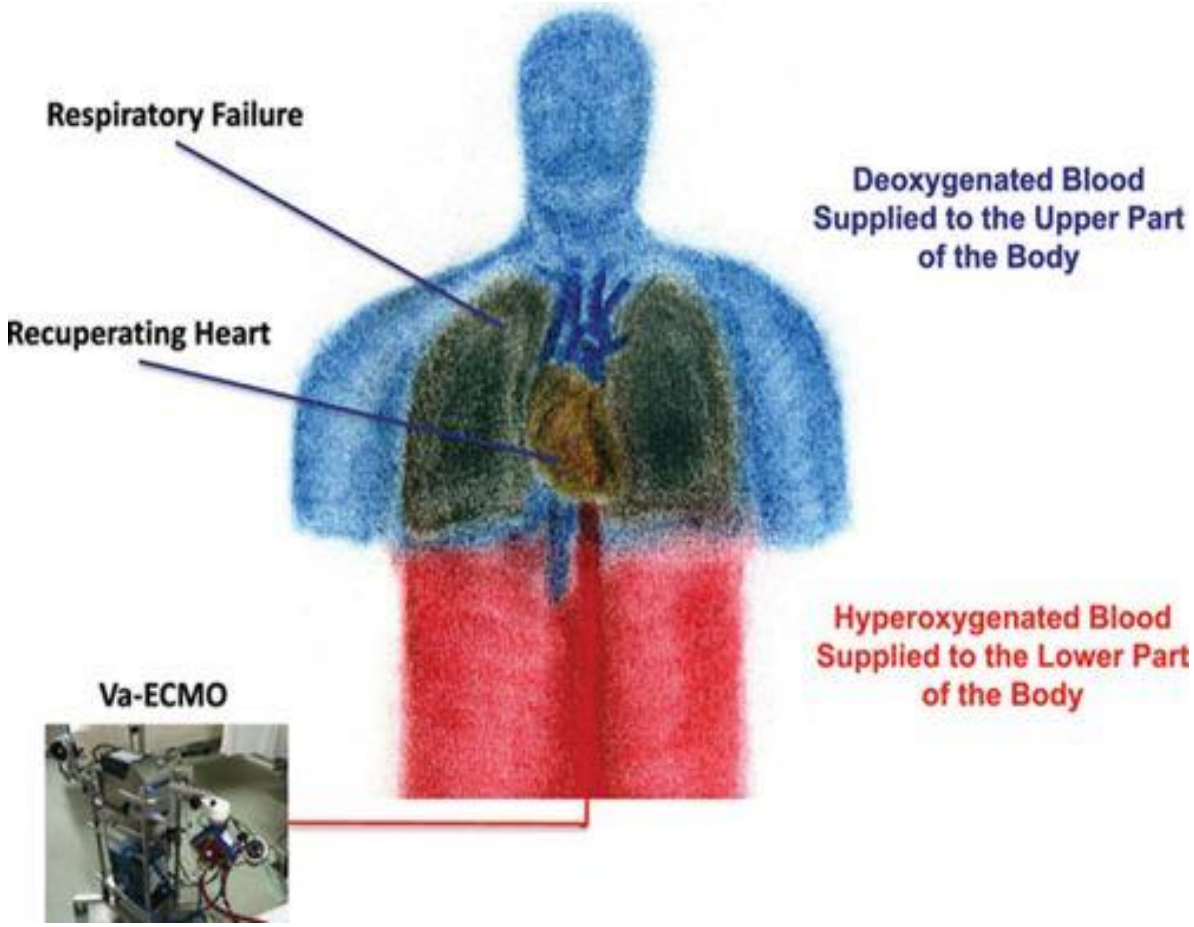


# Monitoring in VA-ECMO



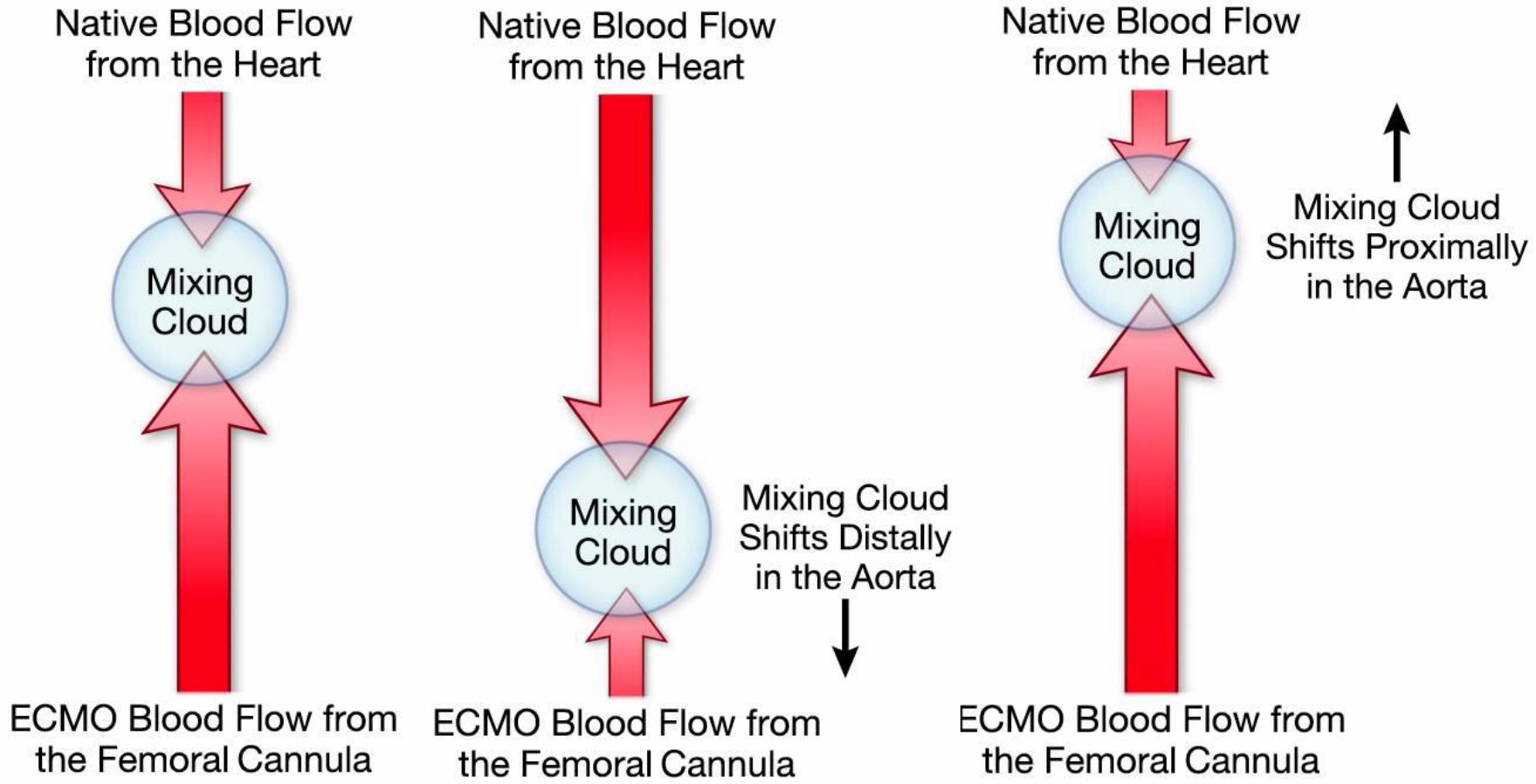

*Ann Transl Med. 2020 Jun; 8(12): 792.*

# Harlequin Syndrome



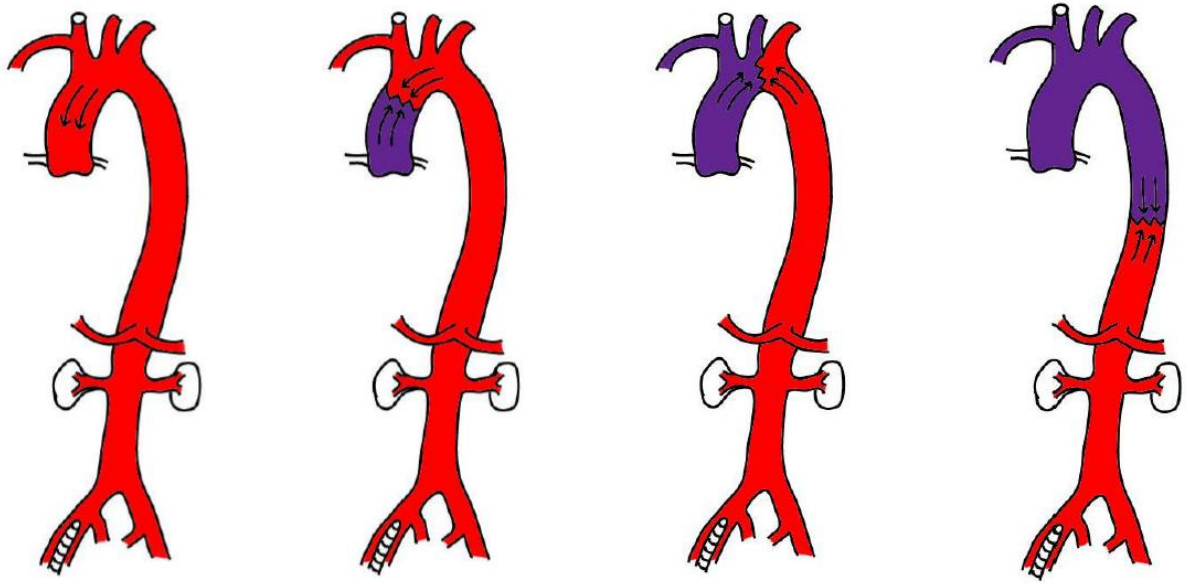

Circulation
Volume 130, Issue 13, 23 September 2014; Pages 1095-1104

# Mixing Cloud in VA-ECMO




# Differential Hypoxia

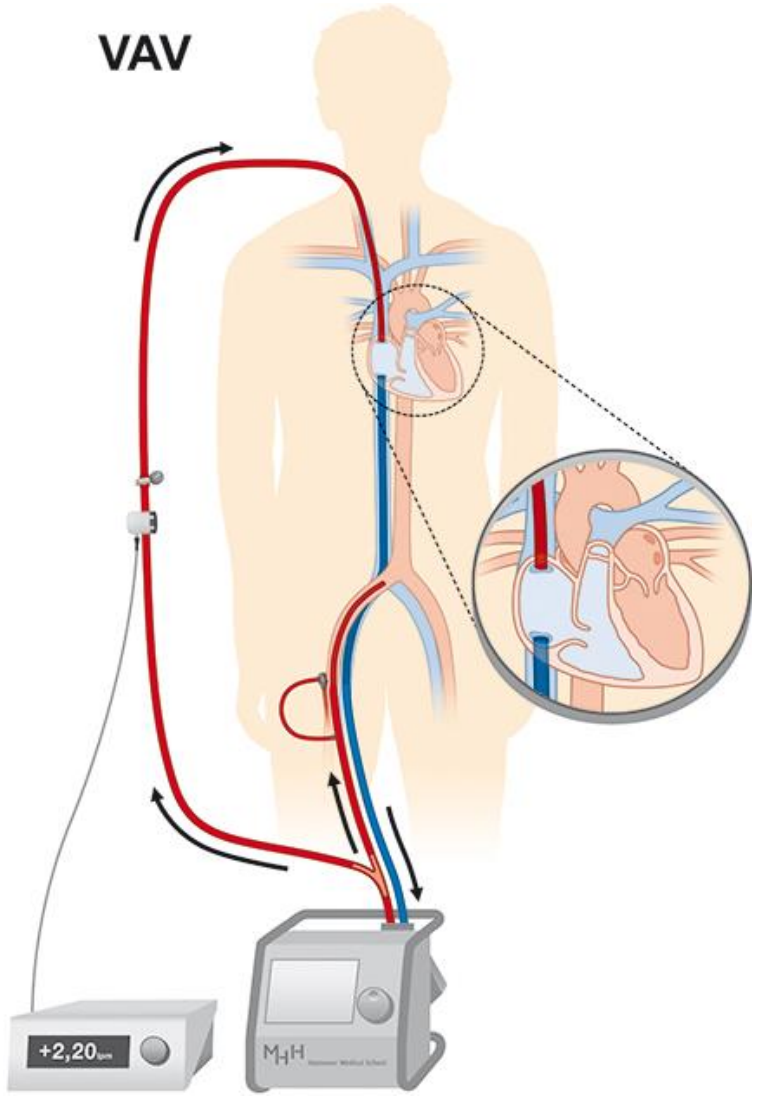
- Flow competition in the Aorta
  - Blue head vs. Red legs
- Monitoring
  - $SpO_2$ probe: Rt. hand or Rt. earlobe
  - ABGA sampling: Rt. radial artery
- Management
  - Adequate mechanical ventilation – add NO gas
  - Conversion to Central or V-AV ECMO
  - Weaning to VV ECMO



# V-AV ECMO

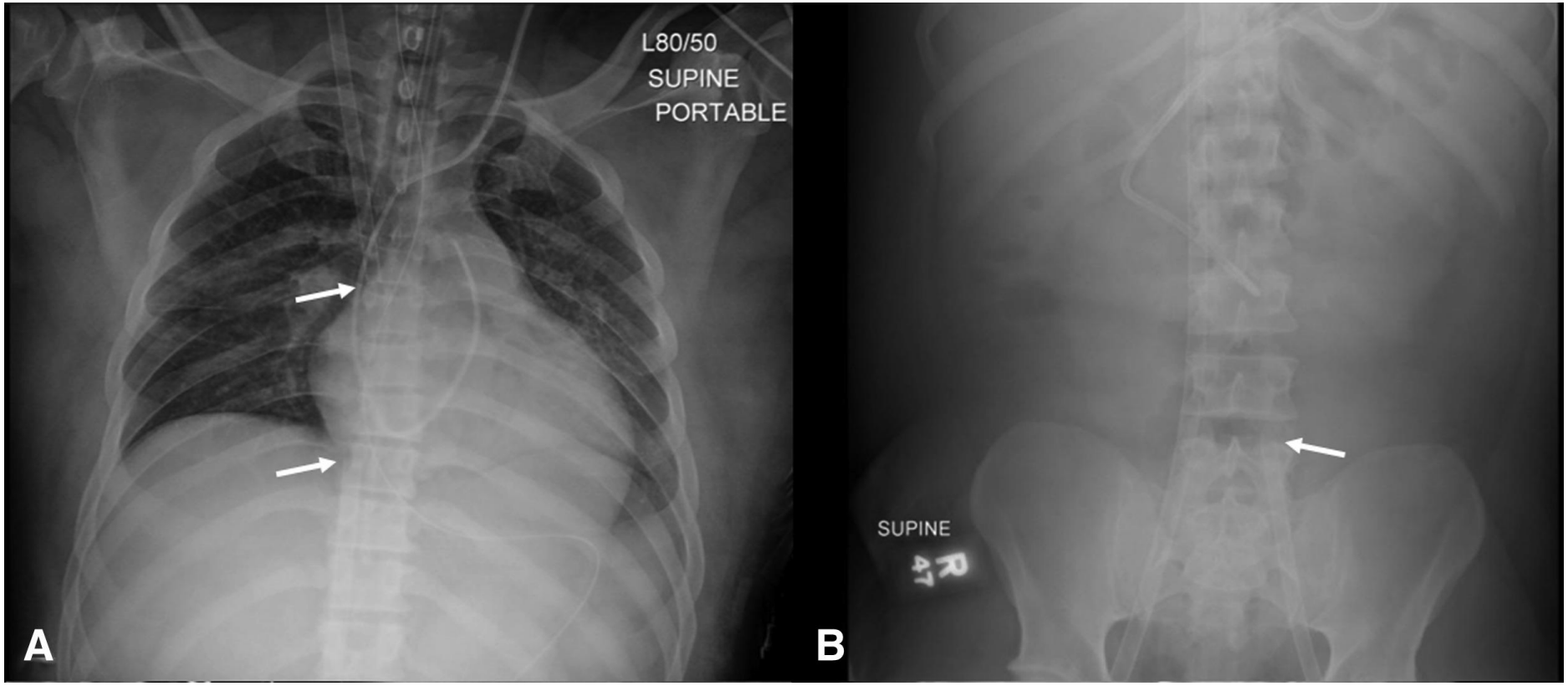
- **Venous return flow**
- 10% of total flow
  - Improvement in LV oxygen tension
- 30% of total flow
  - Mean LV saturation 74% → 94%
- 0 → 1.5L /min
  - Mean Ao. Saturation 81% → 99%

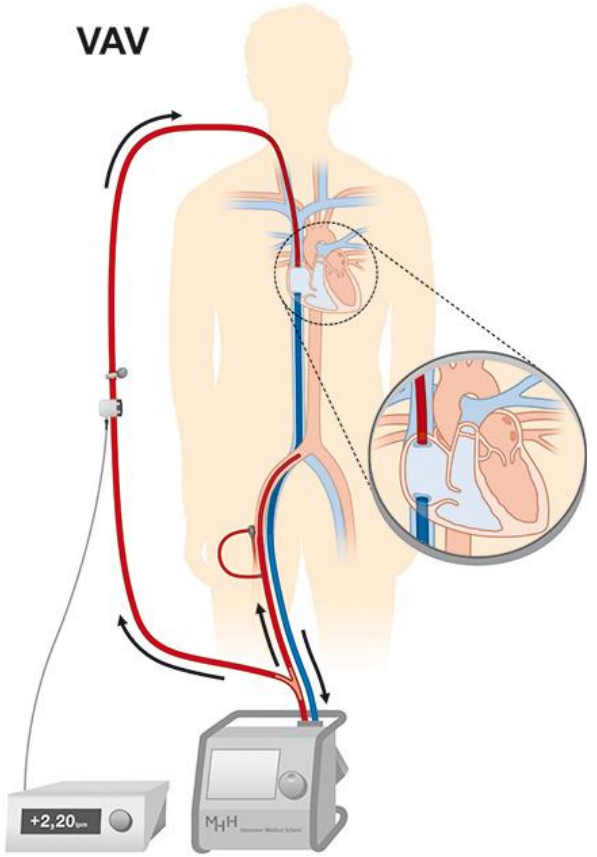
- Maintain flow > 1.5-2L/min
  - Minimize thrombus formation




*JTCVS Tech. 2021 Feb 24;8:77-85.*

# V-AV ECMO



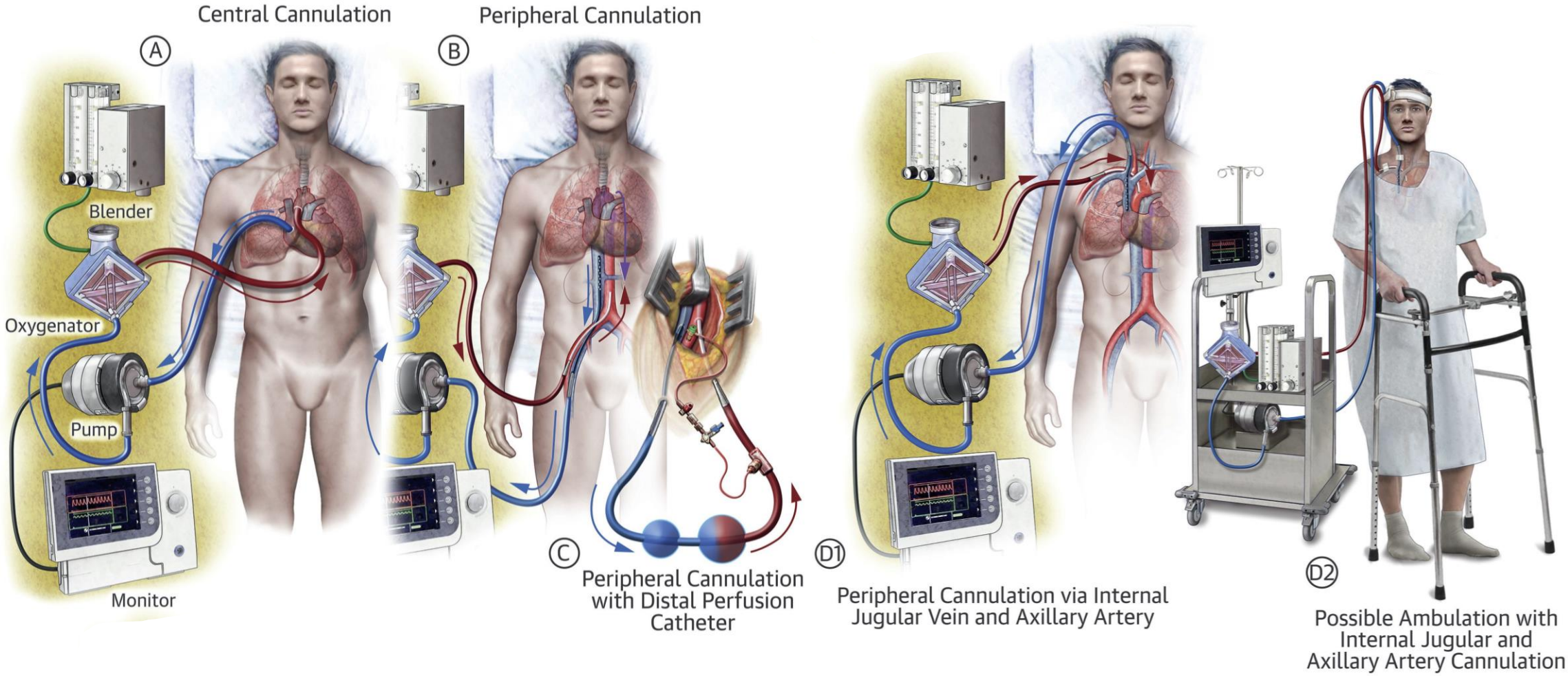




**Venous drainage – Venous Perfusion cannula**
**: 15cm apart to prevent recirculation**

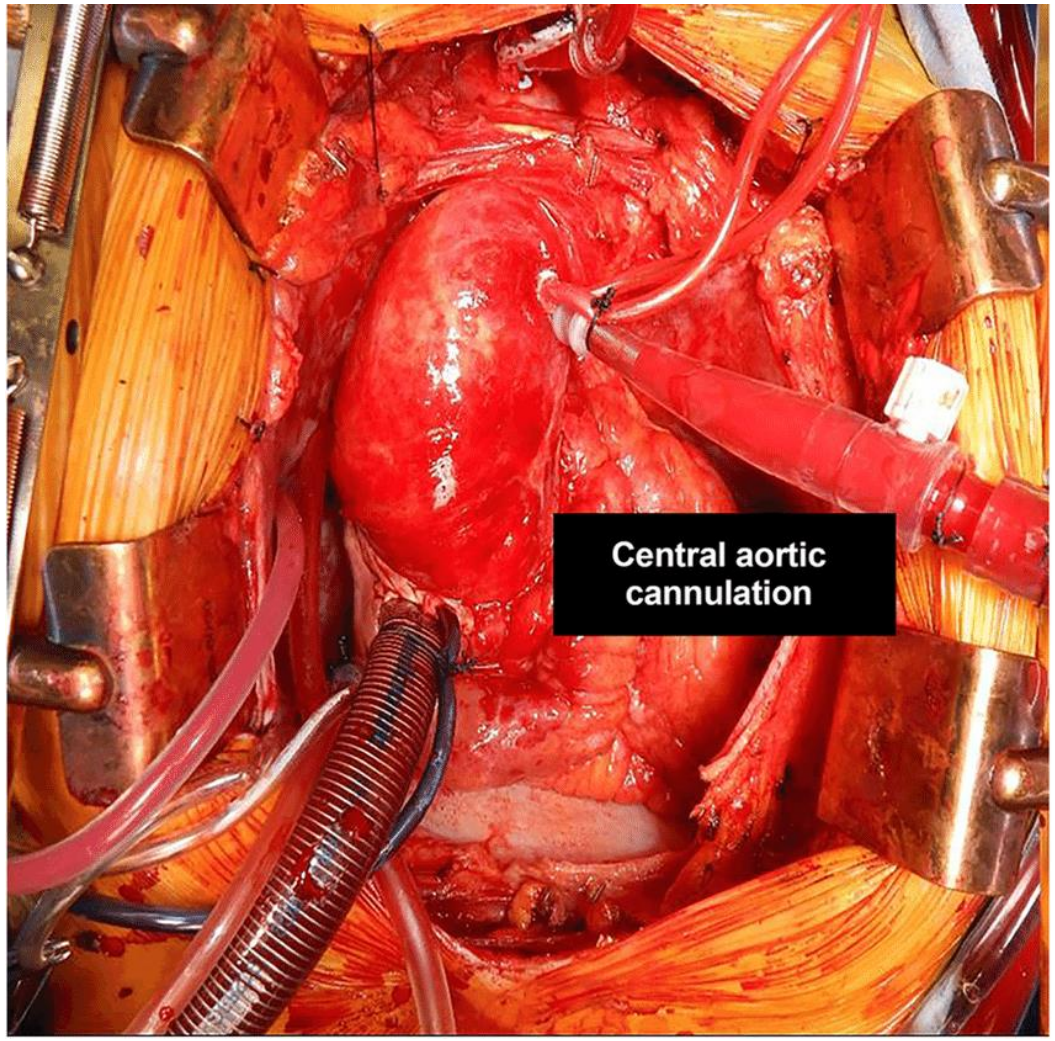
*JTCVS Tech. 2021 Feb 24;8:77-85.*

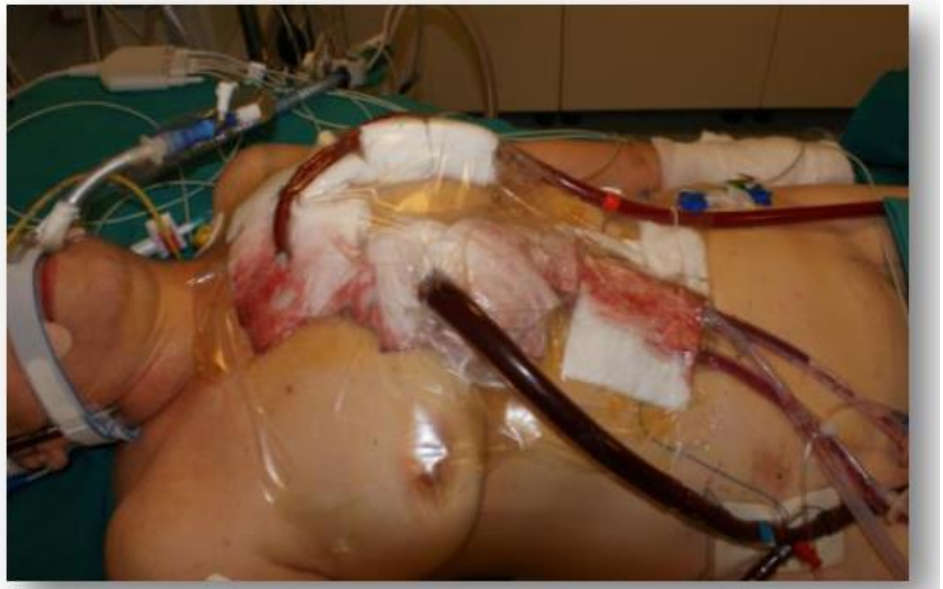
*JACC Heart Fail. 2018 Jun;6(6):503-16.*

# Cannulation Strategies

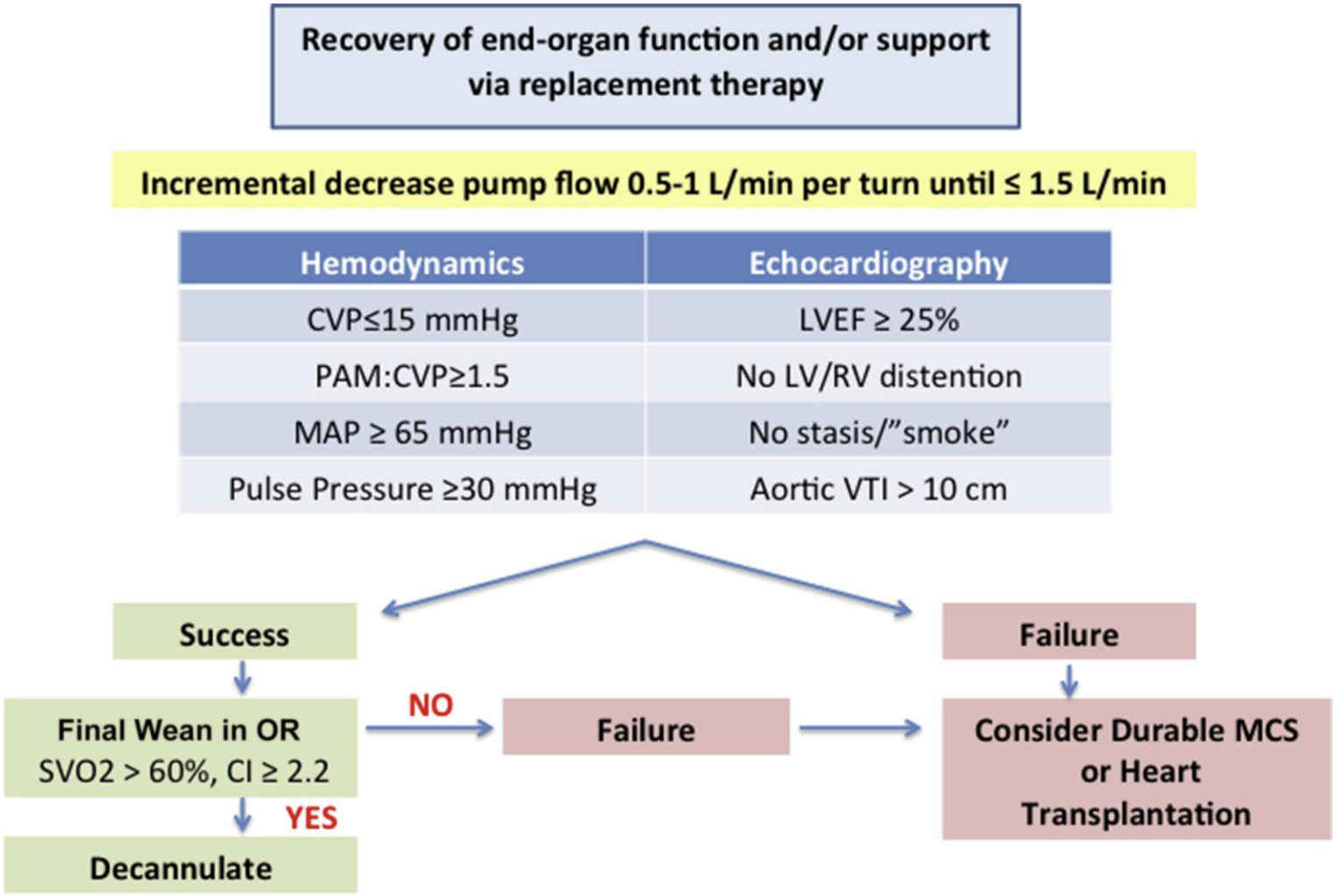


# Cannulation Strategies

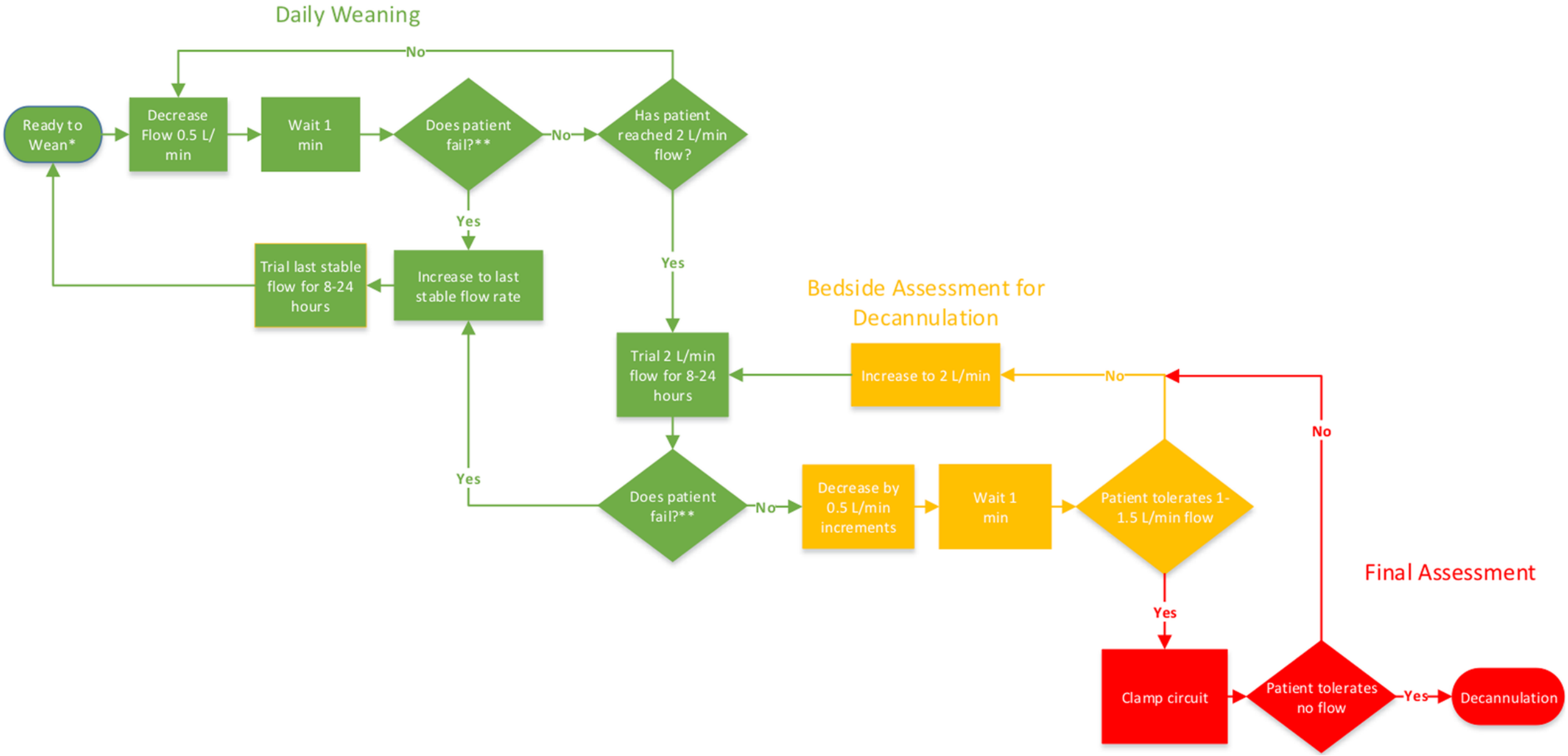


# Weaning from VA-ECMO




*JACC Heart Fail. 2018 Jun;6(6):503-16.*




*Crit Care. 2020 Jun 8;24(1):307.*


THANK
YOU