2019 대한내과학회 춘계학술대회

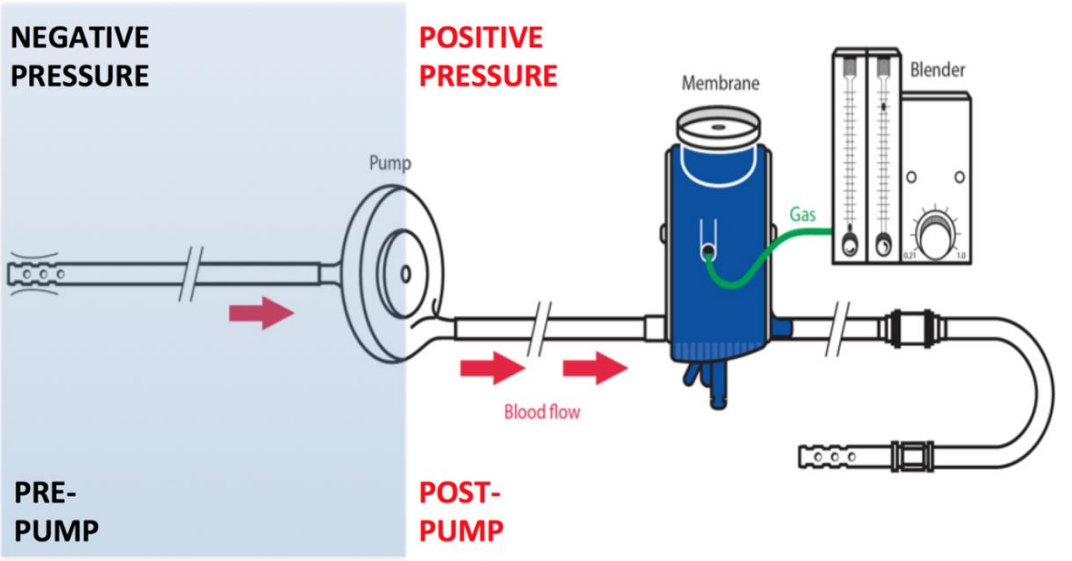
Management of ECMO

부산대학교병원
흉부외과
송승환

Nothing to declare…

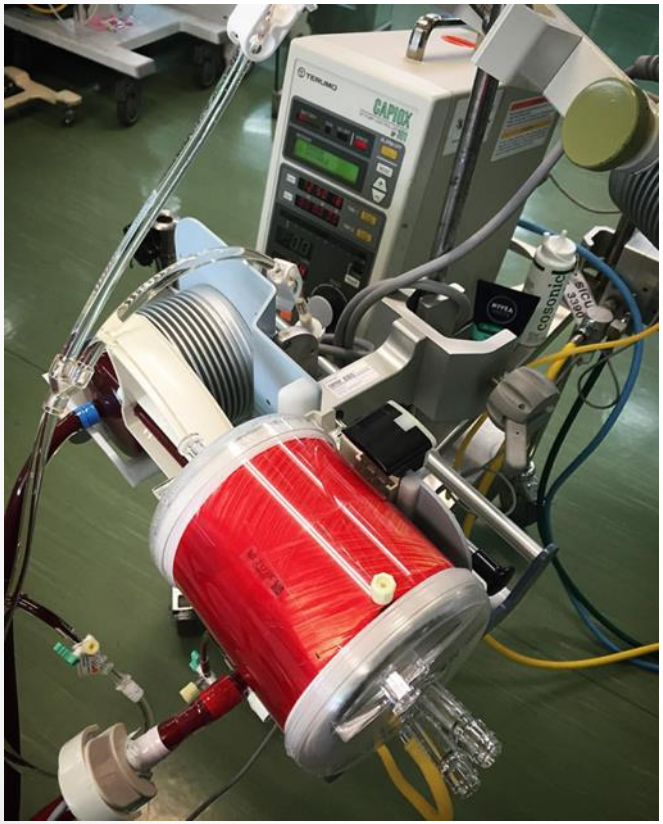
ECMO

- **E**xtra**C**orporeal **M**embrane **O**xygenation
- **ECLS**(ExtraCorporeal **L**ife **S**upport)



Devices

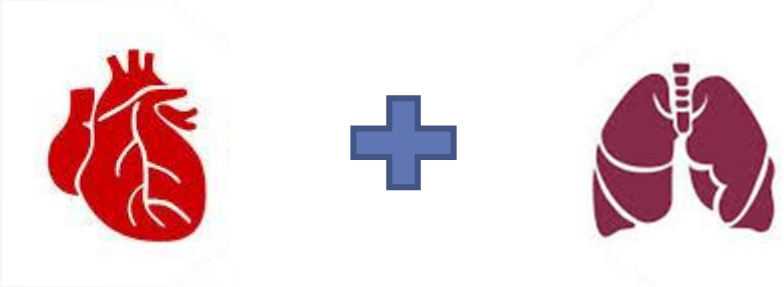
EBS



PLS

Configurations

Venoarterial

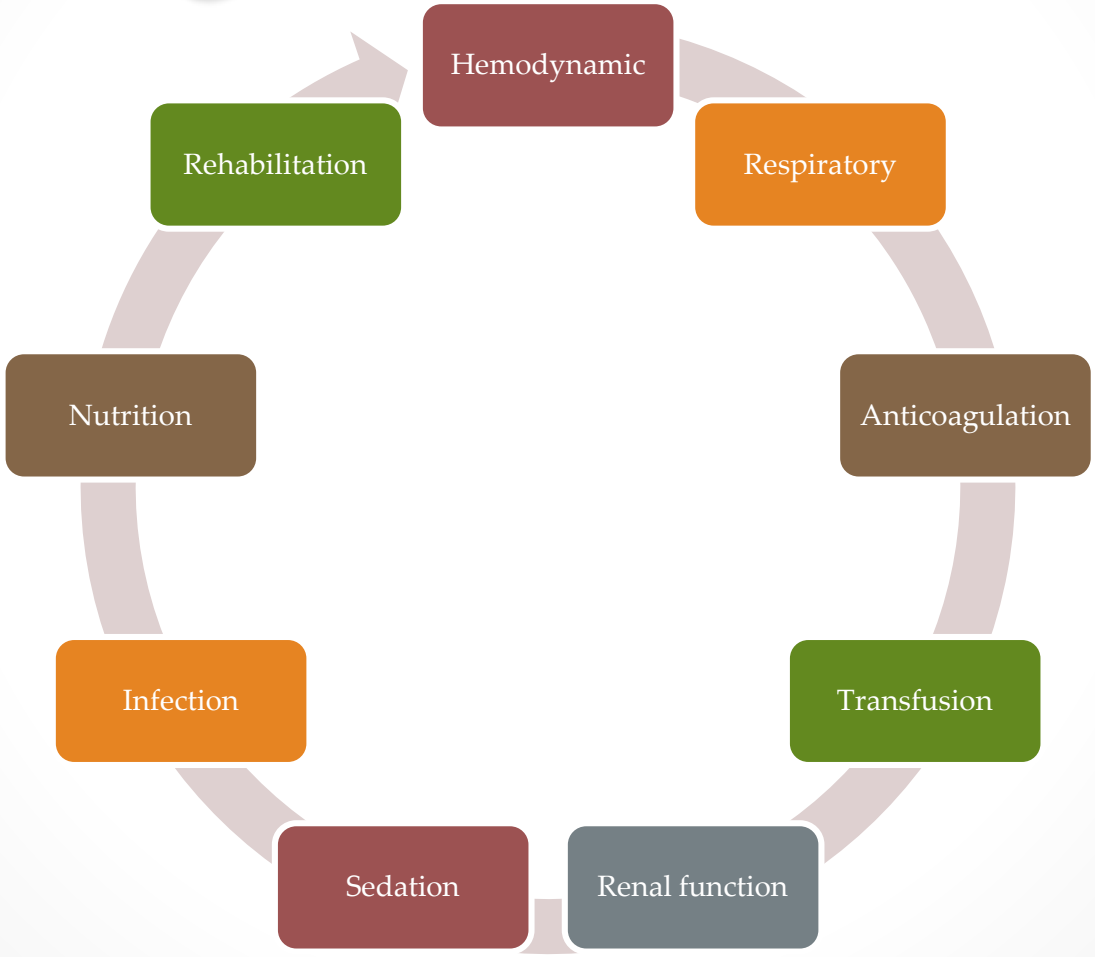


Venovenous

Circulatory support
With oxygenation

Role of ECMO

Management of ECMO



ECMO flow

- 적절한 flow ?
  1. Normal CI = CO / BSA = 2.4 – 4.0 L/min/m^2
  2. Adequate RPM

Flow 를 결정하는 인자

1. Pump speed
2. Size of cannula
3. Position of cannula
4. Patient blood volume

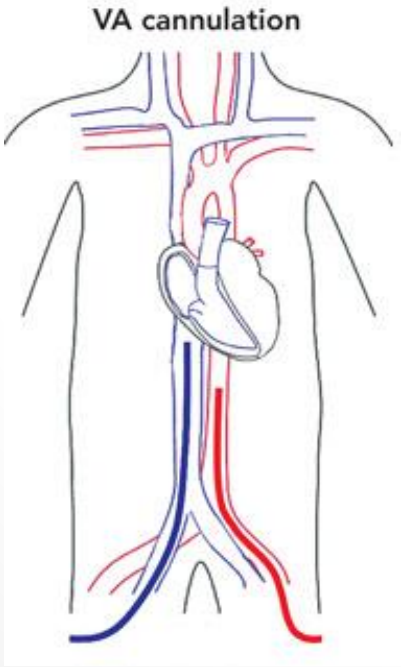
Line Chattering

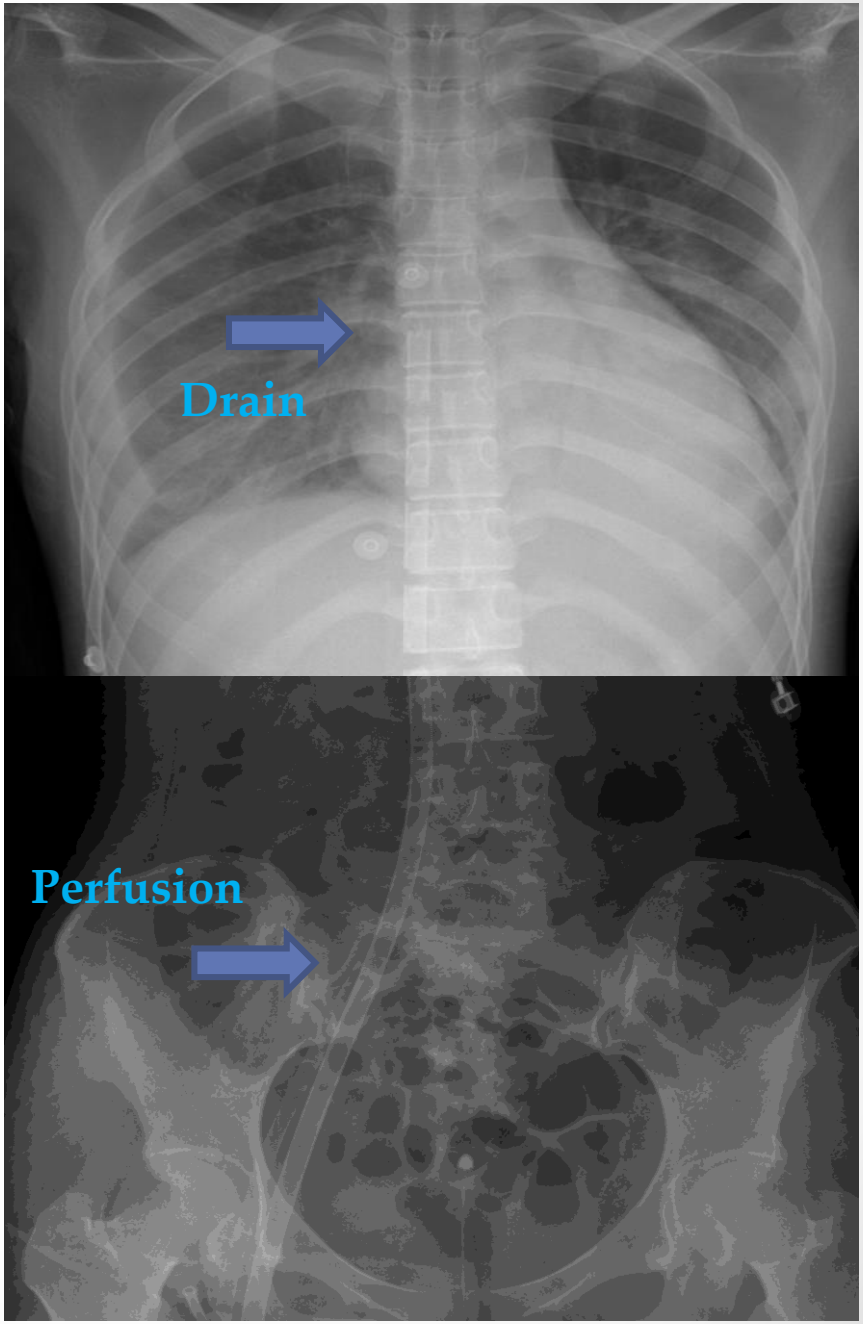
- High negative pressure
- Squeeze blood cells – hemolysis

- Cannula position
- Patient's **low** blood volume

VA ECMO

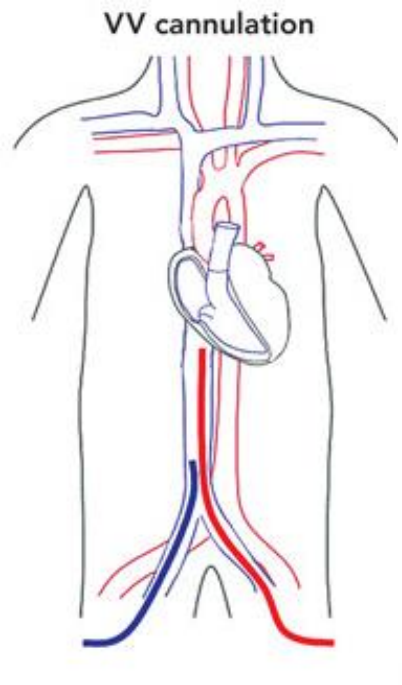
- Drain - **FV**, IJV, RA
- Perfusion - **FA**, axillary artery, aorta

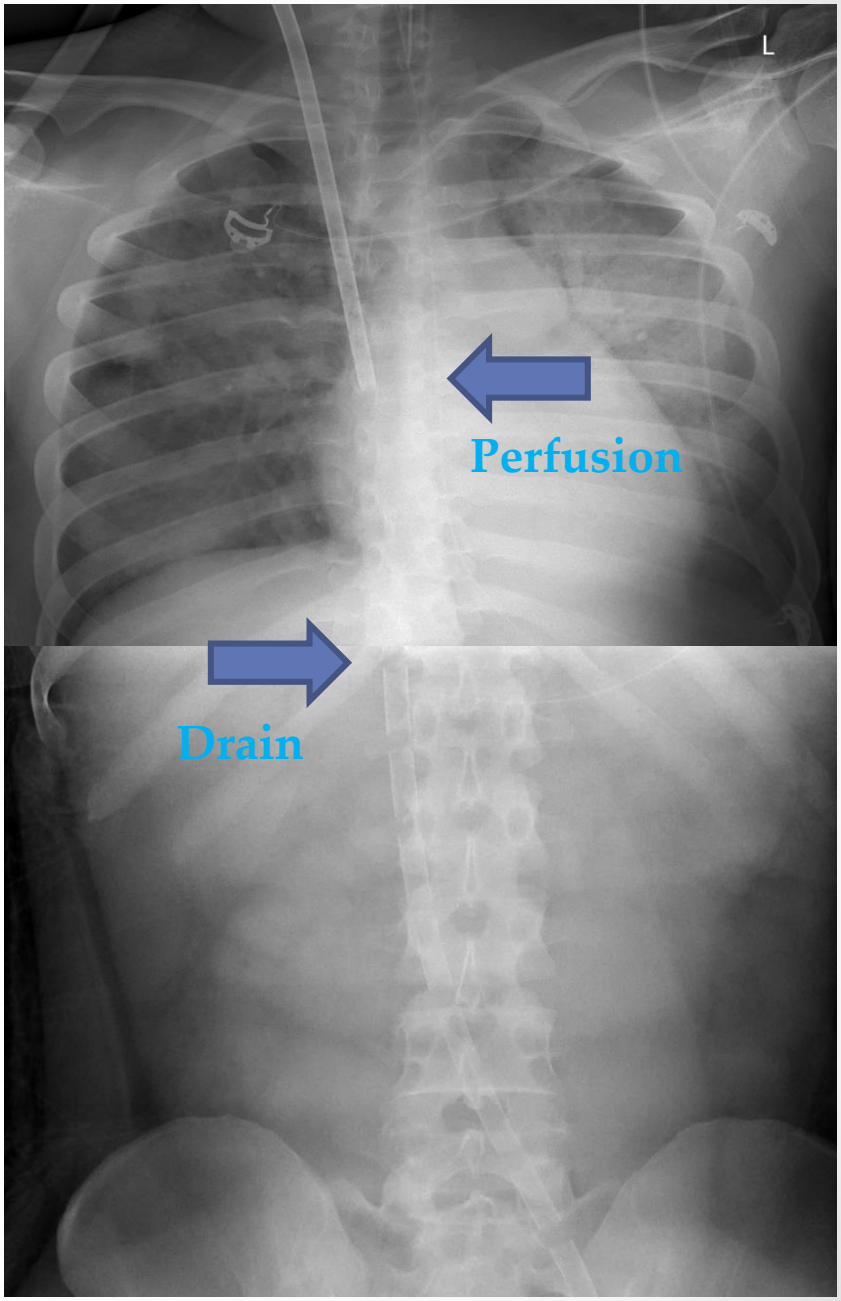




VV ECMO

- Drain **FV**
- Perfusion **FV, IJV**





Veno-venous ECMO

physiologic

"simply **elevate the oxygen** in central venous blood"

Hemodynamic

- Normal blood pressure
- Usually result in **decreasing vasopressor** and inotropic requirements
- **lung rest** -> reduction of intrathoracic pressure
- **Improved myocardial** oxygen delivery
- Maintaining **adequate preload** without concern of worsening lung function

Respiratory support

- **VILI**(ventilator induced lung injury)
- "**Lung protective**" parameters
  - Tidal volume ≤ 6ml/kg
  - Plateau airway pressures ≤ 30 cmH2O
  - PEEP(positive end expiratory pressure) 10 cmH2O
  - Respiratory rate 10~12 breaths per minute
  - FiO2 30 %, accepting PaO2 ≥ 45 mmHg
- Peripheral sat%: 85-92%

ECMO gas exchange

- Ventilator 와 유사
  - **Sweep gas flow** = minute volume

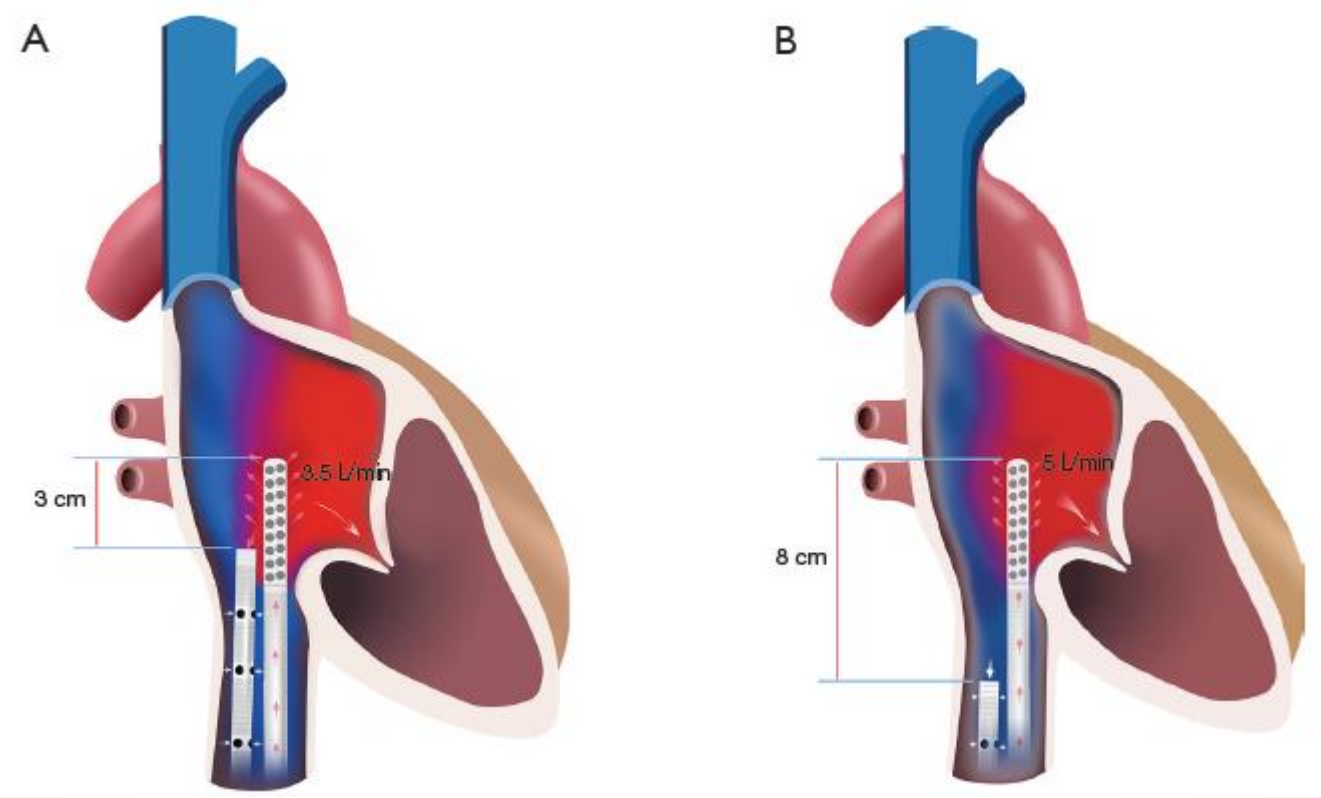
  CO2 clearance 관련
  - ECMO flow : sweep flow = 1:1
  - **FiO2** = ventilator FiO2

  O2 level과 관련

Gas exchange Monitoring

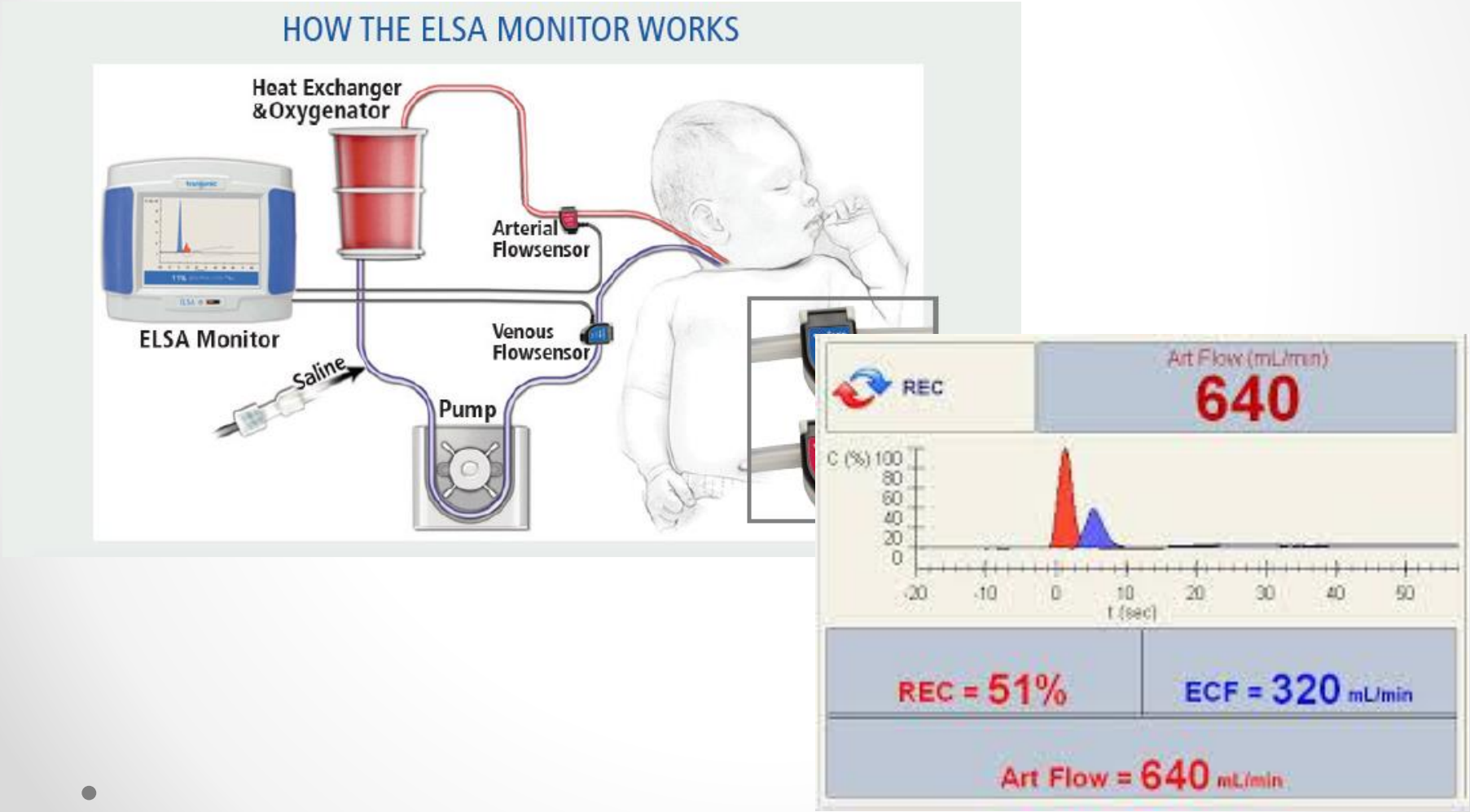
- **ECMO ABGA** = Oxygenator function 을 반영
- 항상 drain line vs perfusion line의 color 차이를 확인

Re-circulation

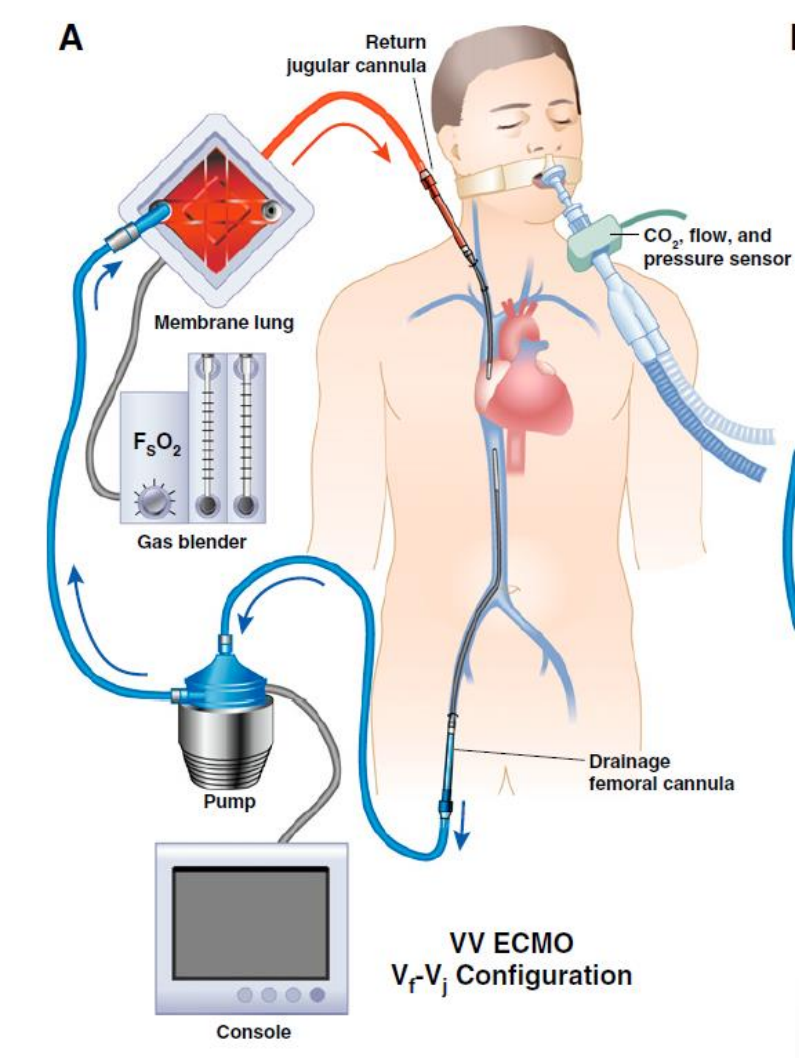


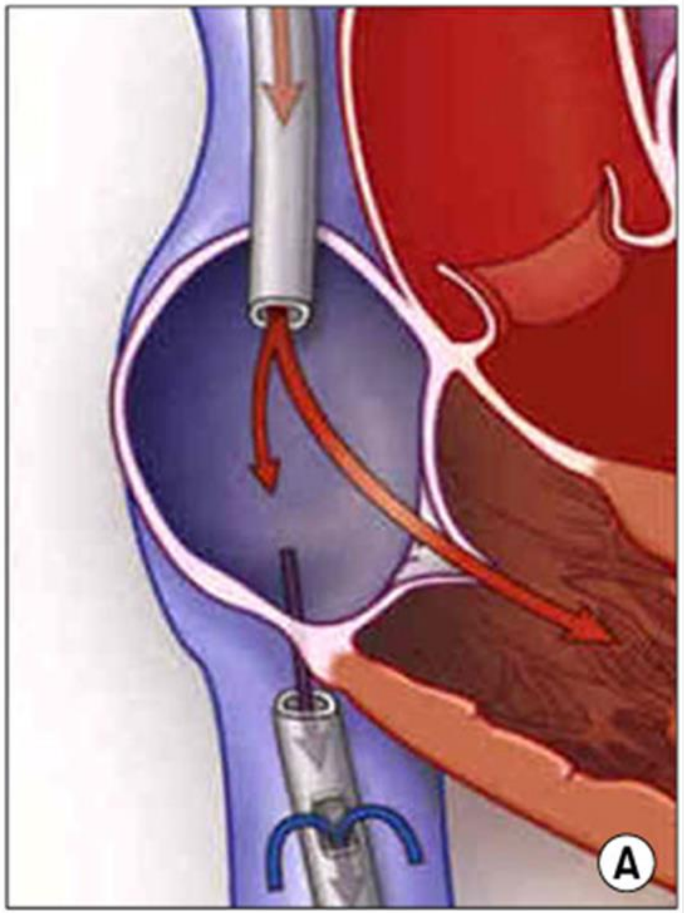
ELSA

(assurance)

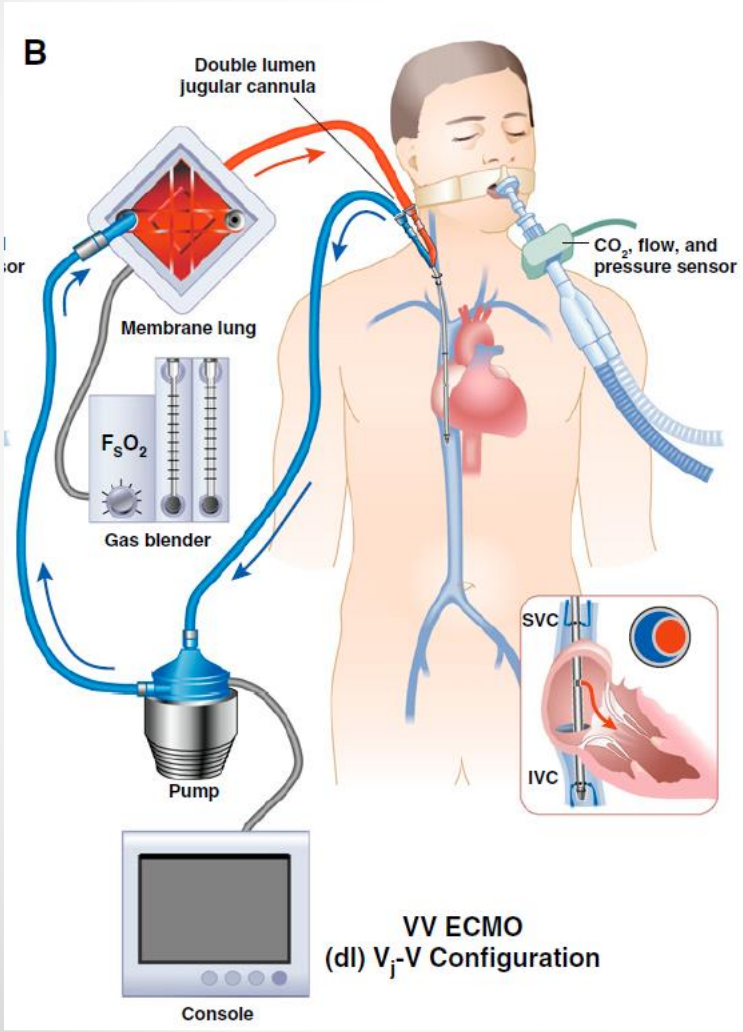


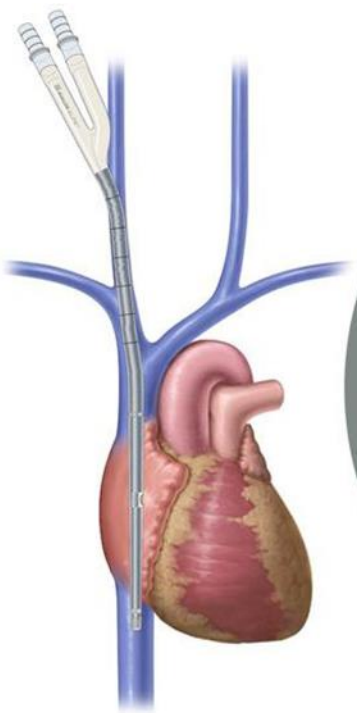
V_f-V_j configuration

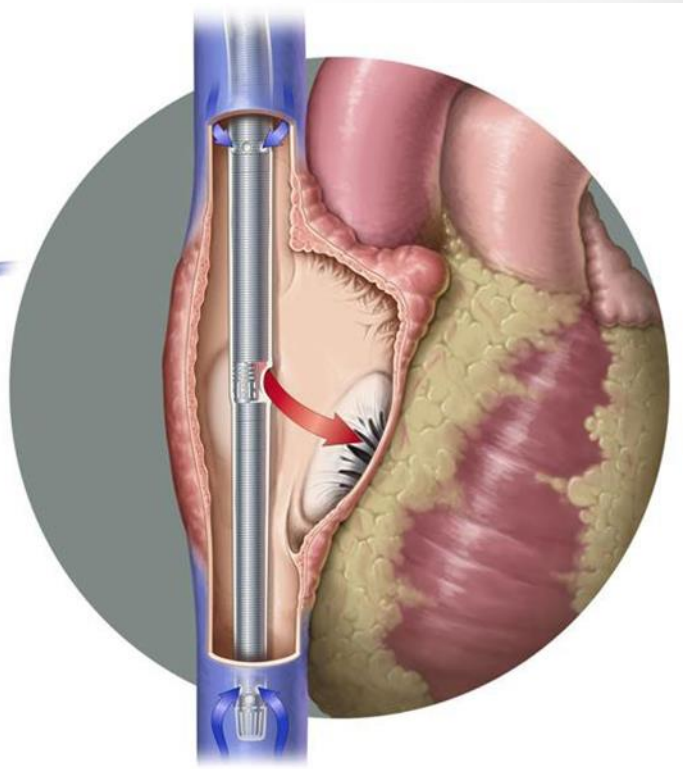




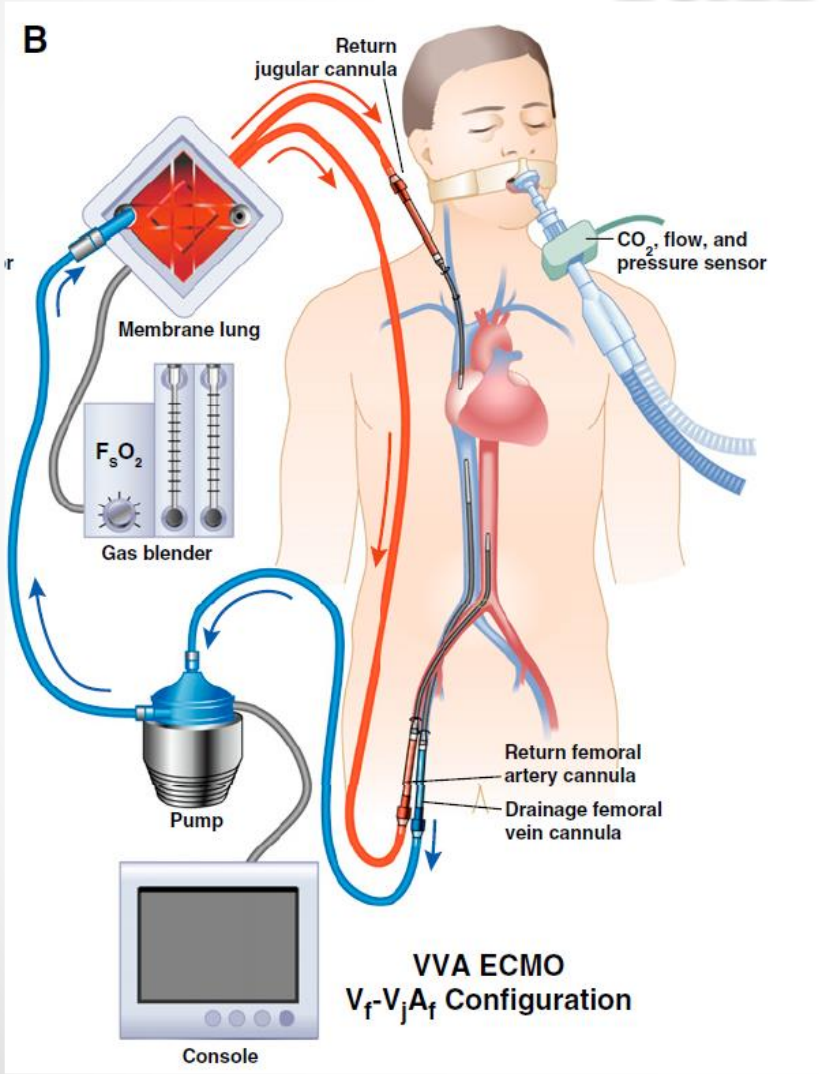
Dual Lumen (dl) V_j-V configuration







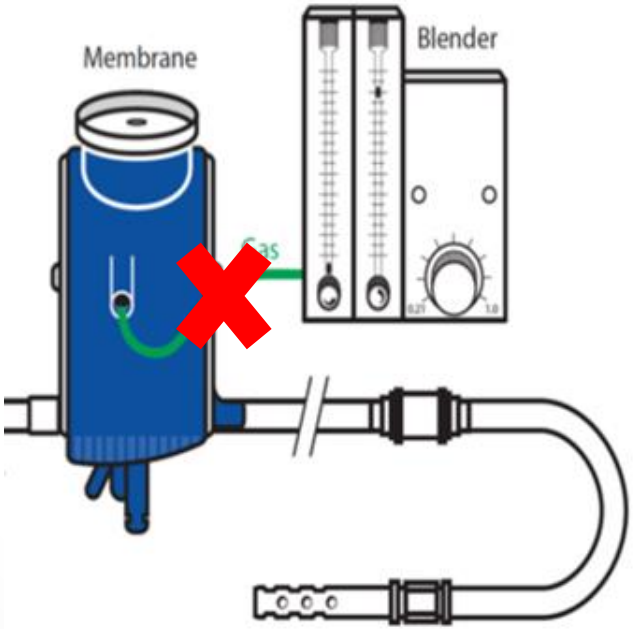
VV ECMO with RV failure



- **V_f-V_jA_f** configuration
- Both, partial support
- Sternotomy, **oxyRVAD**
  - RA-PA

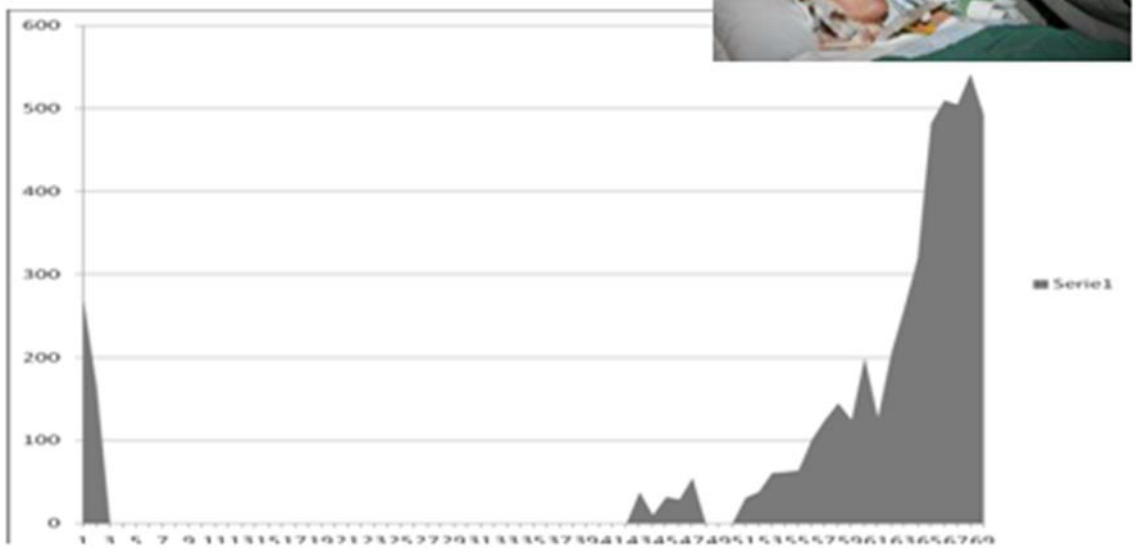
Weaning of VV ECMO

- Capping the gas inlet
- After12-24 hrs observation, decannulate



Lung recovery

Tidal volumes long run ECMO



40 yo, viral ARDS, Awake alert on ECMO,
total consolidation for 50 days

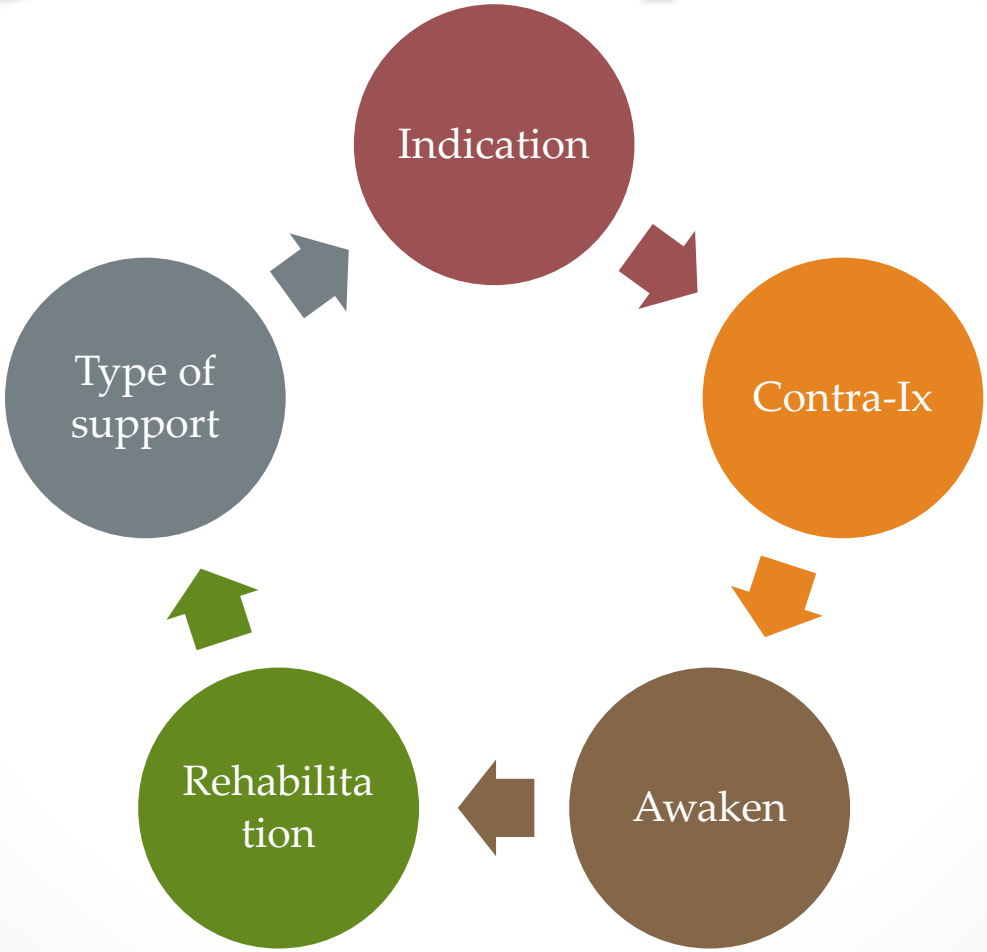
courtesy of Palle Palmer, Karolinska

Change

Change of concept of ECMO

ECMO I	ECMO II
Sedation, Paralysis	Awake, Spontaneous breathing
Intubated	Tracheostomy
Rest vent settings	CPAP, extubate?
Specialist 24/7	ICU Nurse, ECMO Team role
Lung recruitment?	Watch and wait
Bleeding: major	Bleeding: minor

Bridge to transplantation



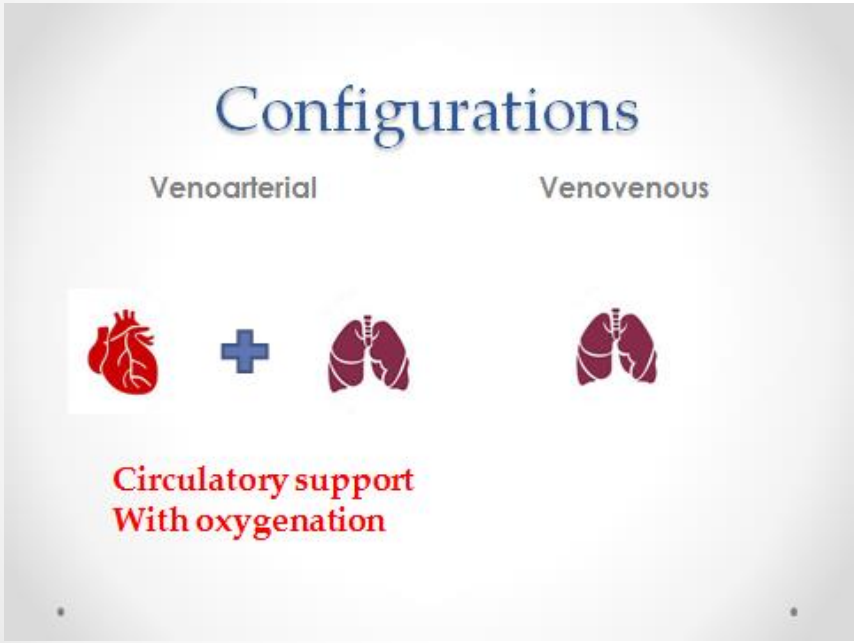
Ambulatory, BTT

Ambulatory Lung Assist
PA-LA implantation, 5 weeks, bridging to transplant
Regensberg, 2007

Veno-arterial ECMO

More complicated

Hemodynamic

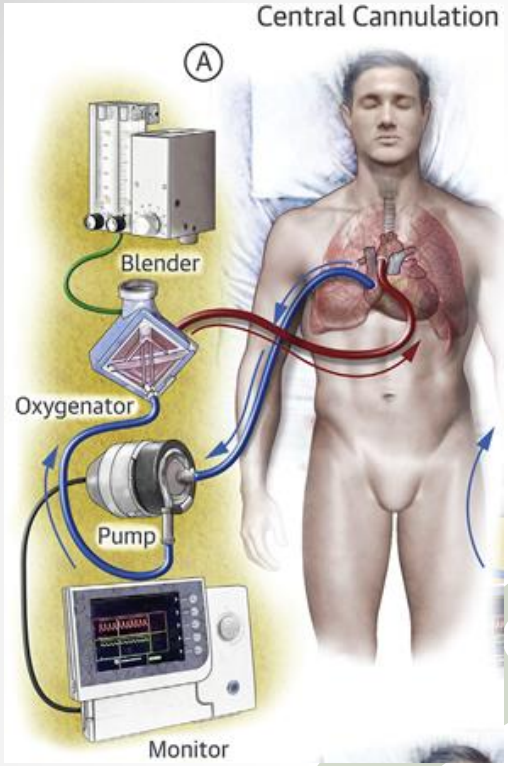


1. Mean arterial blood pressure ≒ **60 mmHg**
2. Discontinue vasoactive agents
3. **Avoid hypertension**
    1. Afterload 증가로 myocardial recovery 를 방해
    2. Centrifugal pump의 경우 venous return을 방해하여 flow 감소를 야기

Monitoring

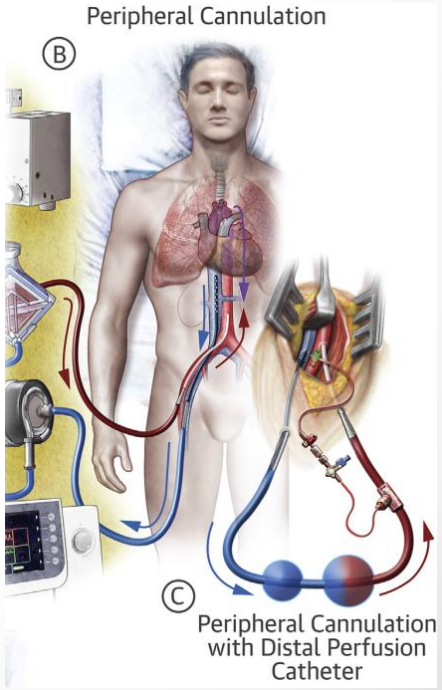
- Monitoring for adequate tissue perfusion
  1. Serum **lactate** level
  2. acidosis
  3. Adequate urine output
  4. Mixed venous saturation (**SVO2**)

     > 70%



- Central cannulation

- Peripheral cannulation



Central vs peripheral

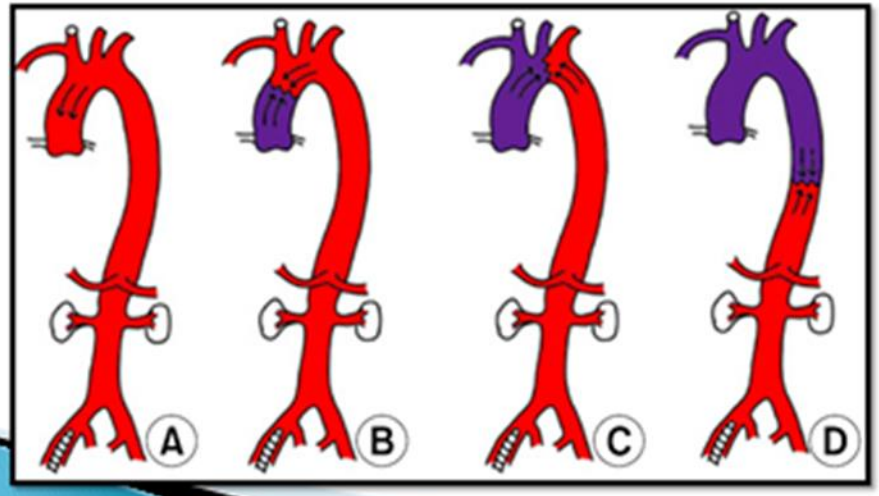
- Open
- Good ECMO flow
- On-site Left vent
- Bleeding

- **Percutaneous**
- Limited flow
- Additional vent procedure
- Harlequin syndrome
- Limb ischemia

Harlequin syndrome

Two circulation syndrome(VA)

1. Rt. Radial a. ABGA
2. Ventilator and ECMO setting
3. Additional catheter (central cannulation, VAV 전환)

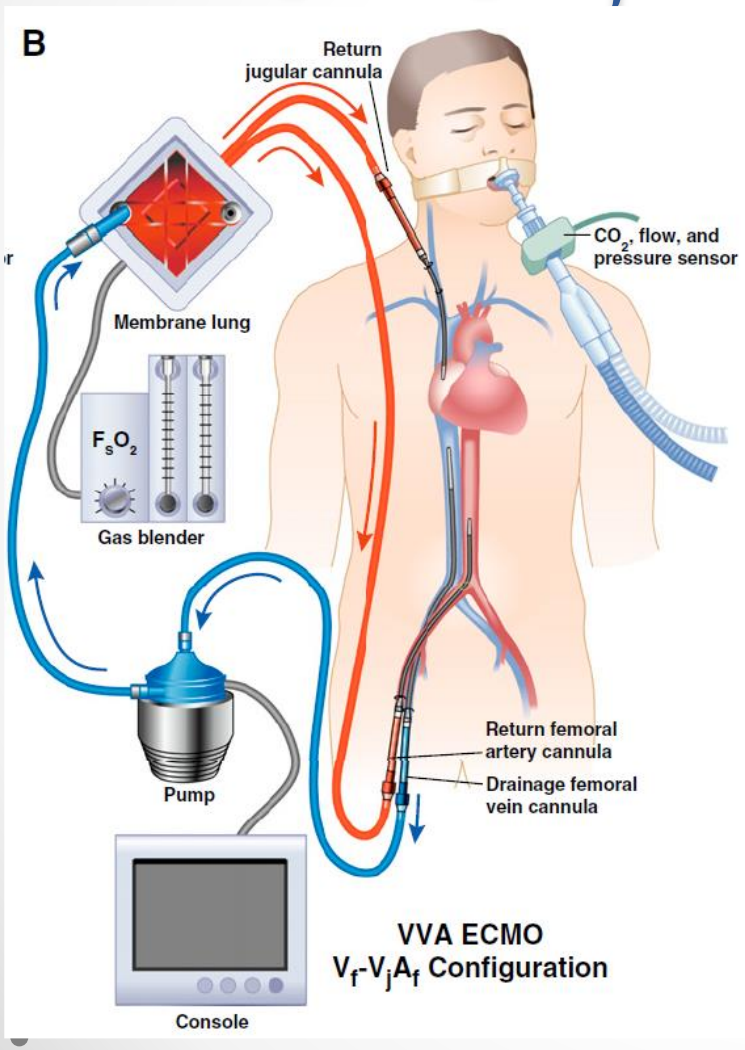


Peripheral Saturation

- SpO2 target
  1. **95**% for VA ECMO

- **Lung rest**
  - Avoid high tidal volume and pressure < 25 cmH2O
- Avoid hyperoxia
- Avoid respiratory acidosis

V_f-$A_f V_j$ configuration



- Peripheral VA ECMO with lung failure

- **V-VA ECMO**

-> VV ECMO

-> weaning

Vent the LV

- Pulmonary edema despite of diuresis and inotropes

Prevent lung injury

Avoid stasis within the LV

Promote myocardial recovery

Venting

- **Septostomy**, trans-aortic venting
- Open **surgical** venting

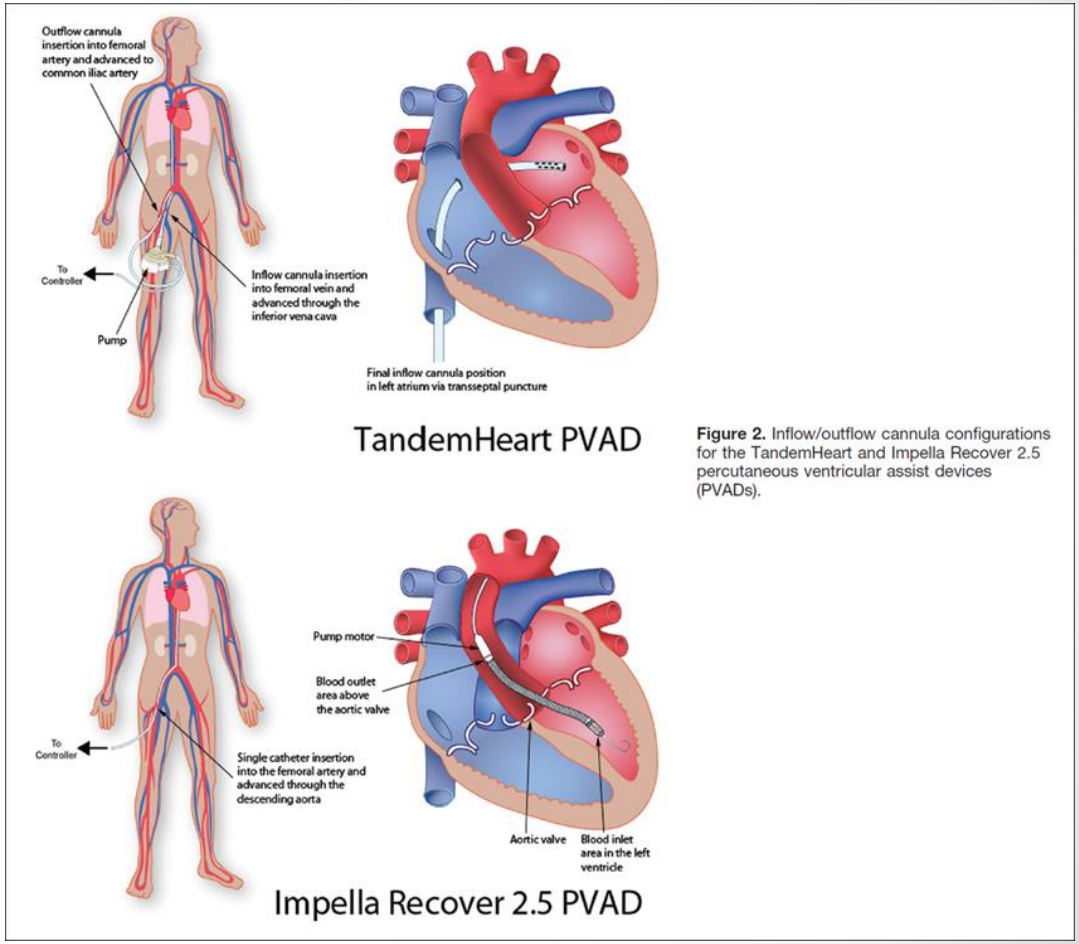
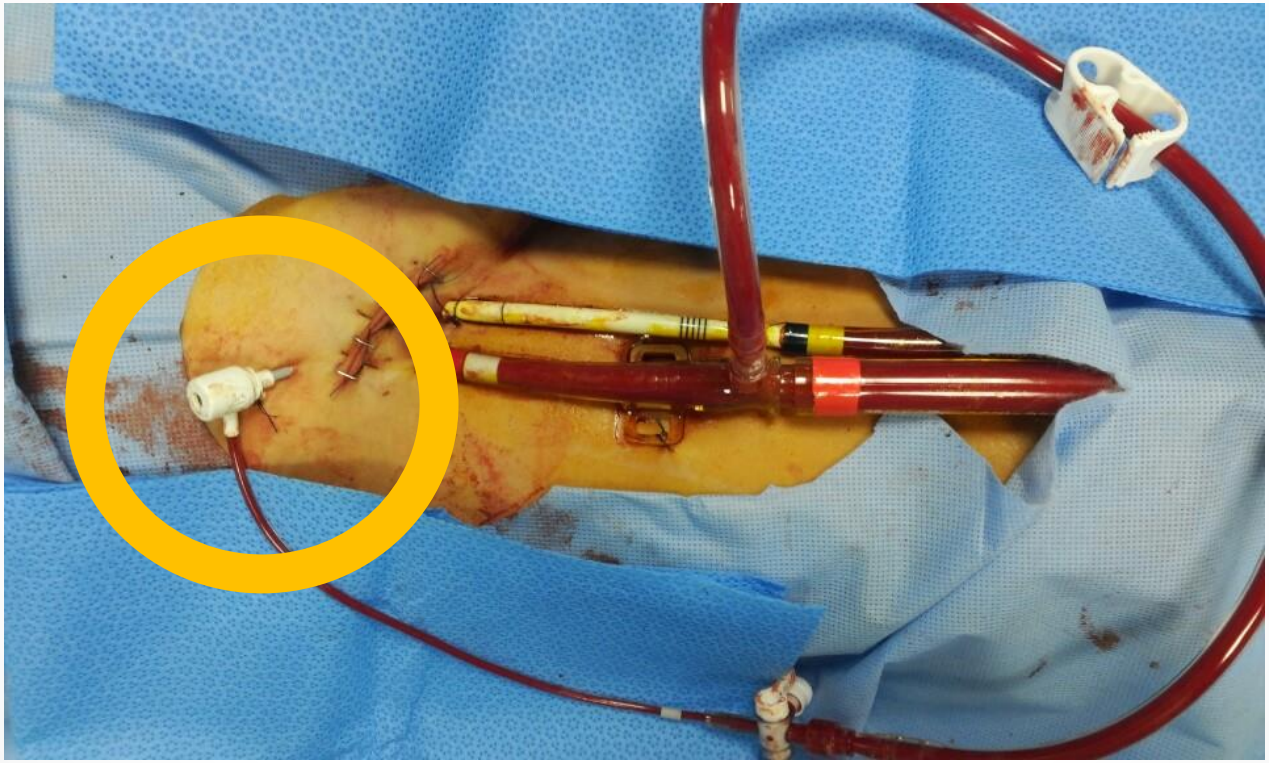


Figure 2. Inflow/outflow cannula configurations for the TandemHeart and Impella Recover 2.5 percutaneous ventricular assist devices (PVADs).

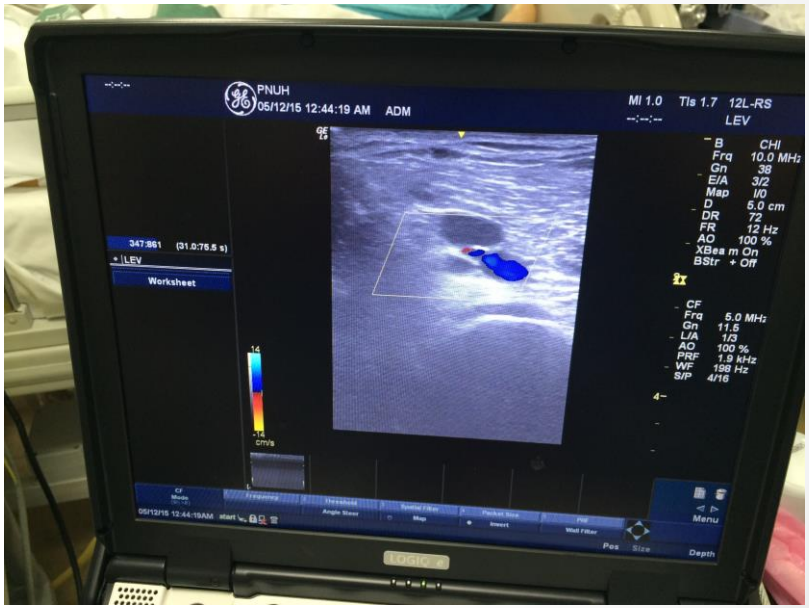
Limb ischemia

- Most fetal vascular complication
- Golden time, doppler check every 2 hrs.
- Reperfusion injury
- Acidosis
- ARF

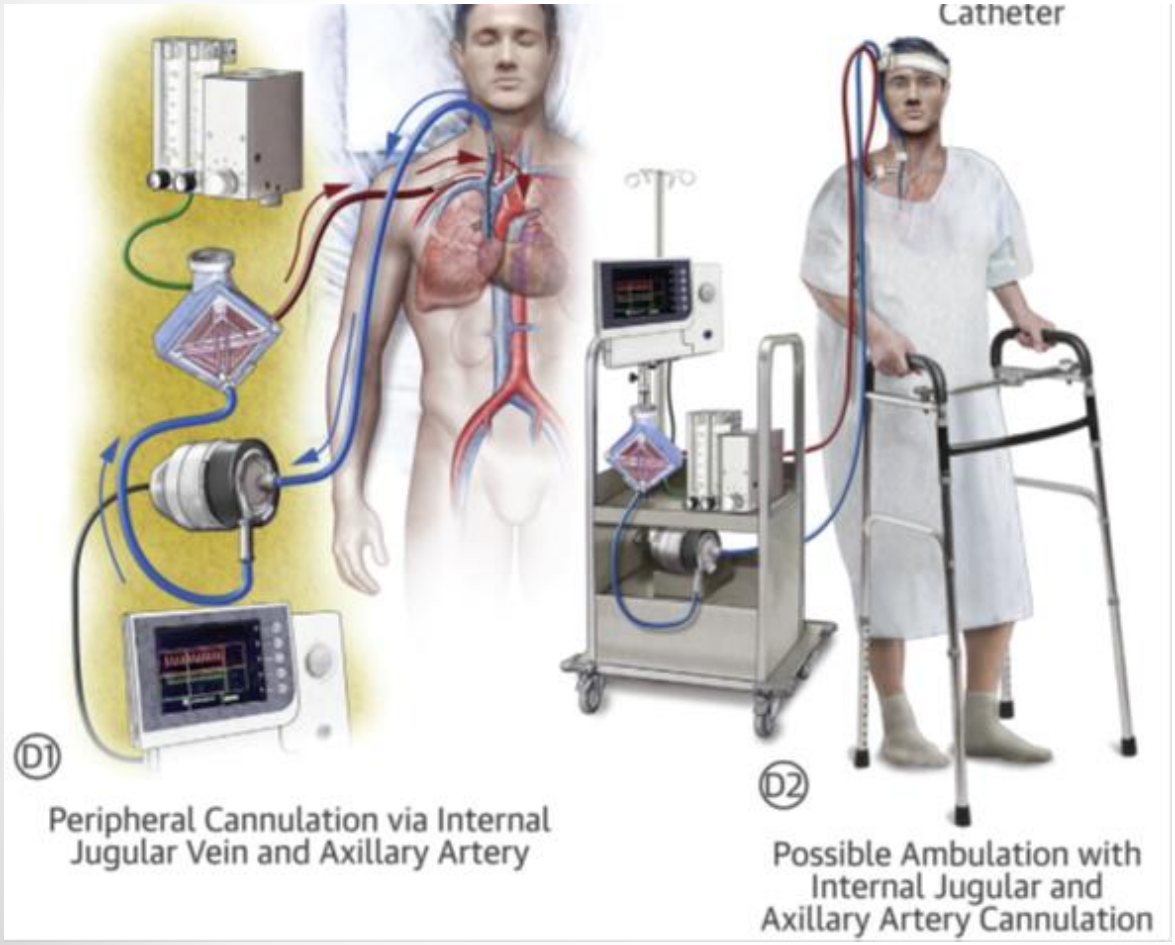
Distal perfusion



Reassurance

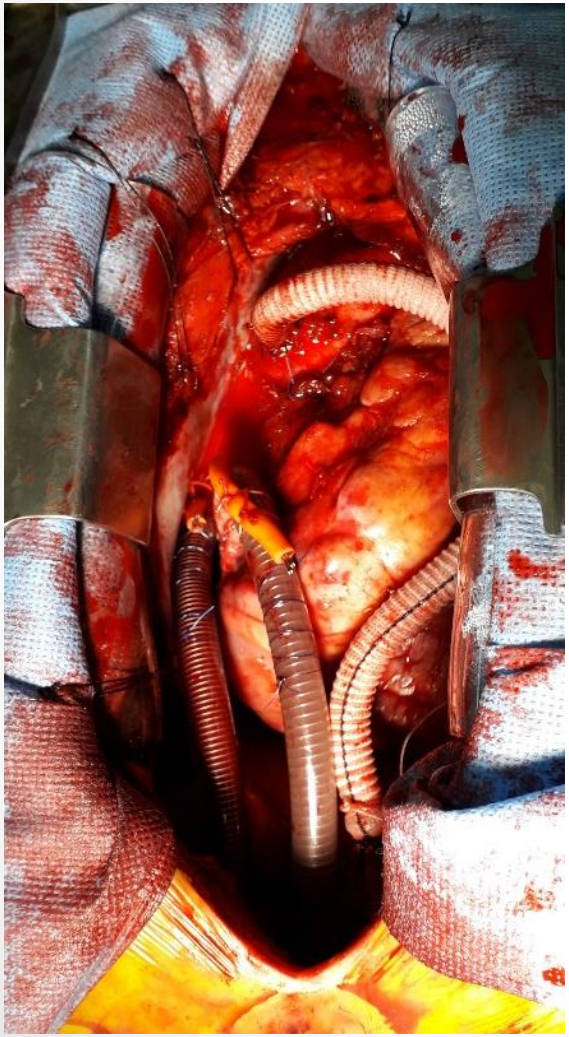


Peripheral, but upper extremities



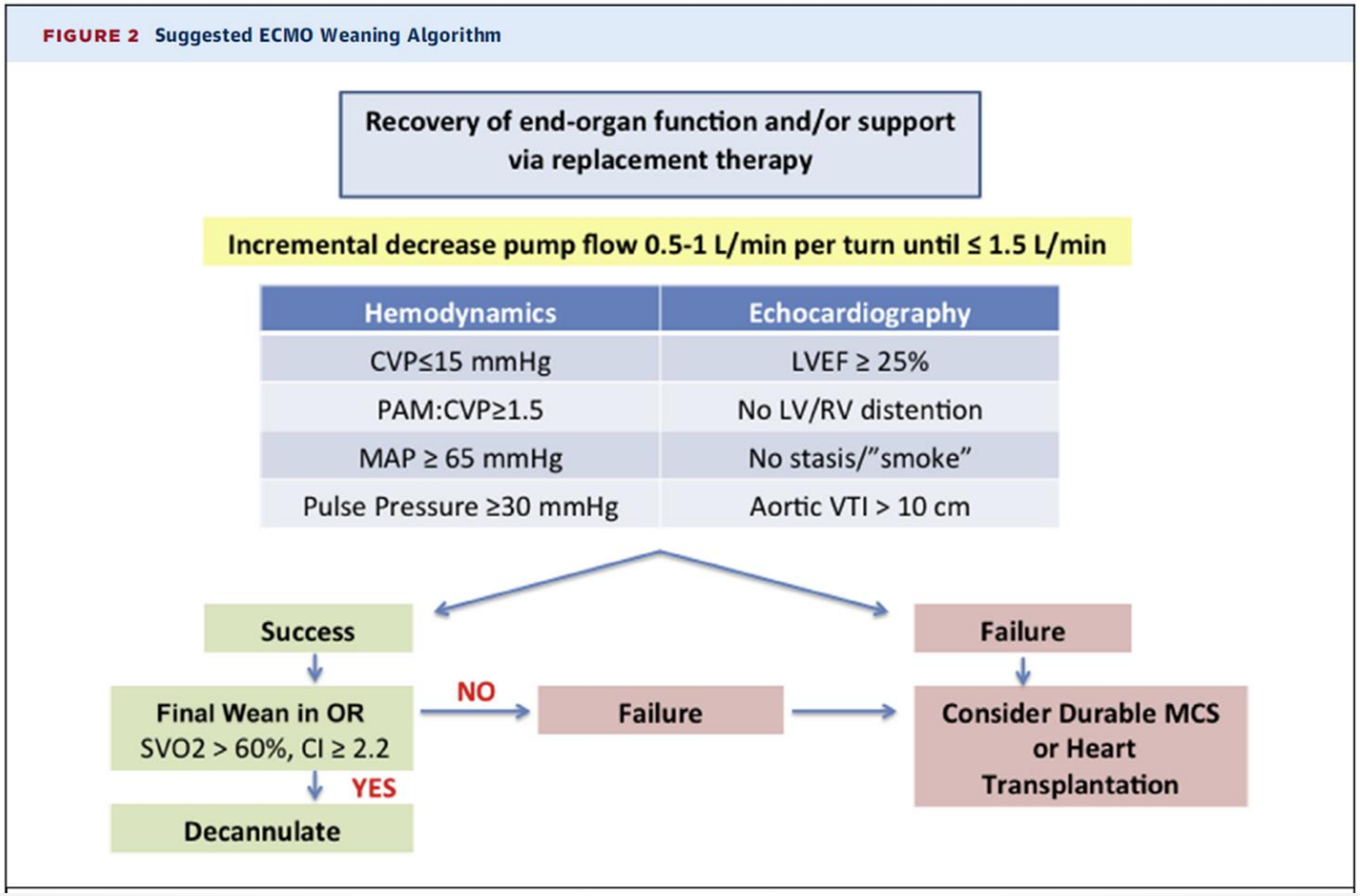
- Jugular v. – subclavian a.
- Need open technique
- Arm swelling

Central ECMO



RAv_a-Ao configuration

Wean ECMO



VTI=Velocity-time integral

Short-term mechanical circulatory support as a bridge to durable left ventricular assist device implantation in refractory cardiogenic shock: a systematic review and meta-analysis

European Journal of Cardio-Thoracic Surgery 52 (2017) 14–25

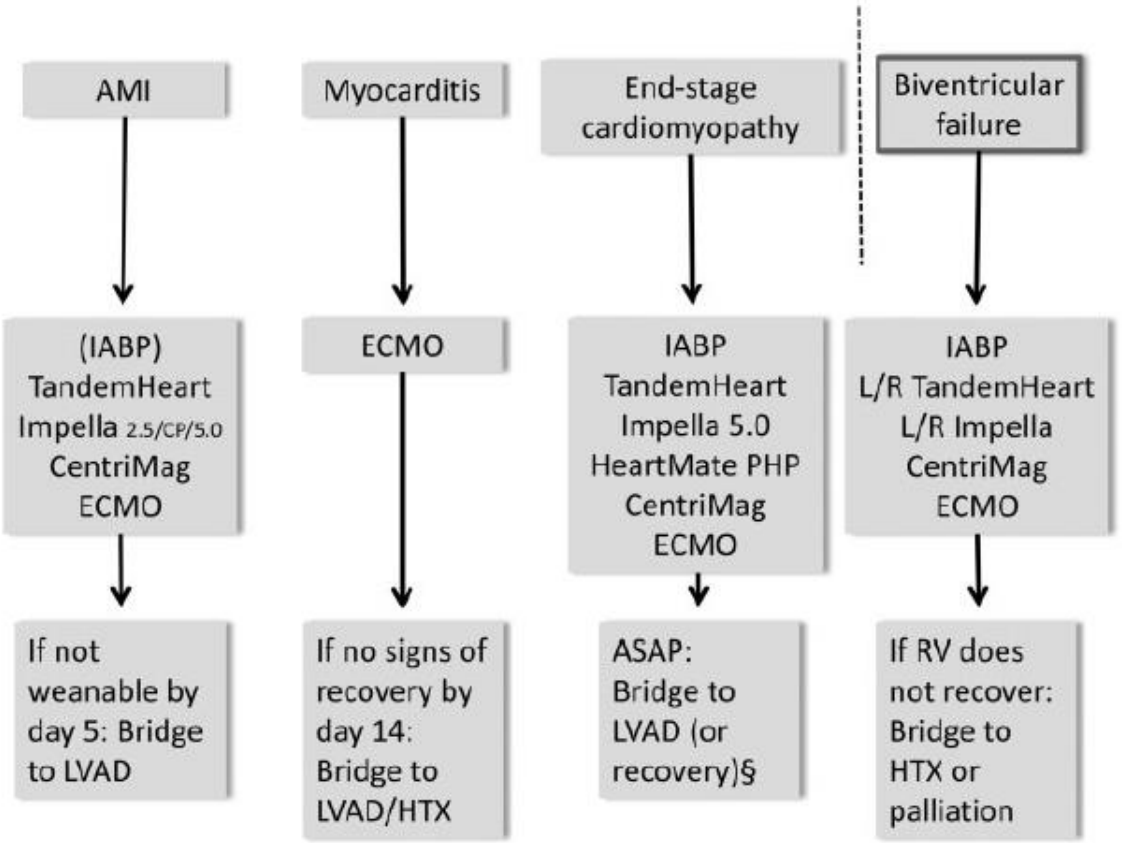


Figure 2: Current application of short-term mechanical circulatory support and possible timing towards durable left ventricular assist device in patients with refractory cardiogenic shock. § Bridge to recovery is only realistic in case of *de novo* heart failure or in acute on chronic heart failure when a clear cause for exacerbation exists.

Common management

Anticoagulation (Heparin)

- Target ACT (activated clotting time) : 180-220 sec
- aPTT, factor Xa assay
- Futhan, argatroban

Blood product administration

- Platelet count > 10 만/mm^3
- Hematocrit > 35-40 %
- Fibrinogen > 150 mg/dl (50-100 mg in 1 pack of cryoprecipitate)
- FFP
  - Hypovolemia, 응고인자부족, **AT III** 부족
  - Vit. K 같이 보충하는 것이 좋다
- Albumin > 2.5 mg/dl
- Electrolyte imbalance (potassium…)

Practice

Table 7-3. Laboratory Schedule.

Anticoagulation Lab	Guideline
ACT	Q1h – Q2h
aPTT	Q6h – Q12
Anti–factor Xa Assay	Q6h
Platelets	Q6h - Q12h
INR	Q6h - Q12h
Fibrinogen	Q12h - Q24h
CBC	Q6h - Q12h
Antithrombin Level	Daily - PRN
Thromboelastography	Daily – PRN for bleeding or clotting complications

Table 7-4. Blood Product and Factor Replacement.

Anticoagulation Lab	Guidelines
Platelets	Platelet transfusion to maintain counts >80,000 µL to 100,000 µL
INR	FFP transfusion to maintain INR <2.0
Fibrinogen	Cryoprecipitate to maintain fibrinogen >100 mg/dL OR >150 mg/dL if bleeding or prior surgical intervention
Hematocrit	PRBCs to maintain hematocrit >30% (consider higher goal for neonates and children with cyanotic congenital heart disease or lower goal for stable, adult patients)
Antithrombin	>50%-80% (>0.5-0.8 u/mL), consider AT replacement if on maximum dose of UNFH and unable to obtain therapeutic anti-factor Xa assay

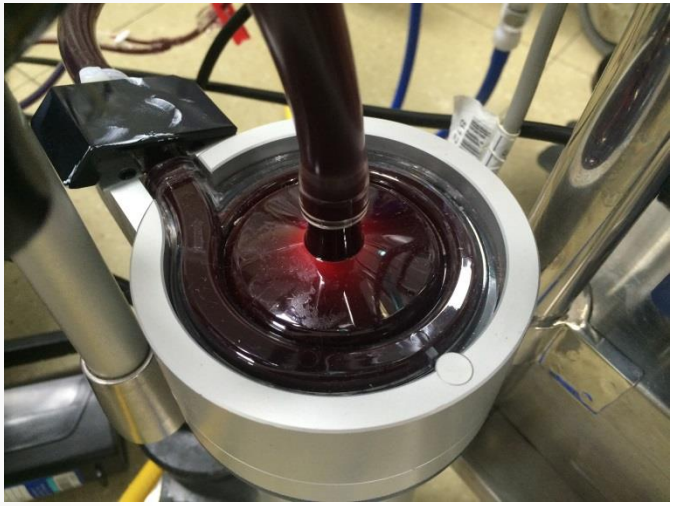
Cannula site Bleeding

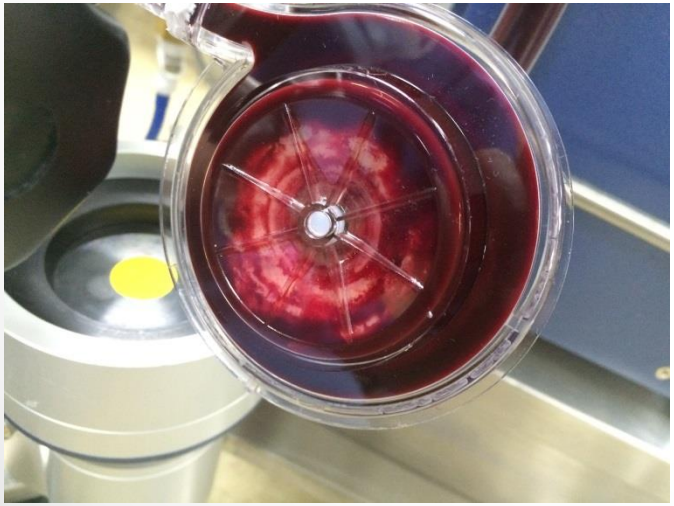
- Compression
- Purse-string suture
- Coagulopathy 교정
- Revision

Fixation

ECMO emergencies

Pump failure



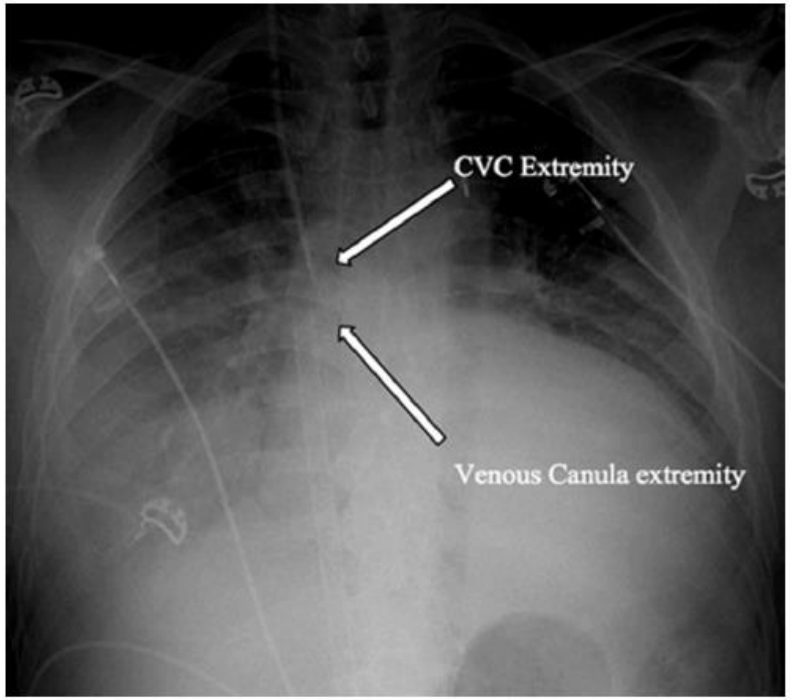


- Acute thrombosis
- **Circuit change**

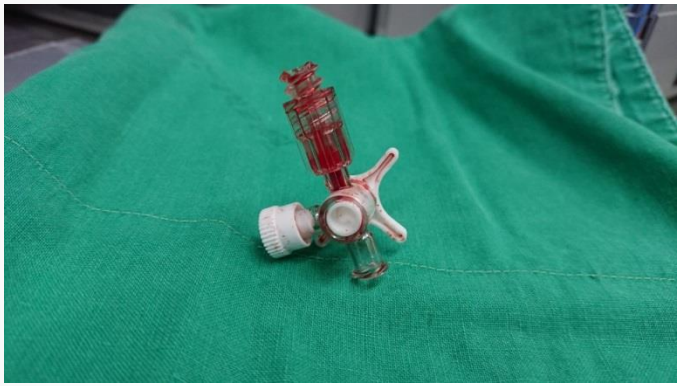
Air embolism

Massive air embolism from central venous catheter during veno-arterial ECMO therapy

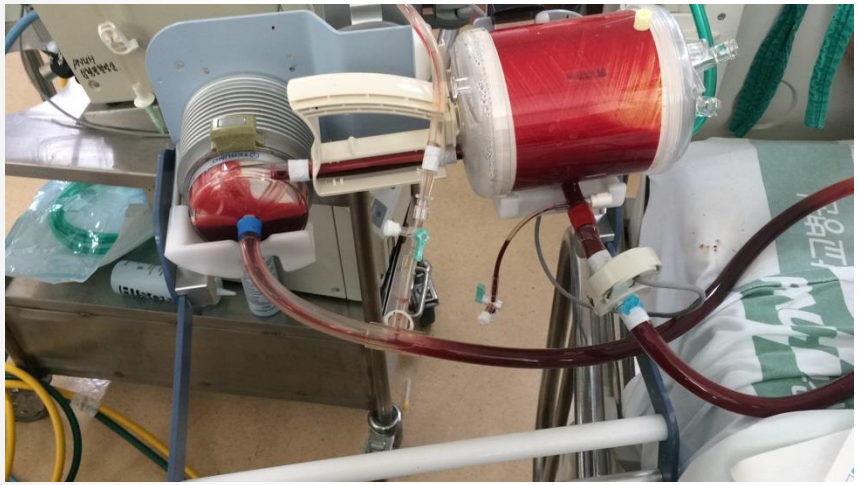
Anaesth Crit Care Pain Med 37 (2018) 271–272



Rupture of circuit



Accidental de-cannulation



- **C**lamp
- **C**ompress
- Stop pump

- **C**all for help
- Resuscitate the patient

Shut down

- Re-booting
- Another machine

- **Hand crank**

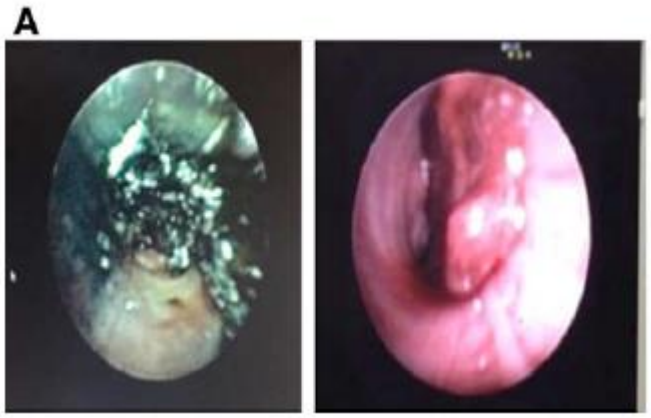
ASAIO Journal 2019

Recovery from Total Acute Lung Failure After 20 Months of Extracorporeal Life Support

Kristen Nelson-McMillan,*†‡ Luca A. Vricella,*¶ Dylan Stewart,*¶‖ John Young,** Ashish S. Shah,†† Narutoshi Hibino,*¶ # and John D. Coulson*‡§

Table1. Organ Support by Phase

	ECMO (Phase 1)	ECMO (Phase 2)	ECMO (Phase 3)	ECMO (Phase 4)	ECMO (Phase 5)
ECLS Day #	1–7	7–61	61–420	420–552	553–605
Type of extracorporeal support	VA-ECMO	VV-ECMO	RVAD-oxygenator "CentriMag with Quadrox"	Peds RVAD-oxygenator "PediMag with Ped-Quadrox"	ECCOR
Supports oxygenation	X	X	X	X	
Supports carbon dioxide removal	X	X	X	X	X
Supports left ventricle	X				
Supports right ventricle	X		X	X	



Viable exit strategy

Management goal

Timely change of type of support

Thank you for your attention