ECMO in a Community ICU

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No Disclosures
No Off-label Use

Objectives

WHAT is ECMO

WHY use ECMO

HOW to ECMO

WHO to ECMO

SHOULD you ECMO

What is ECMO

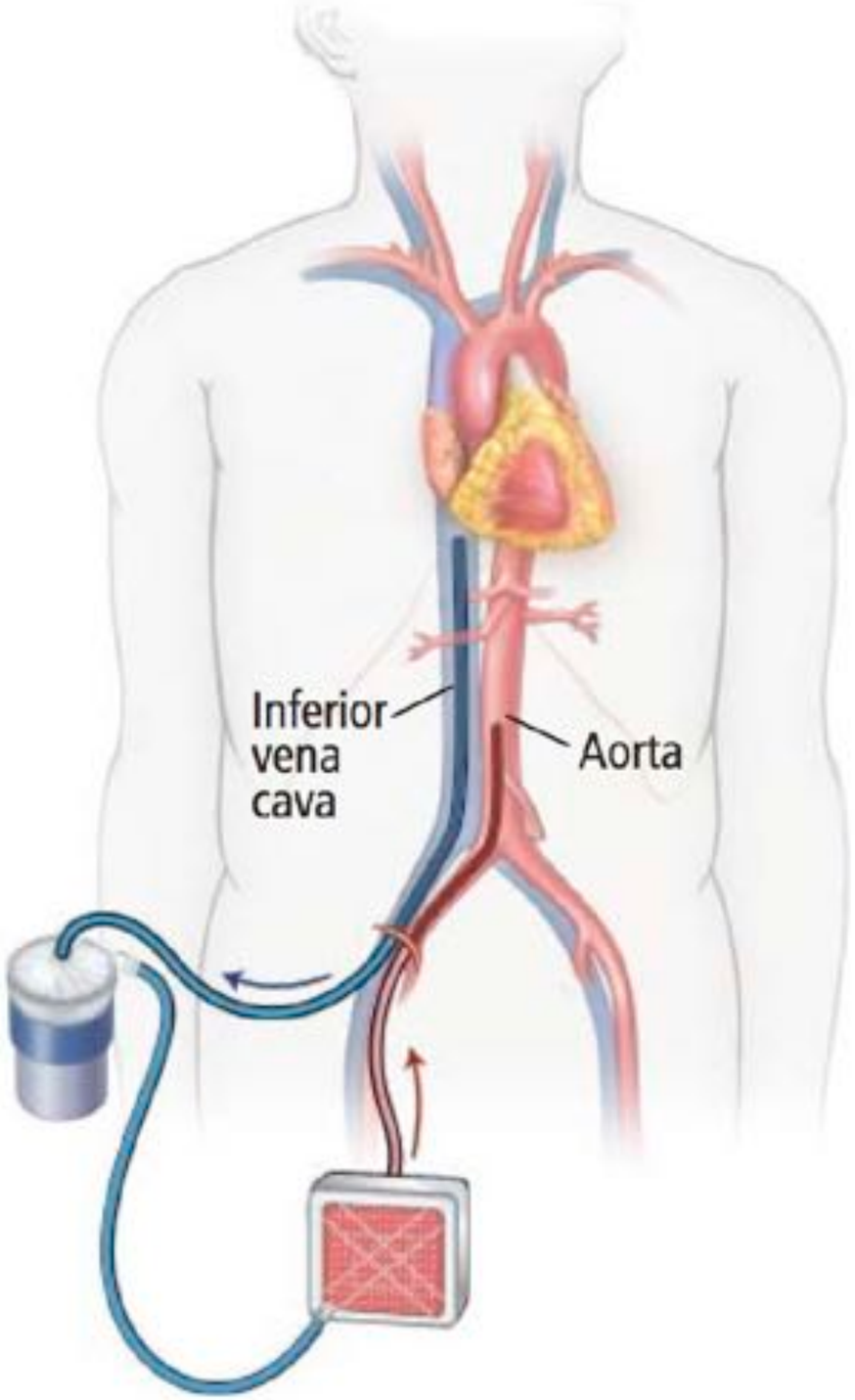
- High risk of death
- Temporary heart/lung support
- Reversible cause

What ECMO can do

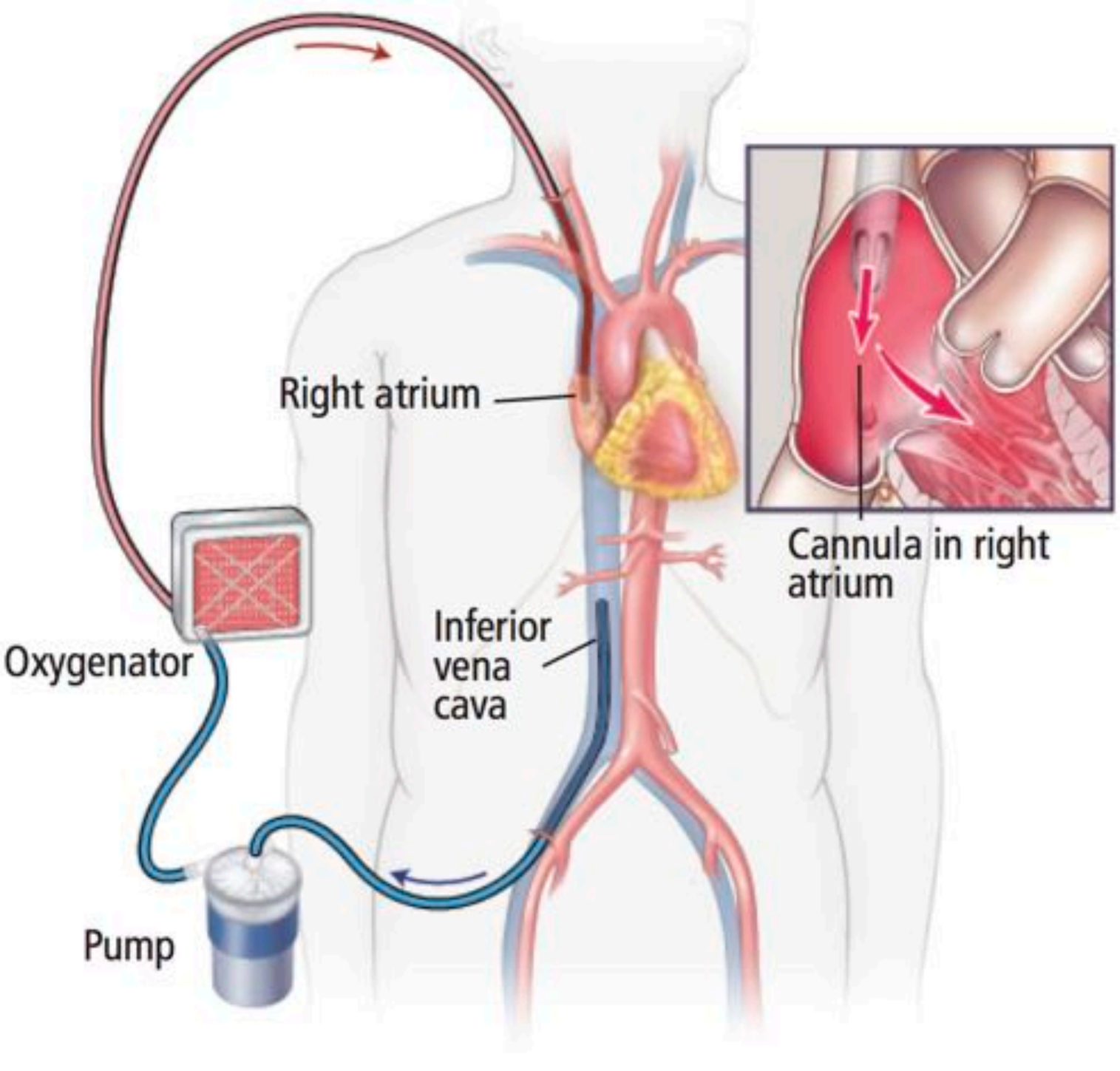
- Oxygenate
- Remove Carbon dioxide
- Perfuse
- Regulates temperature

ECMO doesn't CURE

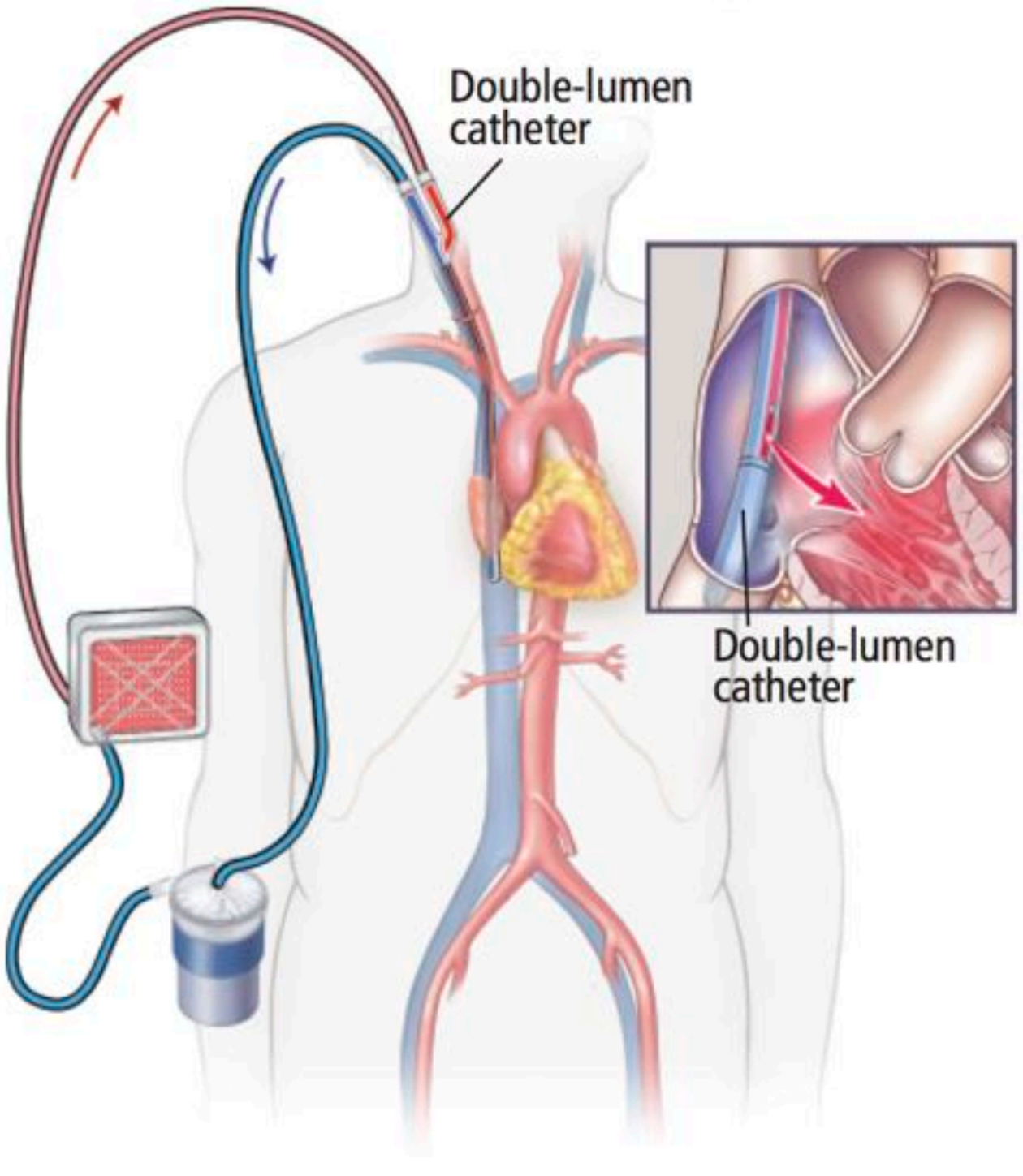
VA-ECMO

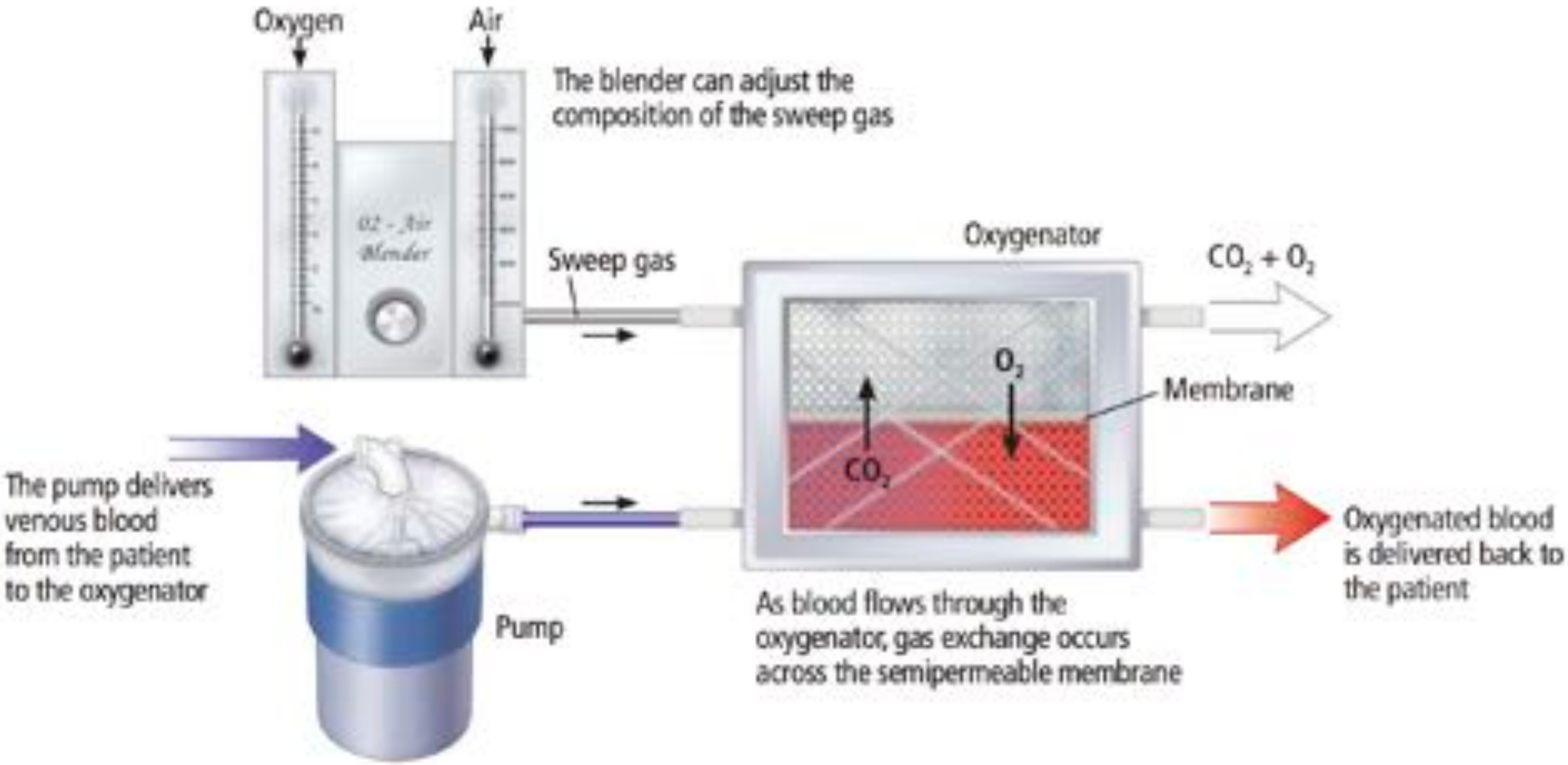


VV-ECMO

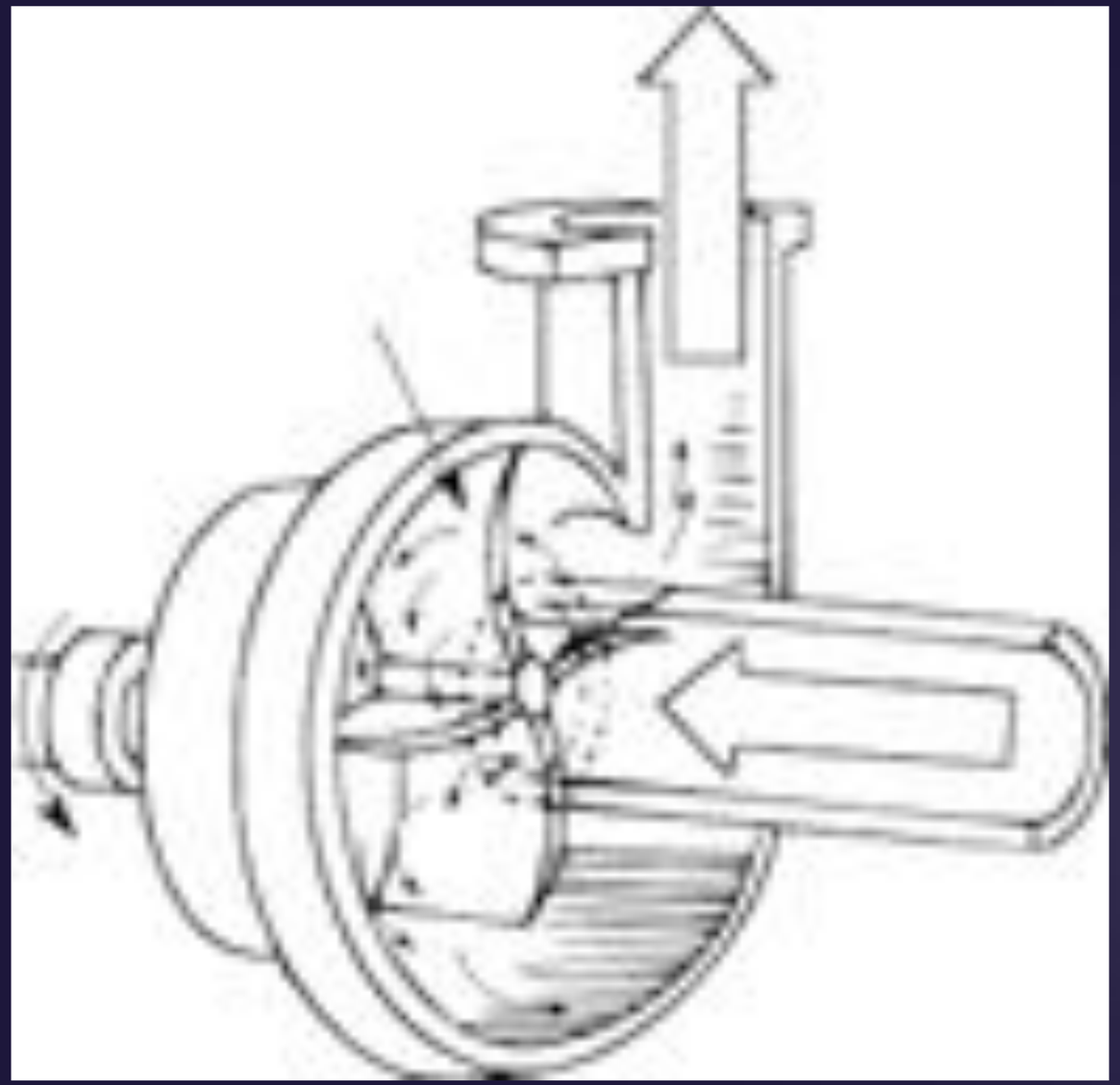

Right atrium
Cannula in right atrium
Oxygenator
Inferior vena cava
Pump

Bicaval Double-lumen VV-ECMO

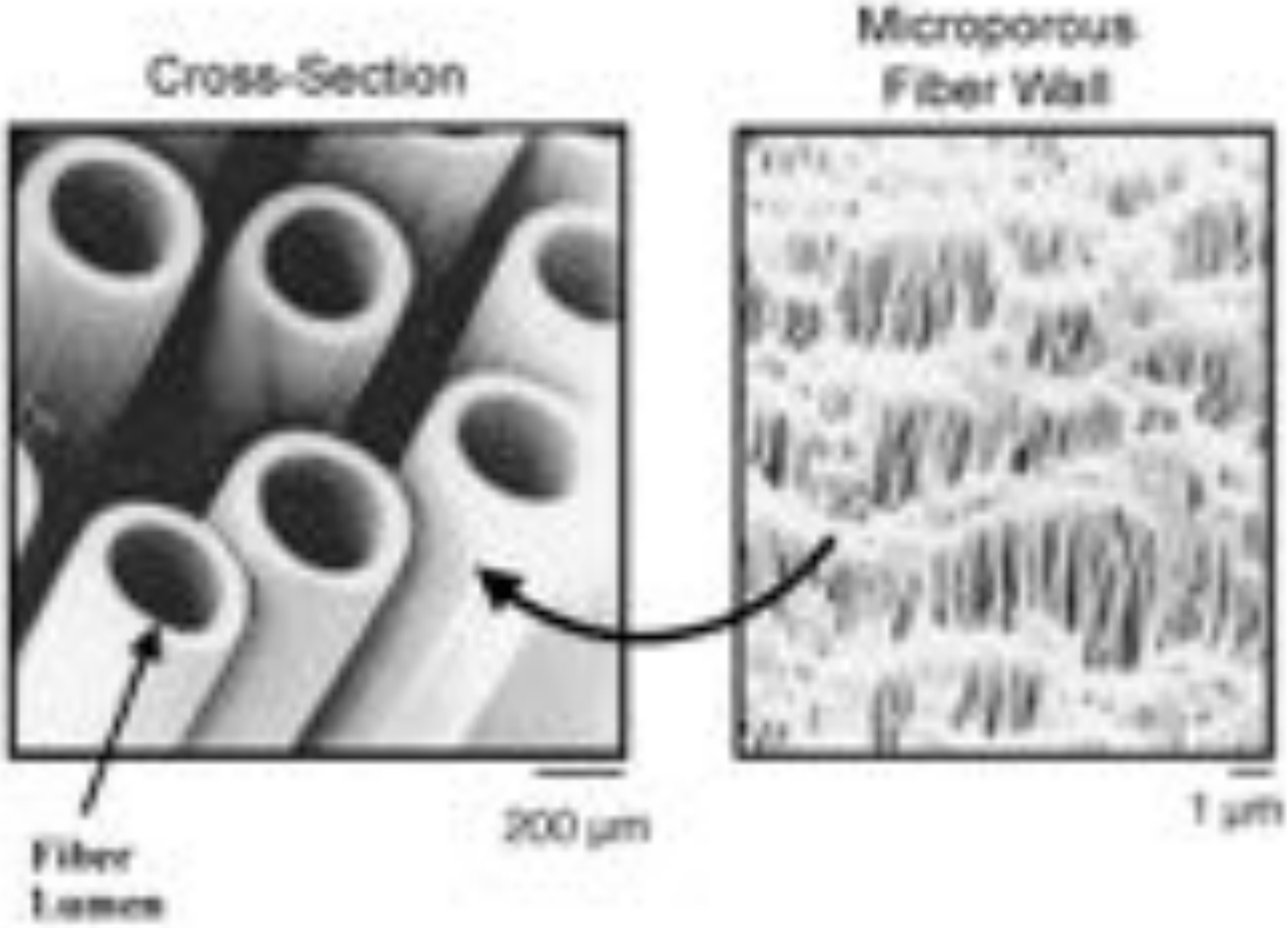



Oxygen
Air
The blender can adjust the composition of the sweep gas
O2 - Air Blender
Sweep gas
Oxygenator
$CO_2 + O_2$
O_2
Membrane
CO_2
The pump delivers venous blood from the patient to the oxygenator
Pump
Oxygenated blood is delivered back to the patient
As blood flows through the oxygenator, gas exchange occurs across the semipermeable membrane


SOFTLINE COATING
MAQUE



ugal

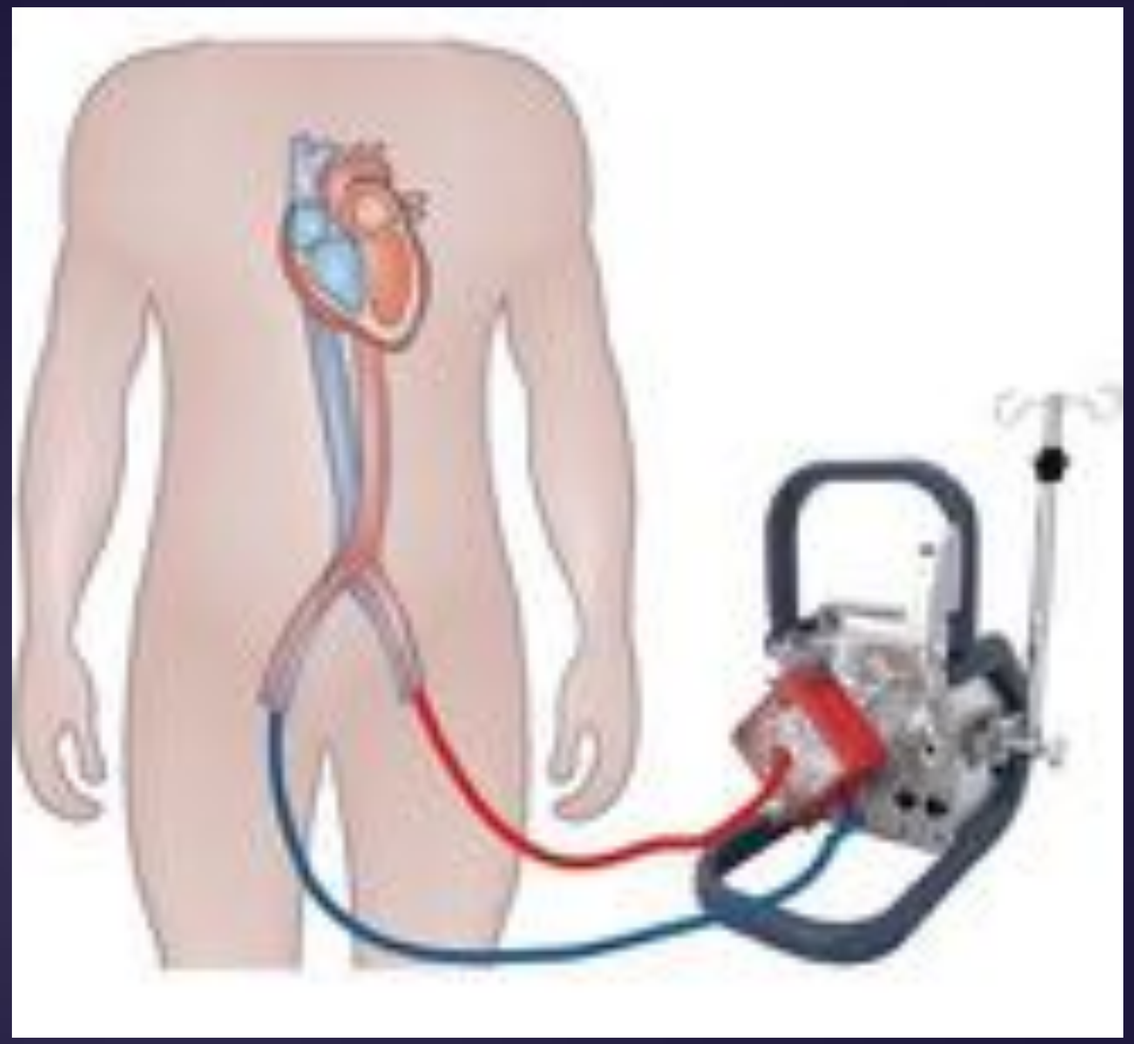

Cross-Section
Microporous
Fiber Wall
200 µm
1 µm
Fiber
Lumen


3961
6.32
MAQUET
PRAXAIR


1000
800
600
400
200
ml/min
O2/AIR
10
8
6
4
2
LPM
O2/AIR
SECHRIST
AIR-OXYGEN
MIXER
FIO2
.21
.30
.40
.50
.60
.70
.80
.90


36.0
37.2
36.3

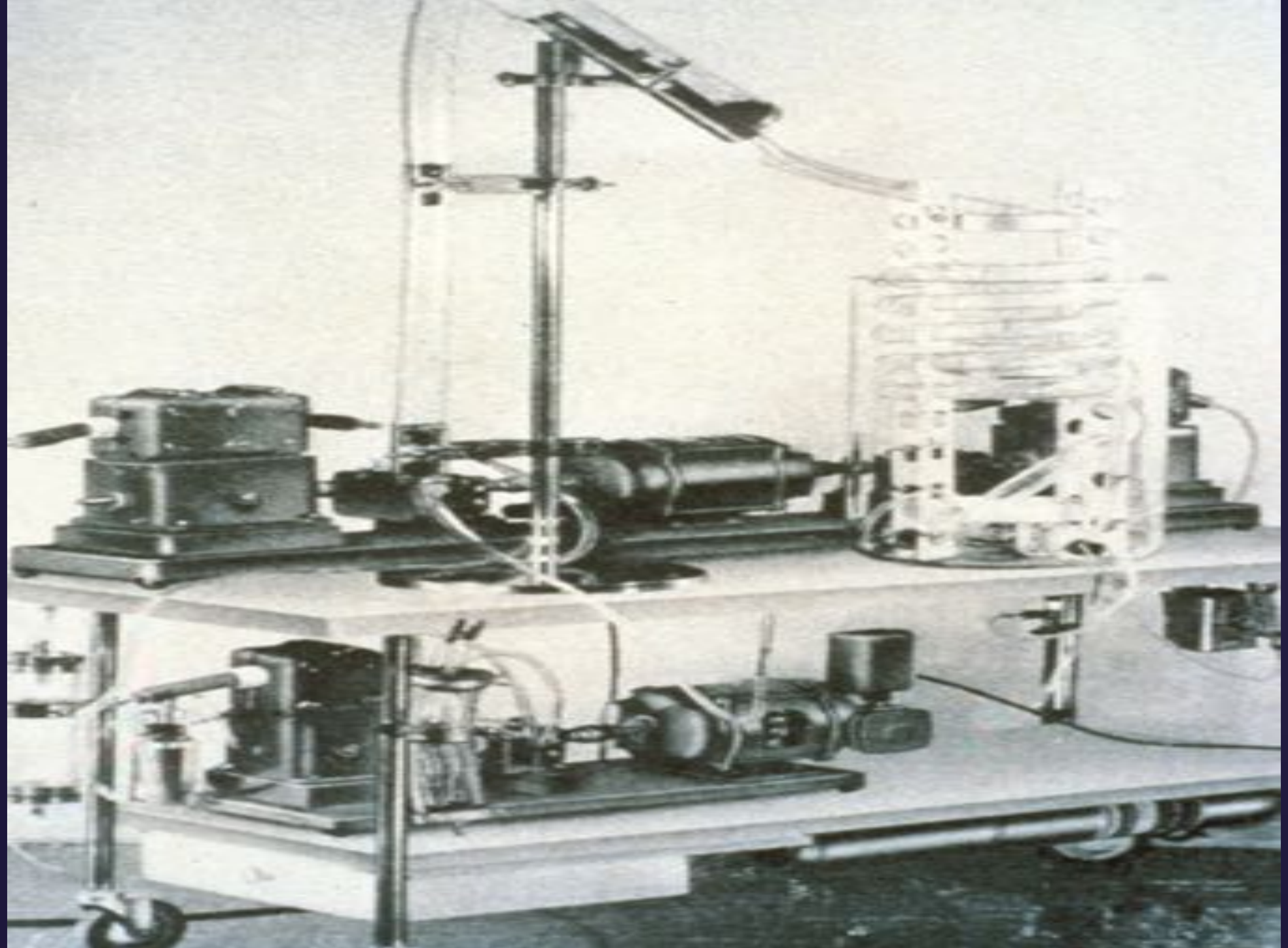

4.20



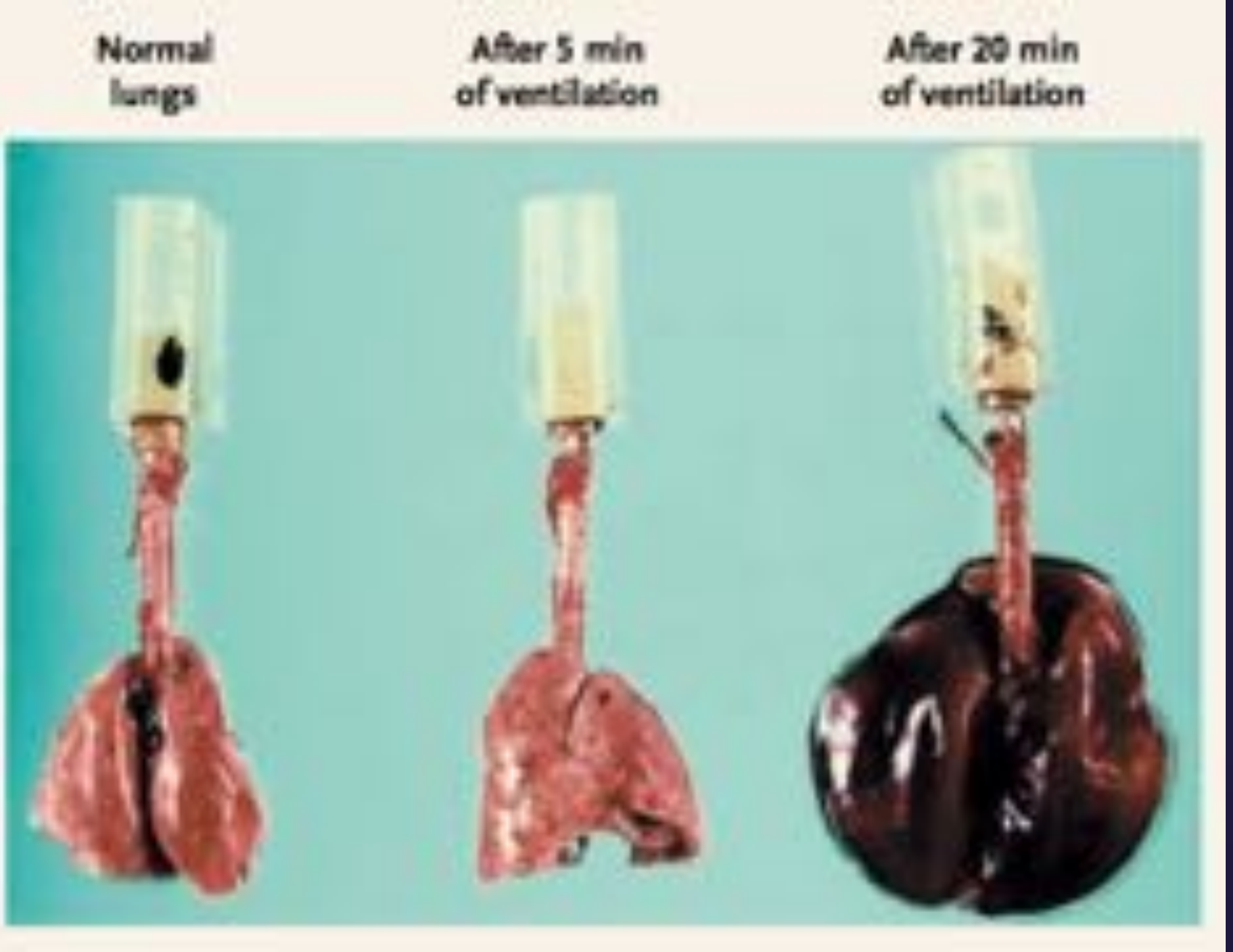

heparin
1340

Why use ECMO


Univ Of Cal Irvine
NEXT RIGHT



ELSO


Normal lungs
After 5 min of ventilation
After 20 min of ventilation

Failed Trials

- Zapol, 1979
- Morris, 1994
- Little used in adults

Vocal Advocates

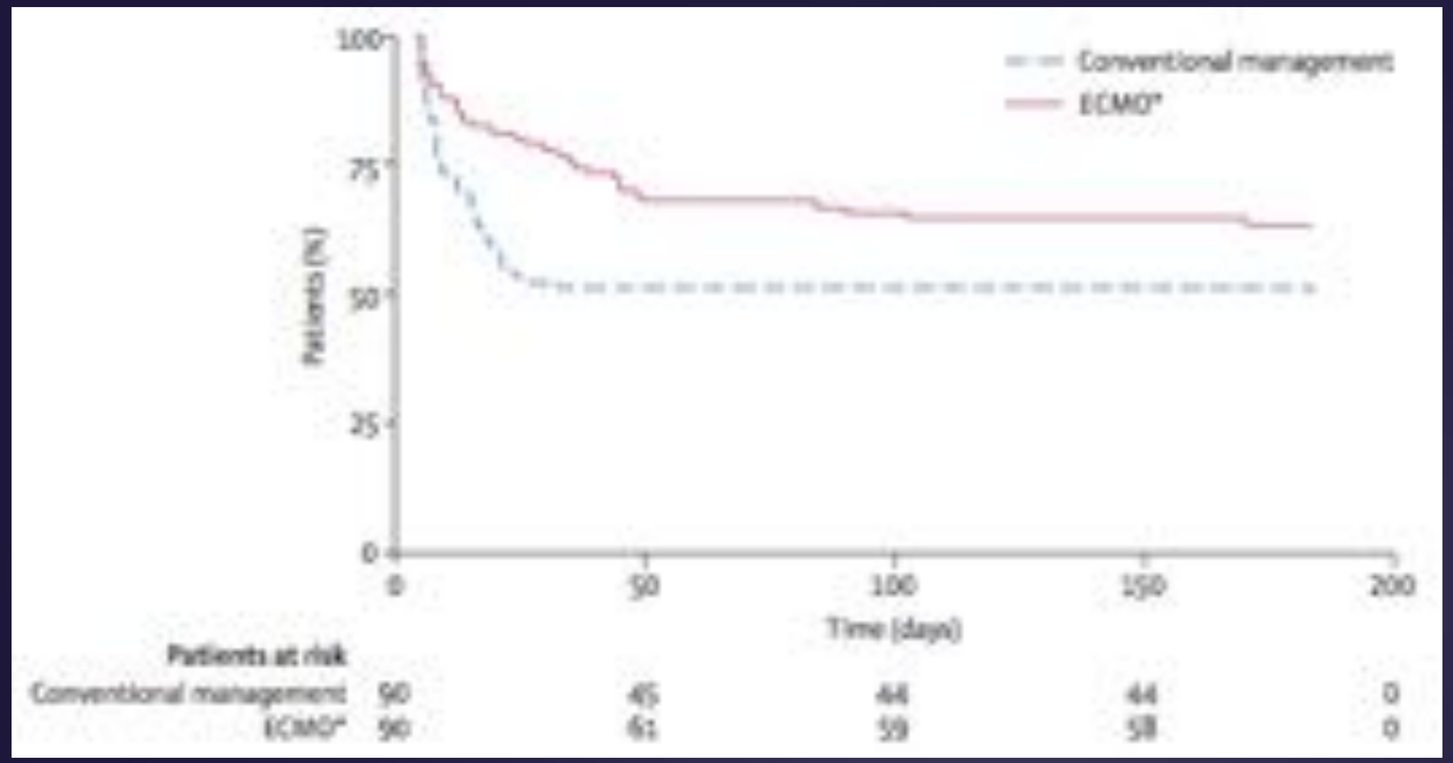
- Limited training
- Intensive anticoagulation
- Excessive volume and pressure during mechanical ventilation.

CESAR Trial

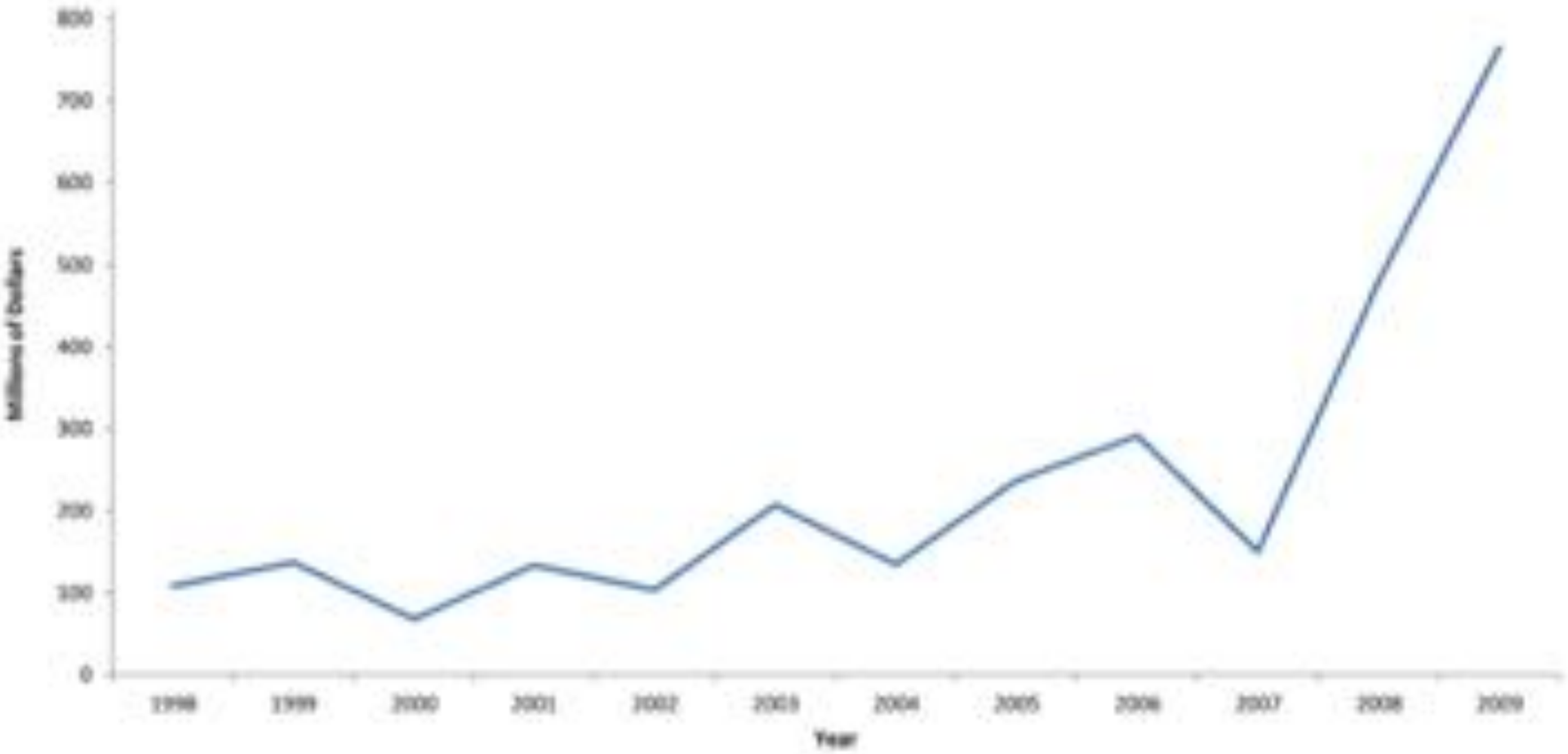
Efficacy and economic assessment of conventional ventilatory support versus extracorporeal membrane oxygenation for severe adult respiratory failure (CESAR): a multicentre randomised controlled trial

Giles J Peek, Miranda Mugford, Ravindranath Tiruvoipati, Andrew Wilson, Elizabeth Allen, Marianna M Thalanany, Clare L Hibbert, Ann Truesdale, Felicity Clemens, Nicola Cooper, Richard K Firmin, Diana Elbourne, for the CESAR trial collaboration

CESAR Trial



- Only 75% of pts in ECMO arm received (68 of 90) actually received ECMO


800
700
600
500
400
300
200
100
0
Millions of Dollars
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
Year

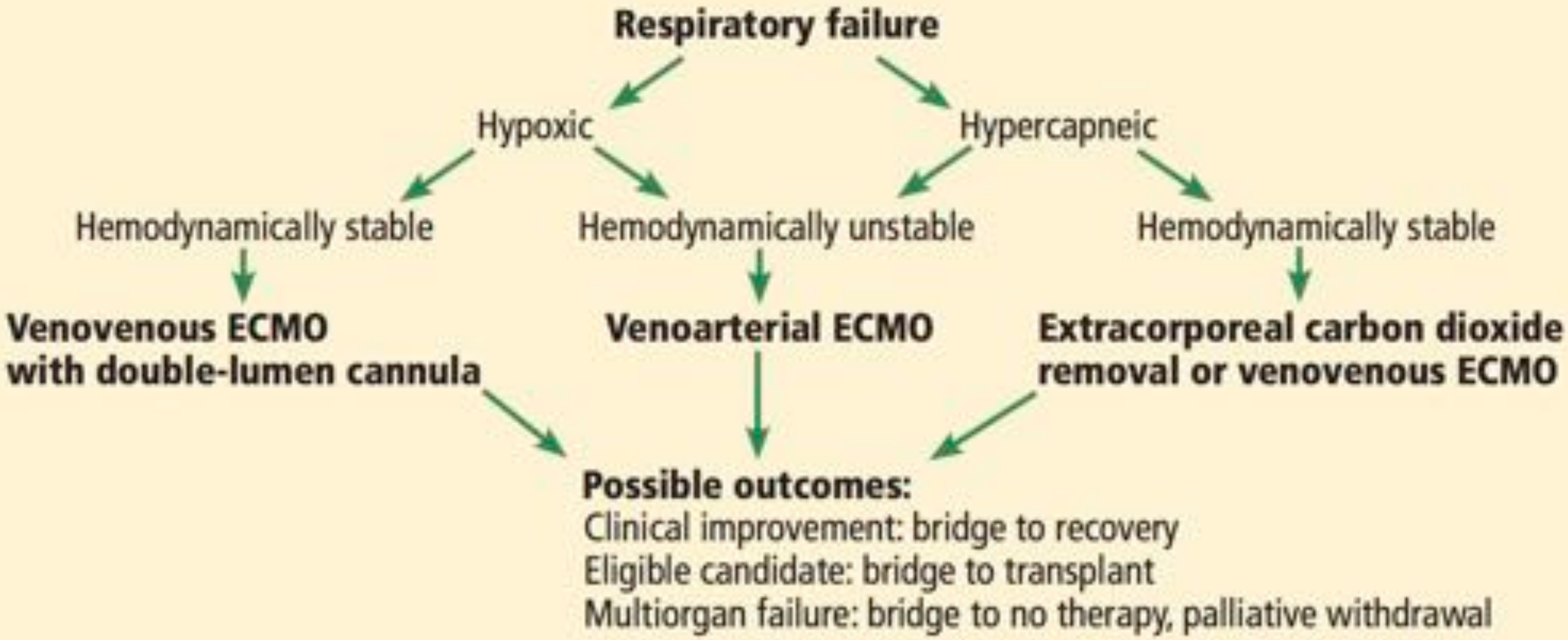
H1N1 Aftermath

- 2009-2011 over 1000 papers published
- AZ ECMO Trial

How To ECMO

Getting the right type

- Getting the right type
- Getting the right size
- Cannulation
  - Not the same as CVC or arterial line
  - Size exposes your technique
  - Never underestimate the damage you can do


Respiratory failure
Hypoxic
Hypercapneic
Hemodynamically stable
Hemodynamically unstable
Hemodynamically stable
Venovenous ECMO with double-lumen cannula
Venoarterial ECMO
Extracorporeal carbon dioxide removal or venovenous ECMO
Possible outcomes:
Clinical improvement: bridge to recovery
Eligible candidate: bridge to transplant
Multiorgan failure: bridge to no therapy, palliative withdrawal

Understanding Oxygen Delivery

- Components of Oxygen Delivery
  - Blood flow
  - Hct
  - Inlet Hgb saturation
  - Oxygenator properties
- Carbon dioxide removal always exceeds oxygen delivery

Understanding Oxygen Delivery

- Metabolic rate drives oxygen consumtption
- O2 Delivery = CO x CaO2
- Oxygen content (CaO2) = (SaO2 x Hgb x 1.34) + 0.003 x PaO2
- EBF/CO, Recirculation blood flow, native lung function
- SaO2 usually 80-90%, paO2 40-50

Controls

- Blood Flow -- RPM, Preload, Afterload, Resistance
- Sweep Gas -- Increases delivered oxygen partial pressure (FDO2)
- Gas Flow rate -- Controls carbon dioxide removal
- Temperature
- Ventilator -- LTV vs Lung rest vs Extubate

Monitoring

- Pulmonary artery catheter
- BIS monitoring
- Pulse-oximetry multiple limbs
- Labs
  - Patient ABG, Pre- / Post-Pump ABGs
  - Lactic acid
  - Plasma free hemoglobin
  - Fibrinogen

Problems

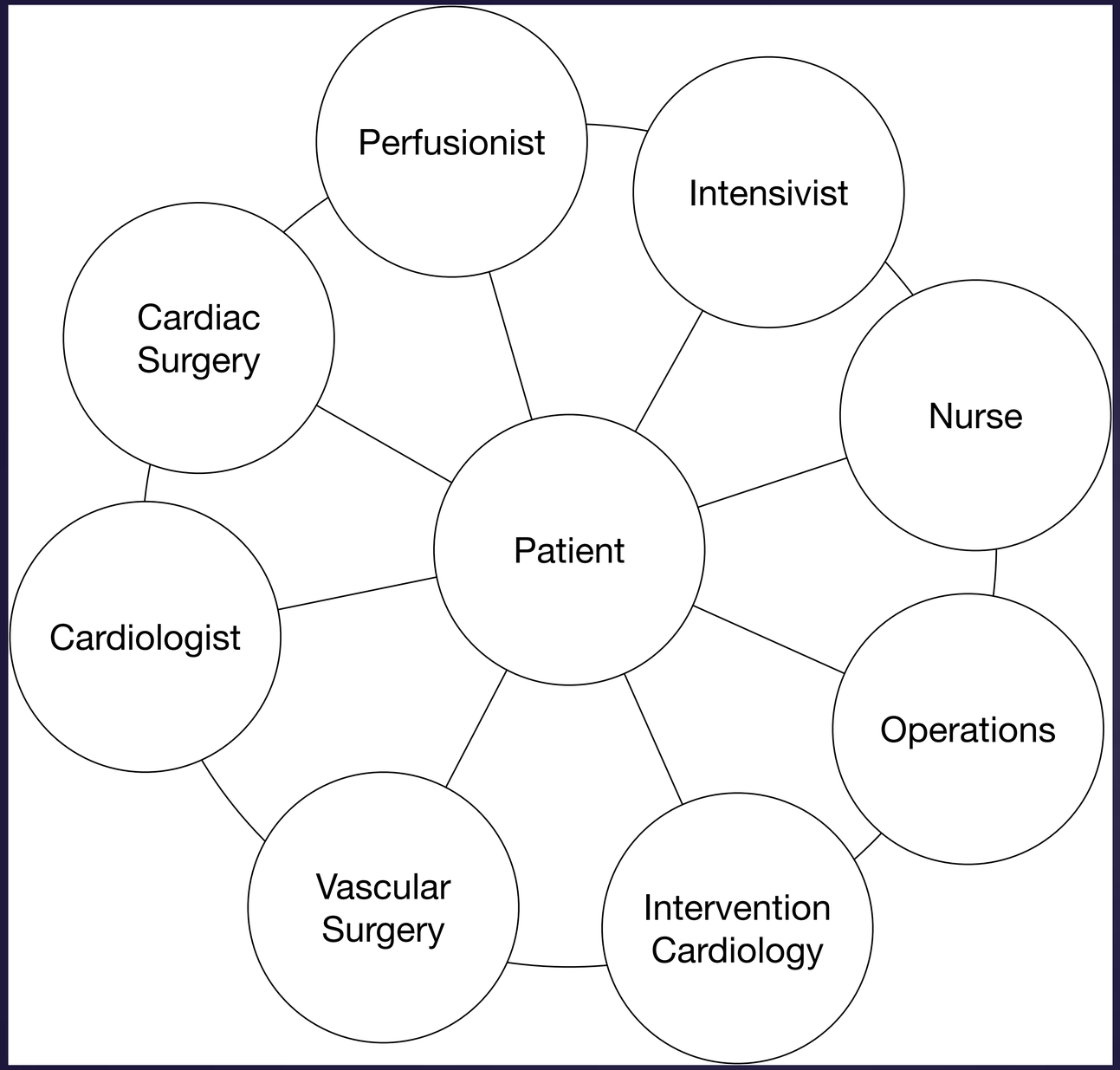
- Bleeding, bleeding, bleeding
  - 43% of patients
  - Cannulation / Surgical sites
  - Intracranial hemorrhage
  - Gastrointestinal hemorrhage

Problems (cont)

- Clotting including HIT
- Renal Failure
- Pump Thrombosis
- Mechanical Failure
- Limb ischemia
- Infection

Best Practices

- Consider ECMO Early
- Don’t Use the Lungs
- Minimize Sedation


Perfusionist
Intensivist
Cardiac Surgery
Nurse
Patient
Cardiologist
Operations
Vascular Surgery
Intervention Cardiology

Organized Program

- Daily Multidisciplinary Rounding
- Monthly multidisciplinary ECMO Conference
- Monthly Operational Meeting
- Level 1 ECMO Call System
- ECMO Database
- Credentialling
- Operational Committee

Culture of Safety

- Checklists
- Order sets
- Continous team training
- Simulation
- Review Your Work
- Partner with ELSO

Who to ECMO

Getting the Right Patient

- Toughest Part
- Somebondy will benefit from ECMO
  - Does ECMO fix the problem
  - Not too sick to benefit (duration, severity of organ failure)
- Comorbidities
- Has an “out” clause

Generally Favored (Respiratory)

- ARDS (PaO_2/FiO_2 100-150)
- Status asthmaticus
- Exacerbation of COPD ($PaCO_2$ >80, pH <7.15)
- Primary graft dysfunction following lung transplantation (within 7 days)
- Pulmonary vasculitis (Goodpasture's, ANCA-associated, Autoimmune)

Generally Favored (Cardiac)

- Myocardial infarction-associated cardiogenic shock
- Pulmonary embolism with cardiogenic shock
- Drug overdose with profound cardiac depression or arrhythmia
- Extracorporeal cardiopulmonary resuscitation
- Acute fulminant myocarditis
- Postcardiotomy or post-heart transplant cardiogenic shock
- Primary graft failure after transplant
- Bridge to VAD or transplant

Absolute Contraindications

- Uncontrolled active hemorrhage
- Terminal illness
- Irreversible or end-stage heart or lung failure in patients who are not candidates for transplant

Relative Contraindications

- More than 7 adys of mechanical ventilation
- Multiorgan failure (especially renal failure)
- Irreversible neurologic injury
- Malignancy, solid-organ transplant, or immunosuppresion
- Contraindications for anticoagulation

Softer Contraindications

- Advanced age
- Weight
- Pregnancy/Postpartum
- Trauma

Making the Decision

- Clinical Triggers for evaluation
- Decision support
- Often very limited time
- Often limited information
- Review all decisions
- Shares cases / Review Registry
- Be willing to be wrong

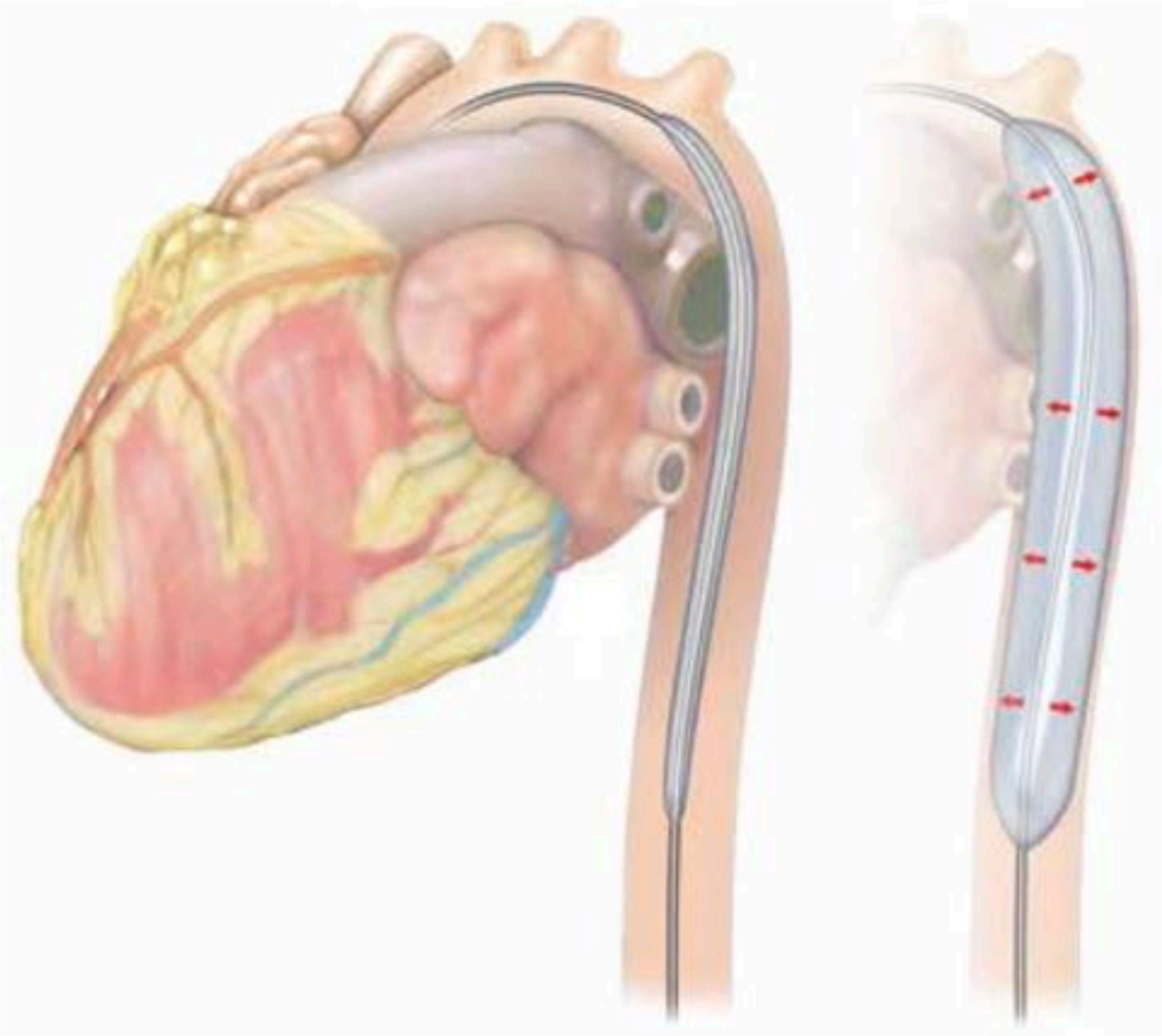
Should you ECMO

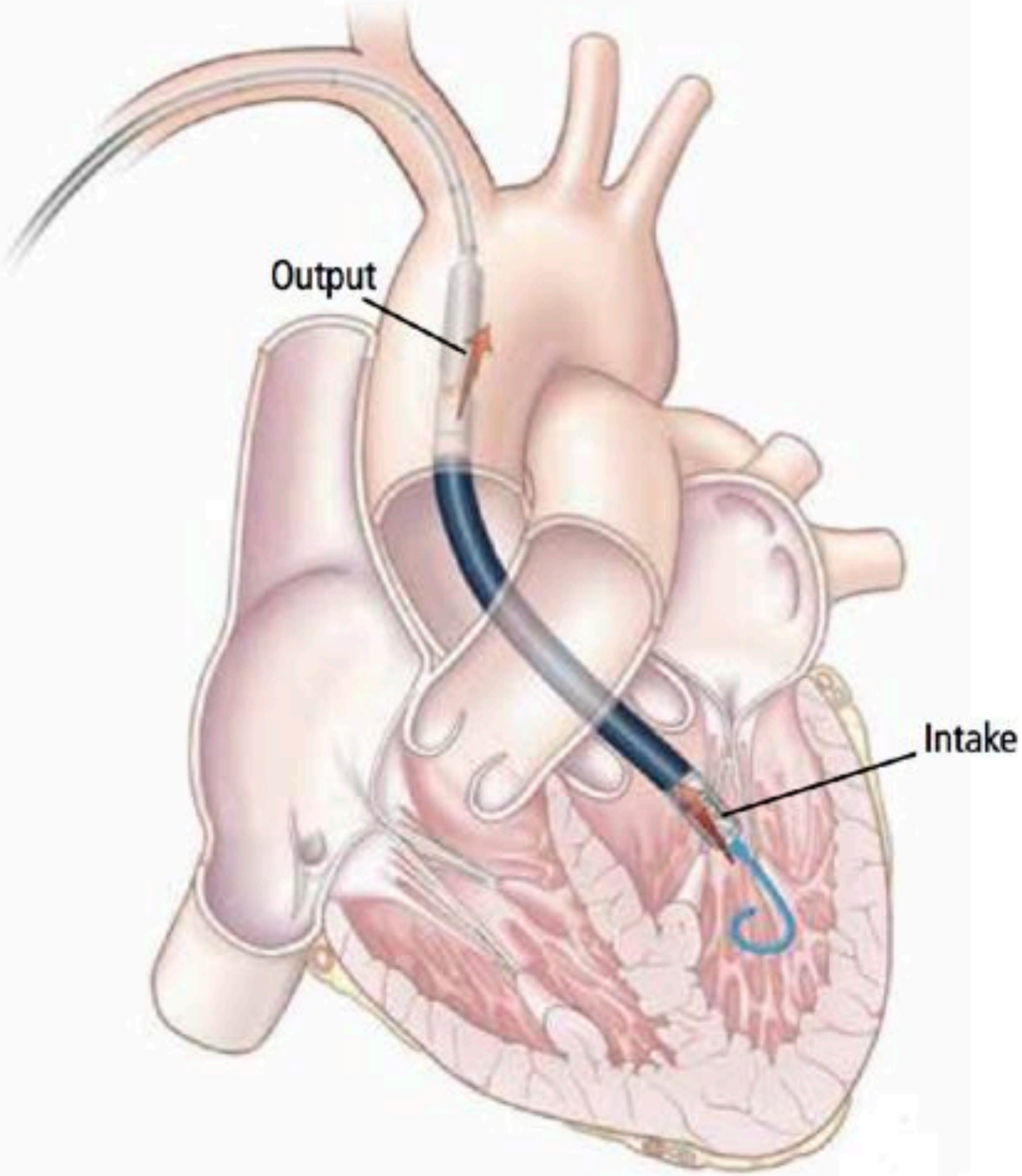
Getting the Ethics right

- How old is too old…or better yet…how young is too young?
- Concrete resuscitation cutoff vs. a graded response?
- Only Reverse the Reversible.
- Define “Quality of Life”. How do we determine “Quality of Life”? Who decides this in the heat of the moment? The doctor or the family?
- What is the real goal of resuscitation? Should we only resuscitate people who were previously healthy and have a chance of 100% recovery?
- MD paternalism vs. patient automony = “The Tyranny of Choice.”

Is ECMO the right device

- Refractory Cardiogenic Shock (RCS)
- ECMO
  - Quick placement for acute resuscitation
  - Reestablish perfusion
  - No left ventricular unloading
  - Generates high afterload
  - Impaired coronary perfusion
  - Regional hypoxia




Output
Intake

Is ECMO the right device

- Impella
  - Miniature rotary pump
  - Fully unloads left ventricle
  - Reduces EDV/EDP
  - Reduces myocardial oxygen demand

Key Points

- Two configurations are used in adults: venoarterial, which can provide cardiac or cardiopulmonary support; and venovenous, which provides respiratory support only.
- ECMO is used in adults who are at very high risk of death without it.
- Because ECMO patients must receive anticoagulation, bleeding is a common complication. Others are infection, renal failure, and thrombosis.
- ECMO may provide “lung rest,” allowing lower tidal volumes and pressures and lower fractions of inspired oxygen to be used in mechanical ventilation, strategies associated with lower mortality rates.

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ECLS Registry Report

International Summary

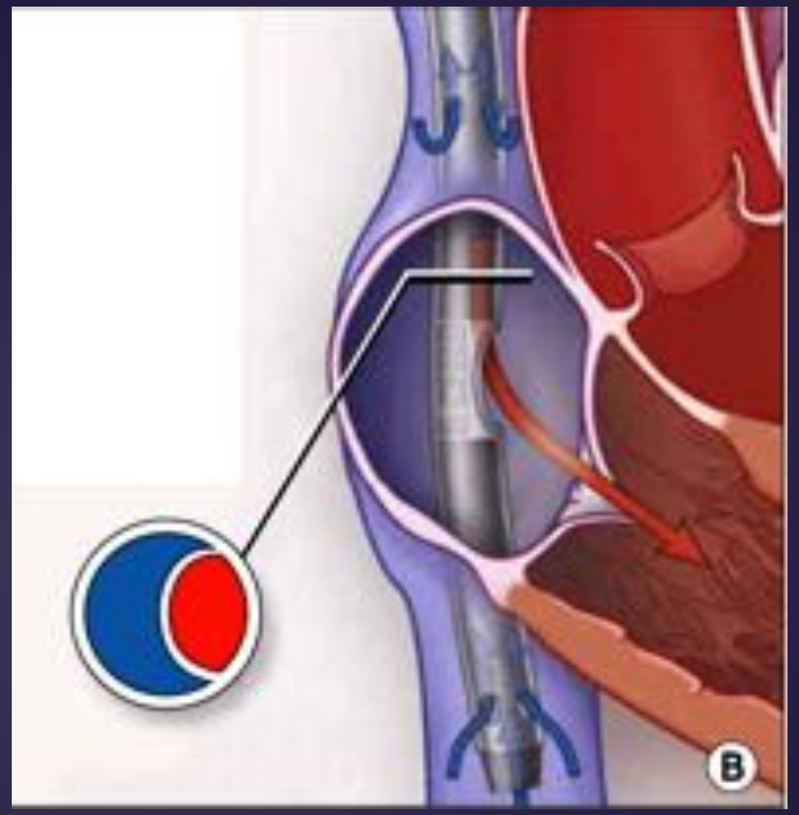
January, 2015

Extracorporeal Life Support Organization
2800 Plymouth Road
Building 300, Room 303
Ann Arbor, MI 48109

Overall Outcomes

	Total Patients	*Survived ECLS*		*Survived to DC or Transfer*	
Neonatal					
Respiratory	27,728	23,358	84%	20,592	74%
Cardiac	5,810	3,600	62%	2,389	41%
ECPR	1,112	712	64%	449	40%
Pediatric					
Respiratory	6,569	4,327	66%	3,760	57%
Cardiac	7,314	4,825	66%	3,679	50%
ECPR	2,370	1,313	55%	976	41%
Adult					
Respiratory	7,008	4,587	65%	4,026	57%
Cardiac	5,603	3,129	56%	2,294	41%
ECPR	1,657	639	39%	471	28%
Total	65,171	46,490	71%	38,636	59%

Avalon Catheter



What We Control

Variable	Importance	Initial Setting
Pump Speed (rpm)	*Blood flow: oxygenate and perfuse*	*To achieve 50-100 mL/kg/min*
Sweep gas flow rate	*Ventilate (CO_2)*	*1:1 gas:blood flow*
F_DO_2	*Analogous to F_IO_2*	*100% oxygen*
Mechanical ventilation	*Minimize lung injury*	*Lung rest*
Anti-coagulation	*Circuit clotting*	*UFH for ACT 180-200 or aPTT 60-80*

E-CPR

Author	Year	Region	Place	N	VF/VT	CPR to ECMO (min)	Survival	Neuro Intact Survival	Notes
Cardiac Arrest									
Chen YS[1]	2003	Taiwan	I	57	61%	48 ± 13		30%	
Shin TG[2]	2011	S. Korea	I	85	29%	42 ± 26		28%	
Haneya A[3]	2012	Germany	I O	59 26	29%	25 [20-50] 70 [55-110]		32%	
Kagawa E[4]	2012	Japan	I O	44 42	52% 55%	33 [25-50] 65 [50-78]		34% 14%	All had ACS, 94% got PCI
Bellezzo JM[5]	2012	San Diego	O	8	N/A	N/A		63%	Cannulation by ED docs on arrival
Fagnoul D[6]	2013	Belgium	I O	10 14	42%	55 [42-60] 67 [56-80]		N/A	
Maekawa K[7]	2013	Japan	O	53	60%	49 [41-59]		15%	
Stub D[8]	2014	Australia	I O	15 11	73% 100%	56 [40-85]		64% 36%	Protocol of mechanical CPR, early hypothermia, ECMO, and PCI
Accidental hypothermia w									
Wanscher M[9]	2012	Denmark	O	7	N/A	226 [178-241]		86%	Boating accident on fjord- teenagers
Ruttmann E[10]	2007	Austria	O	25	N/A	N/A		36%	Mainly drowning and avalanche victims