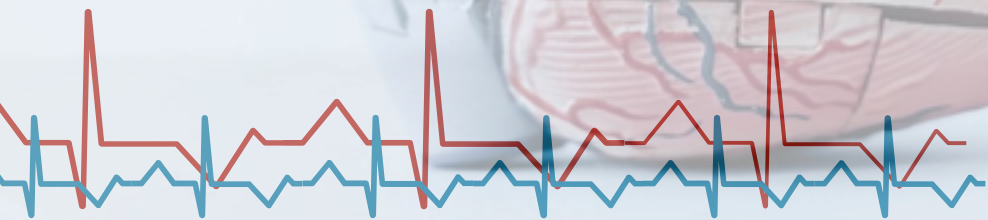
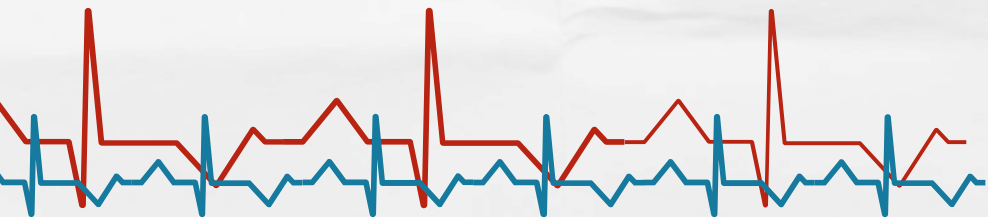


**In the name of GOD
The Compassionate
The Merciful**



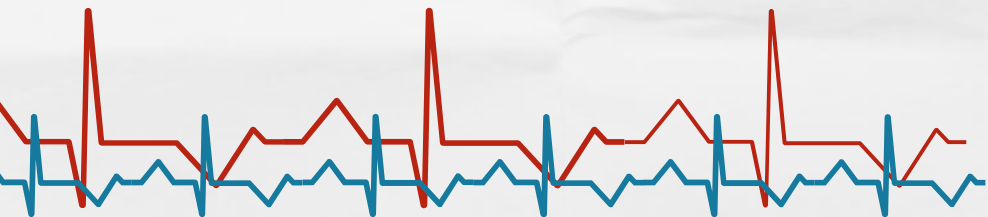
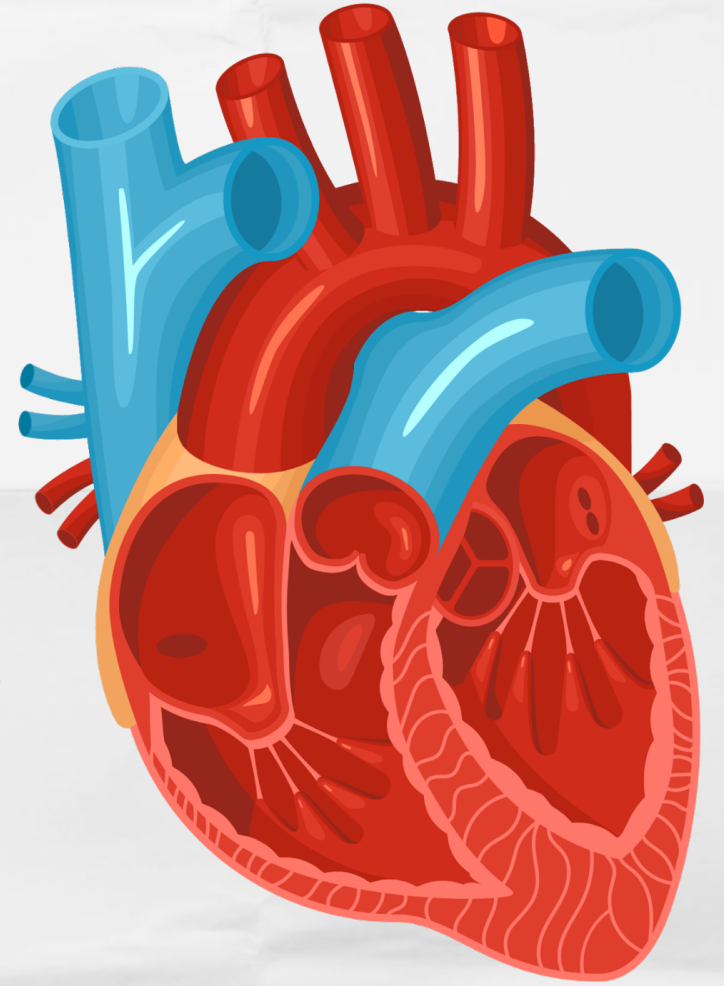
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Venovenous Extracorporeal Membrane Oxygenation

(VV ECMO)



Introduction



The use of venovenous extracorporeal membrane oxygenation (VV ECMO) in adults has rapidly increased worldwide. VV ECMO stands for veno-venous extracorporeal membrane oxygenation. It is a type of extracorporeal membrane oxygenation (ECMO) that provides temporary respiratory support to patients with severe respiratory failure. In VV ECMO, blood is removed from the patient's venous system, oxygenated in an artificial lung, and then returned to the venous system. This allows the lungs to rest and recover while the ECMO machine does the work of breathing.

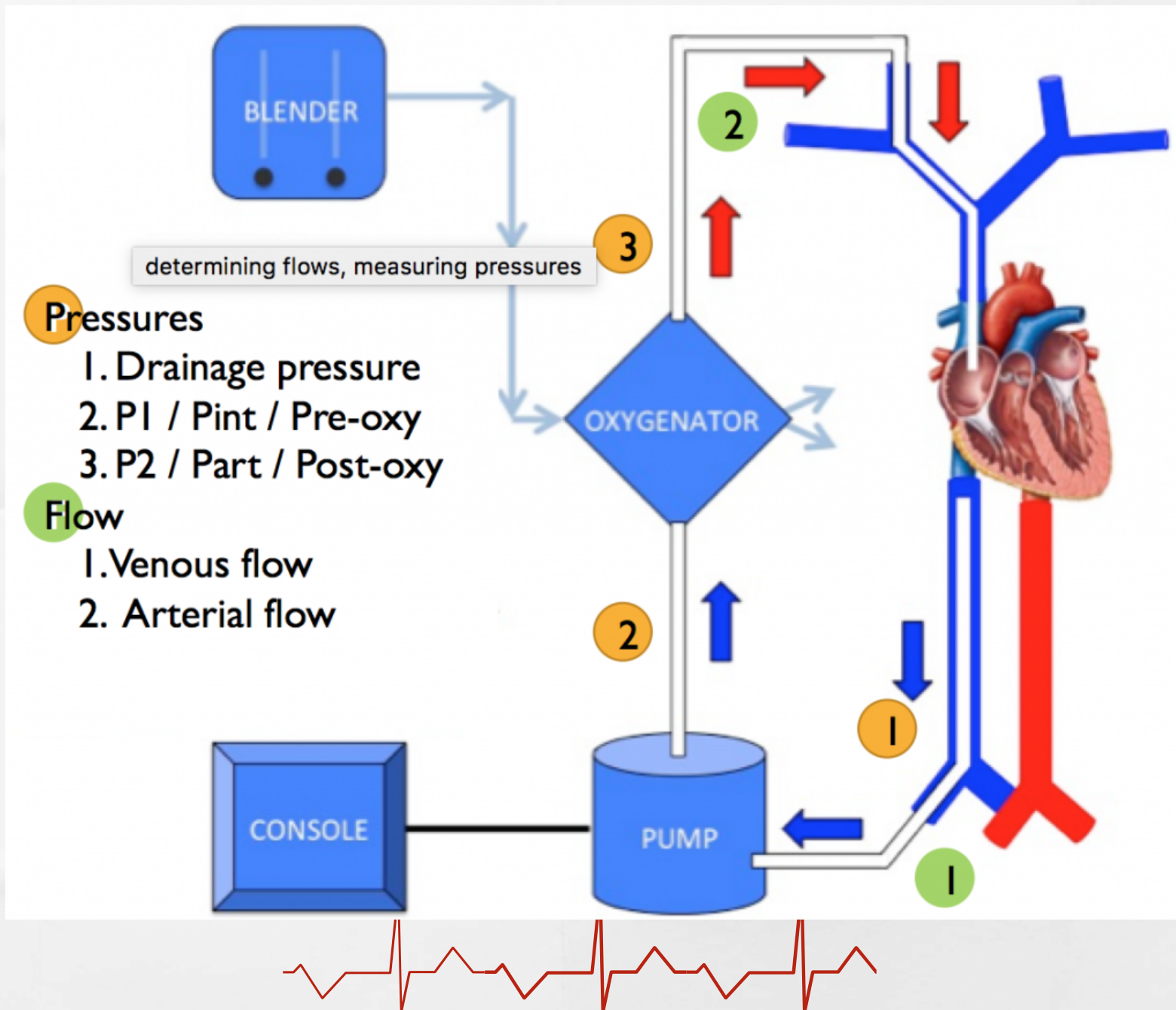


VV ECMO is typically used in patients who have failed conventional mechanical ventilation and are at high risk of death. It can also be used as a bridge to lung transplantation or as a temporary measure to allow patients to undergo other medical procedures.



The procedure to establish VV ECMO involves placing two canulae (thin tubes) into the patient's veins. One cannula is placed in the superior vena cava (SVC), which is a large vein that brings blood from the upper body to the heart. The other cannula is placed in the inferior vena cava (IVC), which is a large vein that brings blood from the lower body to the heart.





Introduction



The cannulae are then connected to an ECMO circuit, which consists of an oxygenator, a pump, and a heat exchanger. The oxygenator is a device that oxygenates the blood. The pump circulates the blood through the circuit. The heat exchanger warms the blood to the patient's body temperature.

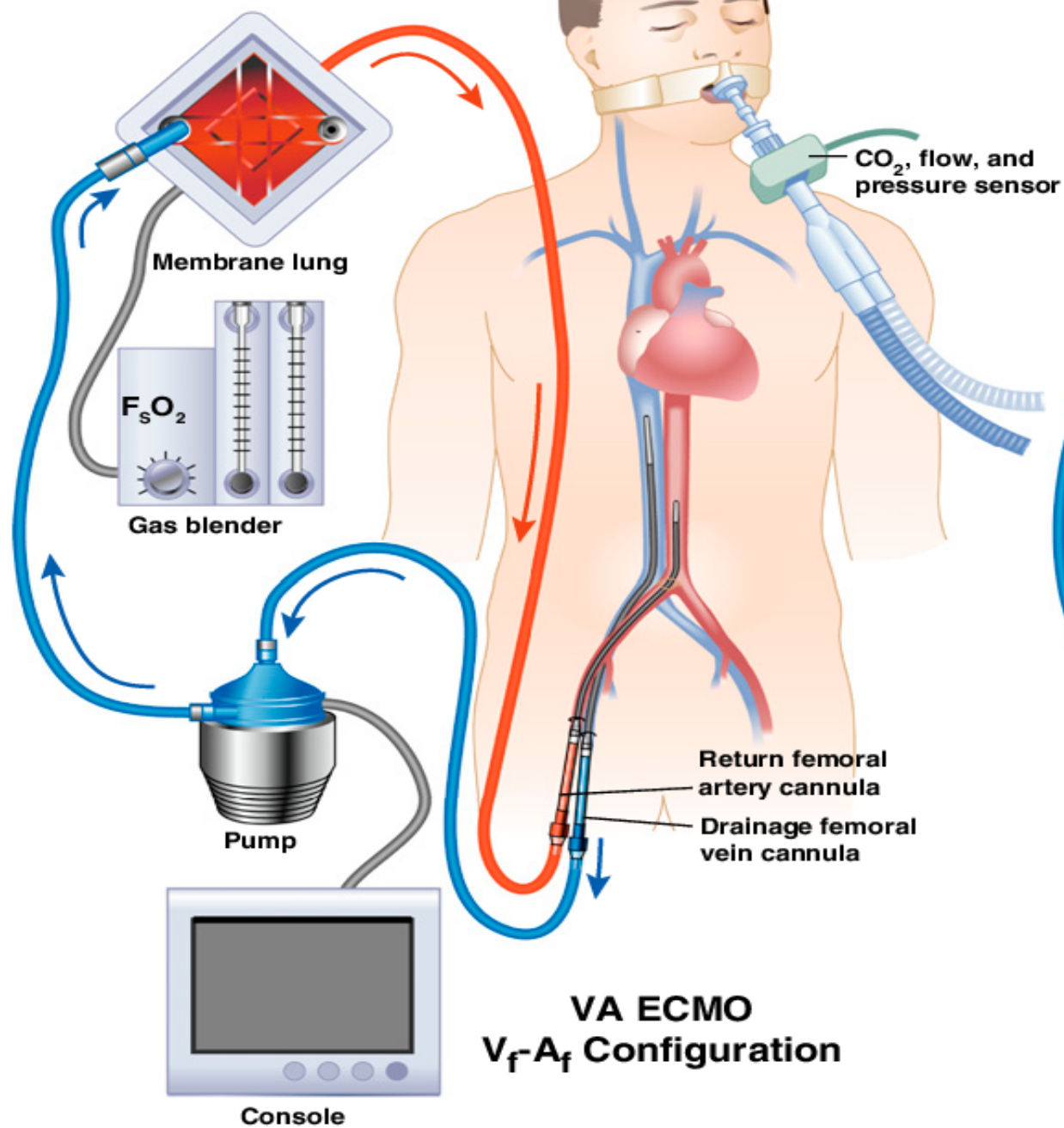
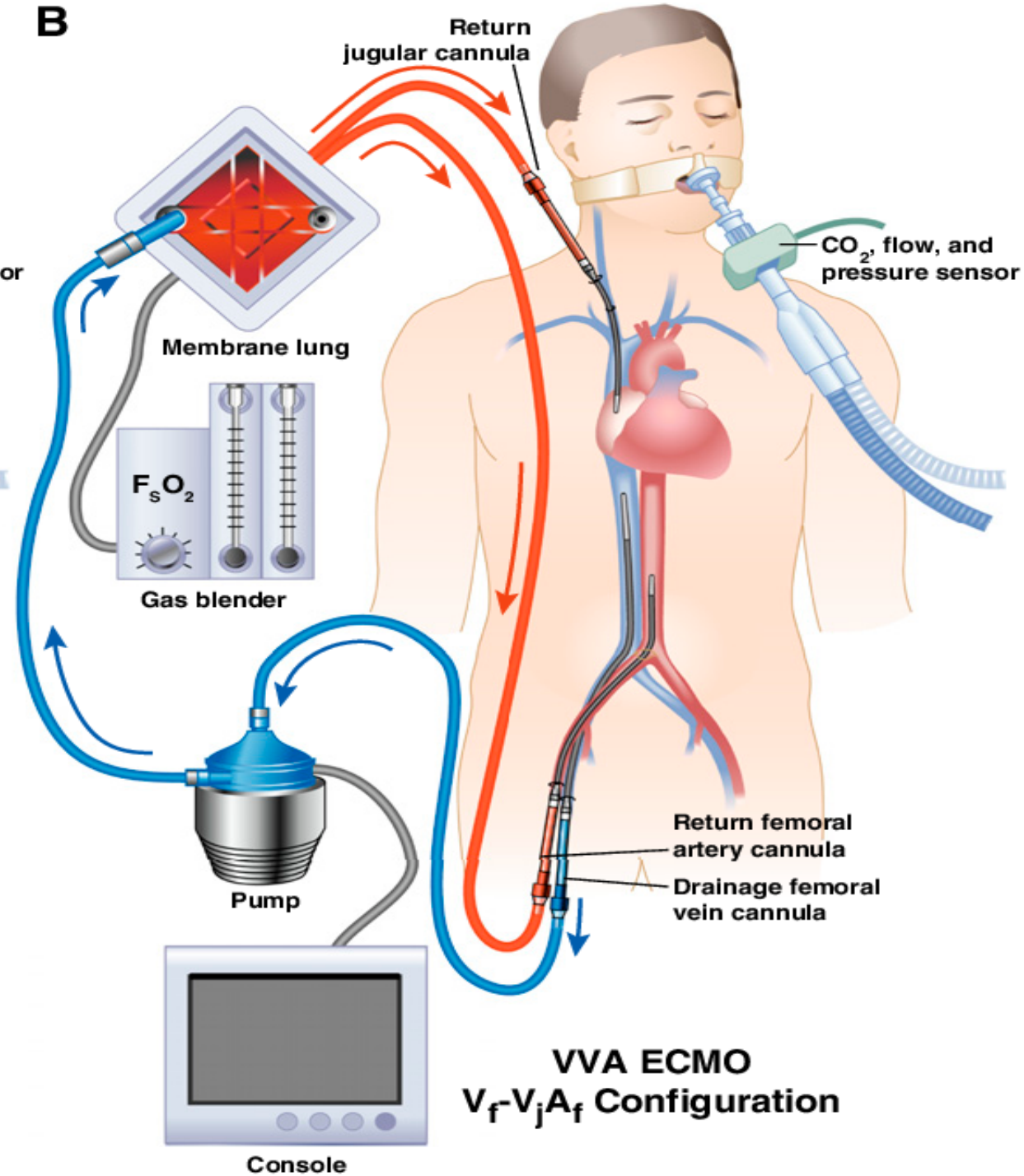


Once the ECMO circuit is in place, the patient is weaned from mechanical ventilation. The ECMO machine takes over the work of breathing, allowing the lungs to rest and recover.



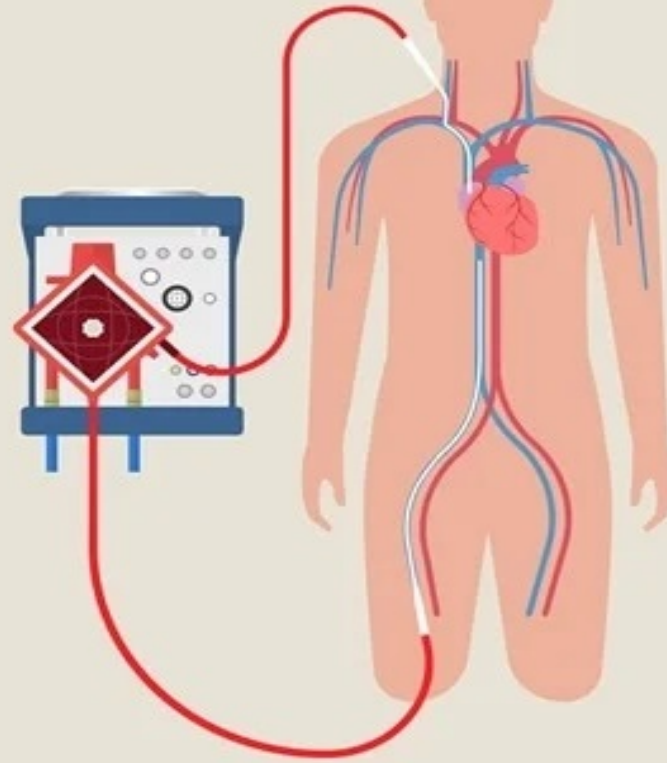
VV ECMO is a complex procedure with some risks, including bleeding, infection, and blood clots. However, it can be a life-saving treatment for patients with severe respiratory failure.



A**B**

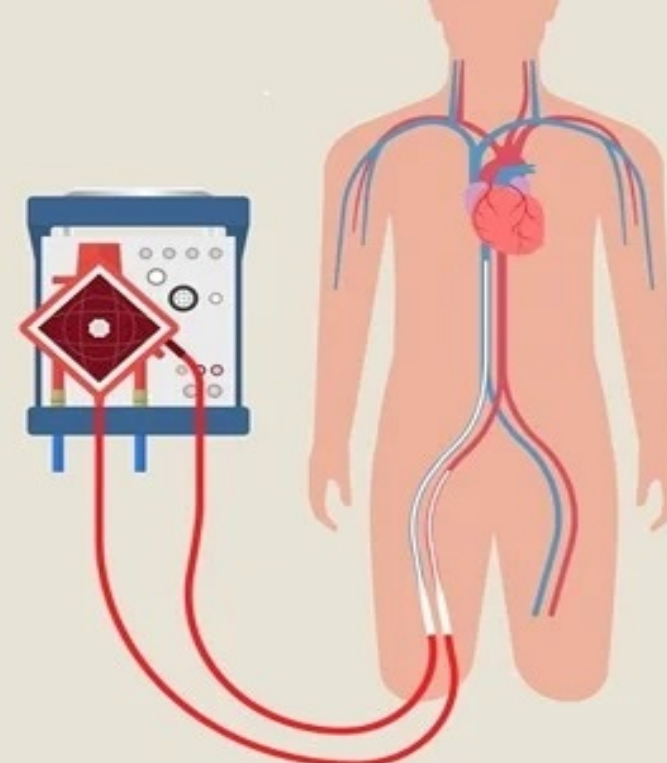
EXTRACORPOREAL MEMBRANE OXYGENATION

VV-ECMO



VENO-VENOUS (VV) ECMO

VA-ECMO



VENO-ARTERIAL (VA) ECMO



Indications for VV ECMO

1

Trauma

2

Acute respiratory
distress syndrome
(ARDS)

3

Severe
pneumonia

4

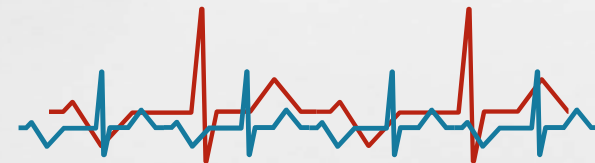
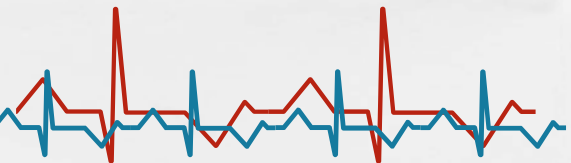
Poisoning

5

Heart failure

6

Near-drowning



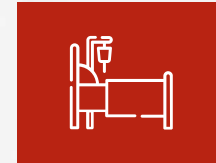
Benefits of VV ECMO



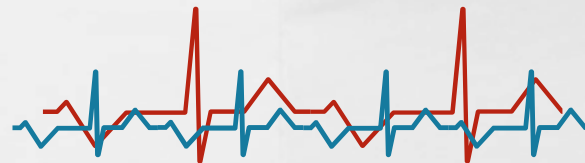
It can provide temporary respiratory support to patients who are at high risk of death.



It can be used as a bridge to lung transplantation.



It can allow patients to undergo other medical procedures that would be too risky without ECMO support.



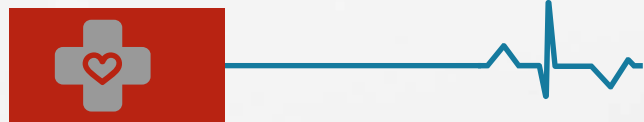
Risks of VV ECMO



Bleeding



Blood clots



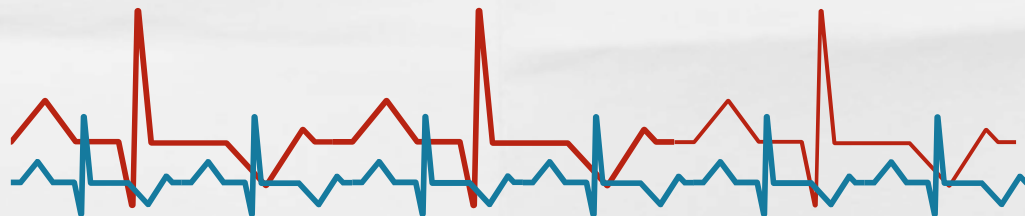
SMOKING



problems



Stroke



**key points from the ELSO guideline
on managing adult patients
supported with venovenous ECMO
(VV ECMO)
for respiratory failure**





Management of Adult Patients Supported with Venovenous Extracorporeal Membrane Oxygenation (VV ECMO): Guideline from the Extracorporeal Life Support Organization (ELSO)

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JOSE ALFONSO RUBIO MATEO-SIDRON, MD,¶ ASAD USMAN^{ID}, MD, MPH,|| AND EDDY FAN, MD, PhD#

Reviewers: NICHOLAS BARRETT, MBBS,** MATTHIEU SCHMIDT,†† THOMAS MUELLER, MD,‡‡ ALAIN COMBES, MD, PhD††
KIRAN SHEKAR, MBBS, PhD§§



Patient selection	Assess reversibility of respiratory failure, refractory hypoxemia ($\text{PaO}_2/\text{FiO}_2 < 80$ mmHg) or hypercarbia ($\text{pH} < 7.25$, $\text{PaCO}_2 \geq 60$ mmHg) despite optimal conventional treatment including prone positioning.
Cannulation	Options include femoral-IJ, bicaval dual lumen, or bifemoral cannulas. Use imaging guidance, size cannulas based on estimated cardiac output needs.
Ventilation	Use lung protective settings - plateau pressure ≤ 25 cmH ₂ O, PEEP ≥ 10 cmH ₂ O, RR 10-15, FiO_2 0.3-0.5. Provide rest while ECMO provides gas exchange.
Hemodynamics	Monitor for hypotension, right heart strain. Fluids, pressors/inotropes used as needed. Echocardiography helps guide management.
Anticoagulation	Follow separate ELSO anticoagulation guideline. Hold heparin 1 hour before decannulation.
Fluids	Initial fluid boluses to support ECMO circuit blood flow, then conservative fluid management and diuresis once stabilized.
Weaning	Assess oxygenation and ventilation reserve before weaning. Gradually reduce sweep gas flow, ECMO flow and FDO_2 while monitoring gases.
Duration	Average 9-14 days support, but may be 4+ weeks if improving or bridge to transplant.
Complications	Manage bleeding, hemolysis, thrombosis, limb ischemia, infection per ELSO Red Book.



For more info:
ECMO circuit flow/hemoglobin.

Table 3. Recommended Mechanical Ventilation Settings During Adult VV ECMO

Parameter	Acceptable Range	Recommendation	Comments
Inspiratory plateau pressure (P_{plat})	≤ 30 cm H ₂ O	< 25 cm H ₂ O	Further reductions in P_{plat} below 20 cm H ₂ O may be associated with less VILI and improved patient outcomes ²⁴⁻²⁶
PEEP	10–24 cm H ₂ O	≥ 10 cm H ₂ O	Reductions in P_{plat} and tidal volume may lead to atelectasis without sufficient PEEP; PEEP can be set according to various evidence-based methods (e.g., ARDSNet PEEP- F_{iO_2} table or Express trial strategy) while maintaining the P_{plat} limit ²⁷
RR	4–30 breaths/min	4–15 breaths/min (set RR) or spontaneous breathing	CO ₂ elimination is being provided primarily by VV ECMO, reducing the need for high minute ventilation (which may be associated with more VILI)
FiO ₂	30–50%	As low as possible to maintain saturations	Oxygenation is being provided primarily by VV ECMO, reducing the need for high F_{iO_2} from the ventilator unless required to maintain adequate oxygenation

ARDS, acute respiratory distress syndrome; PEEP, positive end-expiratory pressure; RR, respiratory rate; VILI, ventilator-induced lung injury.

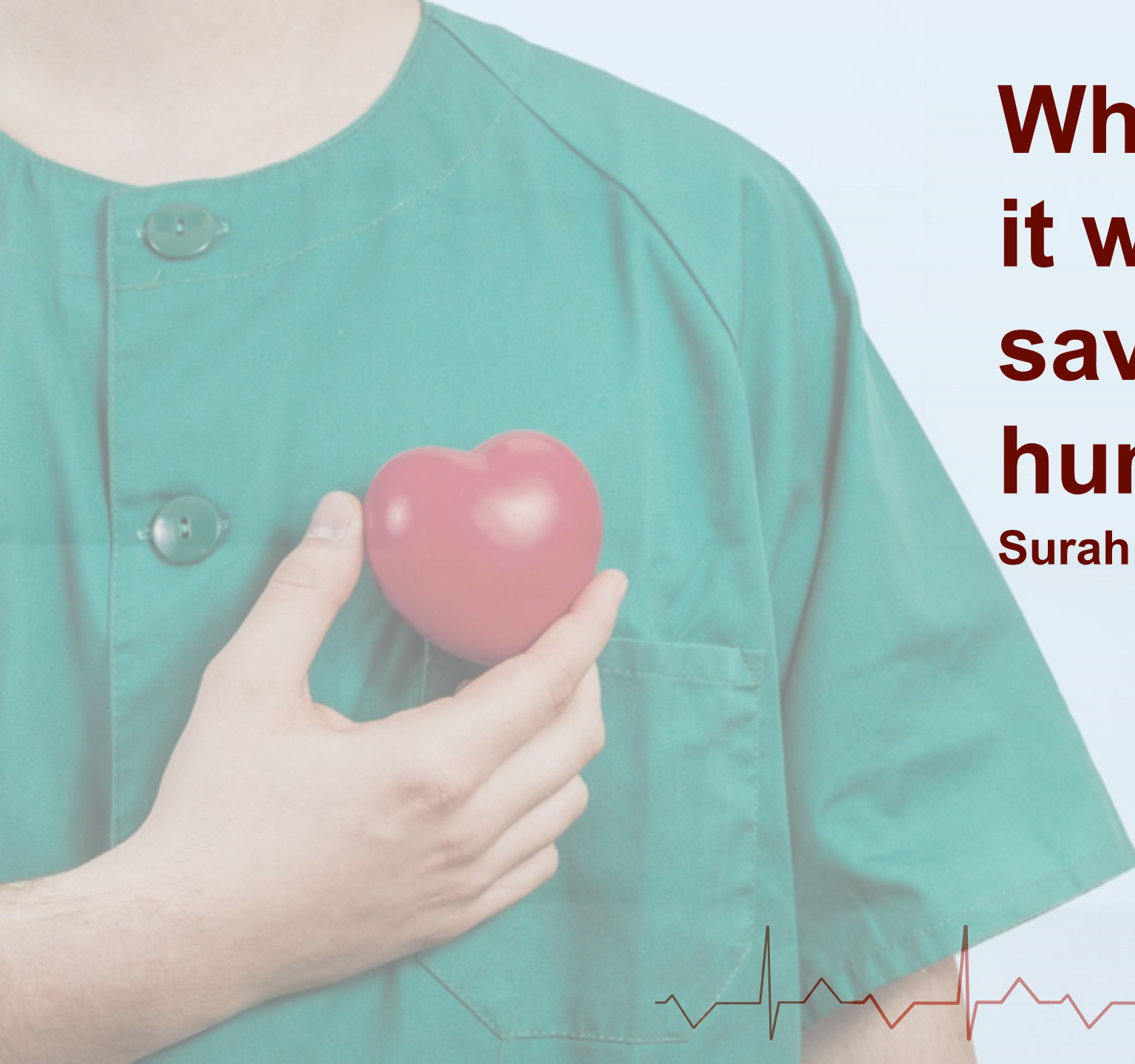


Table 4. Ventilatory Strategies From Recent Clinical Trials for Adult VV ECMO

	CESAR ²	EOLIA ¹	
Ventilatory mode	PCV	V-AC	APRV
Set parameter	10 cm H ₂ O above PEEP	V_T for $P_{plat} \leq 24$ cm H ₂ O	$P_{high} \leq 24$ cm H ₂ O
PEEP (cm H ₂ O)	10	≥ 10	≥ 10
Respiratory rate (breaths/min)	10	10–30	Spontaneous
FiO ₂	0.30	0.30–0.50	0.30–0.50

APRV, airway pressure release ventilation; FiO₂, fraction of inspired oxygen; PCV, pressure controlled ventilation; PEEP, positive end-expiratory pressure; V_T , tidal volume; V-AC, volume-assist control ventilation.



A person wearing green medical scrubs is holding a red heart-shaped object against their chest. The background is a light blue wall with a white door.

**Whoever saves a life
it will be as if they
saved all of
humanity.**

Surah Al-Ma'idah - 32 - Quran



Factors affecting recirculation



Cannula configuration and positioning

The background of the slide features a faint, light blue image of an ECMO cannula on the left side. In the center, there is a large, semi-transparent red heart with a white cross, resembling the Swiss flag. A blue ECG line is positioned above the title, and a red ECG line is at the bottom of the slide.

- In two-site venovenous ECMO with femoral and internal jugular cannulation, the reinfusion jet is directed toward the drainage port.
- When the drainage and reinfusion cannulae are in closer proximity, one can expect a higher amount of recirculation.
- Changes in patient positioning may likewise affect the amount of recirculation, though this relationship is less predictable.

Pump speed, cannula size, and extracorporeal blood flow



- Increases in pump speed and ECMO blood flow rate correlate with increases in recirculation, with varying relationships depending on cannula type, size, and position, and method used to measure recirculation.
- The use of larger canulae may mitigate the amount of recirculation by allowing for higher blood flow rates with less negative venous pressure in the drainage limb.

Changes in intra-thoracic, intra-cardiac, and intra-abdominal pressures

- Increases in intra-thoracic and intra-cardiac pressure (i.e. pneumothorax, pericardial tamponade) will impede venous return to the heart, which may preferentially direct reinfused extracorporeal blood flow toward the drainage cannula, increasing recirculation.
- Extreme elevations in these pressures may lead to cessation of extracorporeal blood flow altogether. Effects on increased intra-abdominal pressure are less well defined.

Direction of ECMO blood flow

The background of the slide features a medical illustration. On the left, a blue ECMO circuit with a white cannula is shown. In the center, there is a faint, light red graphic of a heart with a white cross over it. A blue ECG line is positioned below the title, and a red ECG line is on the right side of the slide. At the bottom, there is a red ECG line.

- In two-site venovenous ECMO with femoral and internal jugular cannulation, the direction of drainage and reinfusion impacts the amount of recirculation.
- Femoral drainage and atrial reinfusion via the internal jugular vein (femoro-atrial flow) results in less recirculation than femoro-atrial flow, making femoral drainage and atrial reinfusion the preferred direction of blood flow for this configuration.

Identifying and quantifying the amount of recirculation

Percent recirculation is quantified by the following equation:

$$\text{Recirculation (\%)} = (\text{SpreO}_2 - \text{SvO}_2) / (\text{SpO}_2 - \text{SvO}_2) \times 100$$

SvO₂ is difficult to measure because of the presence of reinfused oxygenated blood. Several methods have been used to quantify the amount of recirculation. **None of these methods has been definitively shown to accurately measure the percent recirculation**, though trends in each of these values, in conjunction with assessments in SaO₂, may be useful in identifying changes in the amount of recirculation and, therefore, efficiency of the ECMO circuit over time.

Method of estimating % recirculation	Description
CVL ^{*4,11,12}	Formula: $(S_{pre}O_2 - SvO_2)/(S_{post}O_2 - SvO_2) \times 100$ SvO ₂ estimated by measuring venous saturation of blood from SVC or IVC via central venous catheter
SvO ₂ ^{*4,5,11}	Formula: $(S_{pre}O_2 - SvO_2)/(S_{post}O_2 - SvO_2) \times 100$ SvO ₂ = S _{pre} O ₂ when sweep gas turned off and ventilator used to achieve an equivalent SaO ₂
Ultrasound dilution ^{#12}	Saline injected into reinfusion limb; ultrasound sensor detects differences in dilution between drainage and reinfusion limb
Thermodilution ^{#6}	Cold saline injected into reinfusion limb; thermistor-tipped catheter detects changes in temperature in drainage limb
Trending S _{pre} O ₂ ^{#13,14}	Observation of changes in S _{pre} O ₂ and SaO ₂ over time; increasing SpreO2 and decreasing SaO2 suggest clinically relevant recirculation

Table 1. Methods of estimating the amount of recirculation



Alterations in ECMO circuit configuration



Use of a bicaval, dual-lumen cannula

- Bicaval dual-lumen canulae permit venovenous ECMO via a single venous access site. When properly positioned, which usually requires both echocardiographic and fluoroscopic guidance, drainage ports are located in the SVC and IVC and the reinfusion jet is directed toward the tricuspid valve.
- Recirculation with this configuration may be as low as 2%, although malposition of the cannula may significantly increase the rate of recirculation.
- Any adjustment of the cannula after its initial insertion should be done under echocardiographic guidance to ensure appropriate orientation of the reinfusion jet.



Addition of a drainage cannula

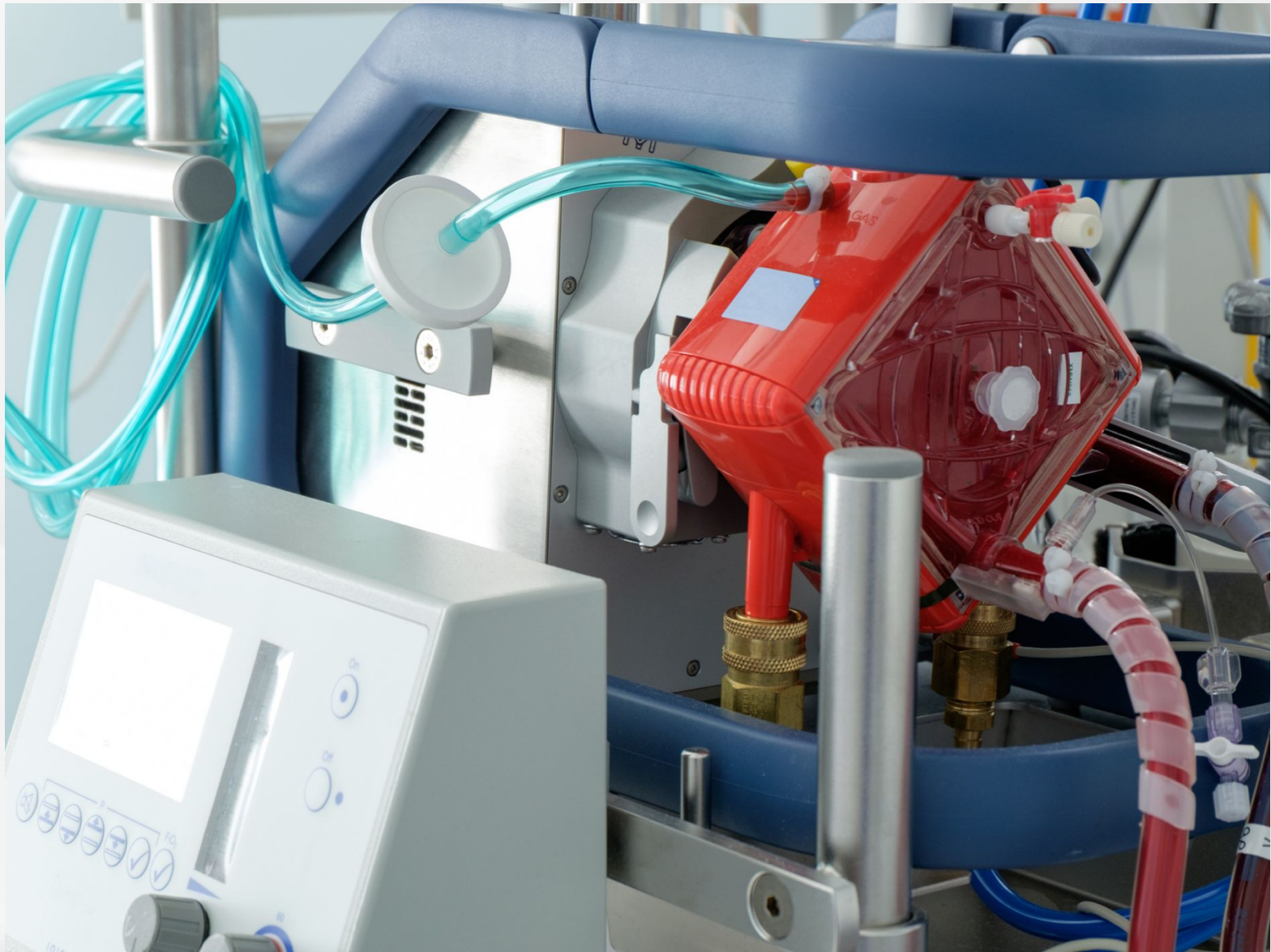
- Given the relationship between pump speed, negative venous pressure and recirculation, an additional drainage cannula may permit comparable blood flow rates to be achieved at lower pump speeds and at less negative pressure, thereby lowering the amount of recirculation.



Manipulation of the reinfusion cannula

- Attempts have been made to alter the reinfusion cannula in a two-site configuration in order to direct the reinfusion jet toward the tricuspid valve, with or without simultaneous repositioning of the drainage cannula. Given the limited data, such approaches are not generally recommended.





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CPR and ECMO: The Next Frontier

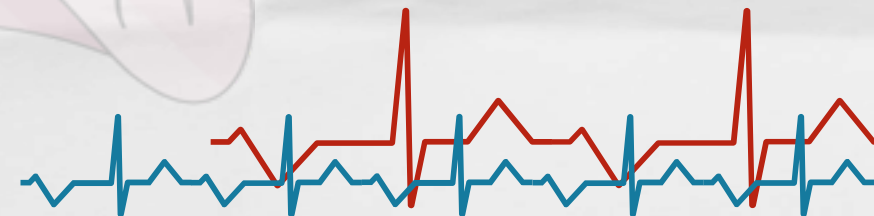
Daniel I. Ambinder, M.D., Matt T. Oberdier, Ph.D.,
[...], and Henry R. Halperin, M.D., M.A.



CONCLUSION



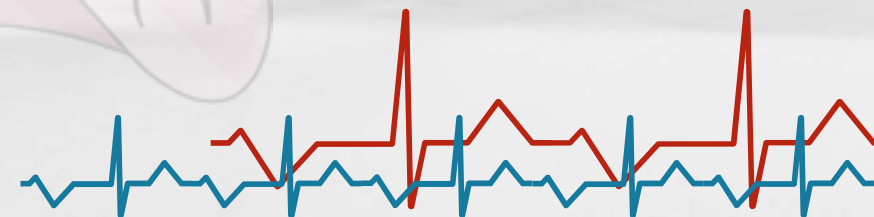
- There are two common configurations of ECMO which enable customization of support for each patient.
- In general, for respiratory support during which oxygenation is affected, such as with severe refractory acute respiratory distress syndrome, veno-venous ECMO (VV-ECMO) can be used to remove deoxygenated blood from the venous system, pass it through an oxygenator, then return the oxygenated blood into the circulation via the venous system.
- However, in cases of cardiac failure during which oxygenated blood is not adequately circulated throughout the body, additional support can be obtained through veno-arterial ECMO (VA-ECMO).



CONCLUSION



- There are abundant opportunities to improve future sudden cardiac arrest outcomes via progress in research and technology of ECMO, and through the synergy of CPR, ECMO, and therapeutic hypothermia.
- These advances will ultimately result in ECMO being more commonly utilized for sudden cardiac arrest at a larger distribution of clinical sites by a more broadly trained pool of providers.
- Organ transplant recipients may also benefit from expanded ECMO application that includes sudden cardiac arrest.



THANKS

DO YOU HAVE ANY
QUESTIONS?

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