MTIS MIAMI TRANSPLANT INSTITUTE SYMPOSIUM 2026

Transplant Critical Care:
Devices and Drugs
2025-2026

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Extracorporeal Membrane Oxygenation in Liver Transplantation: Mayo Clinic Experience—A Case Series and Review

Pramod K. Guru,* Anek Jena,* Himanshi Banker,* Swapna Sarangi,* Devang Sanghavi,* Philip Lowman,* Juan Canabal,* Sean Kiley,* Stephen Aniskevich,† Ryan Chadha,† Archer Martin,† Burcin Taner,‡ Basar Sareyyopoglu,§ Si Pham,§ John Haney,§ Pablo Moreno Franco,* Anirban Bhattacharyya,* and Sanjay Chaudhary*

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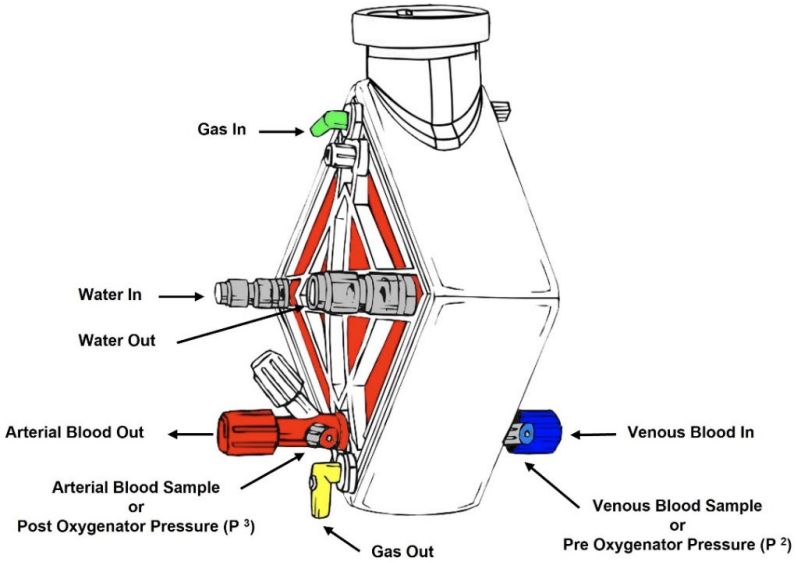
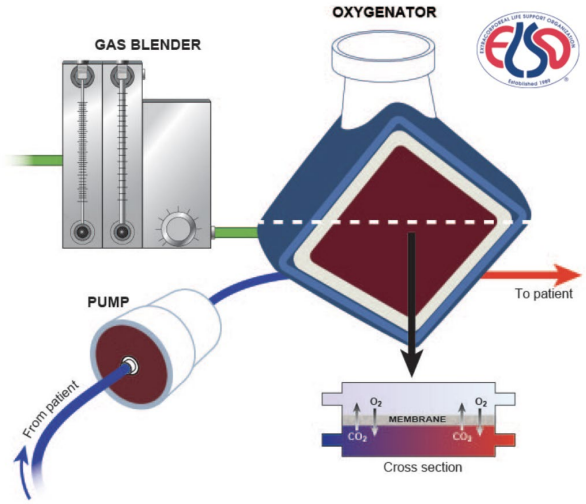
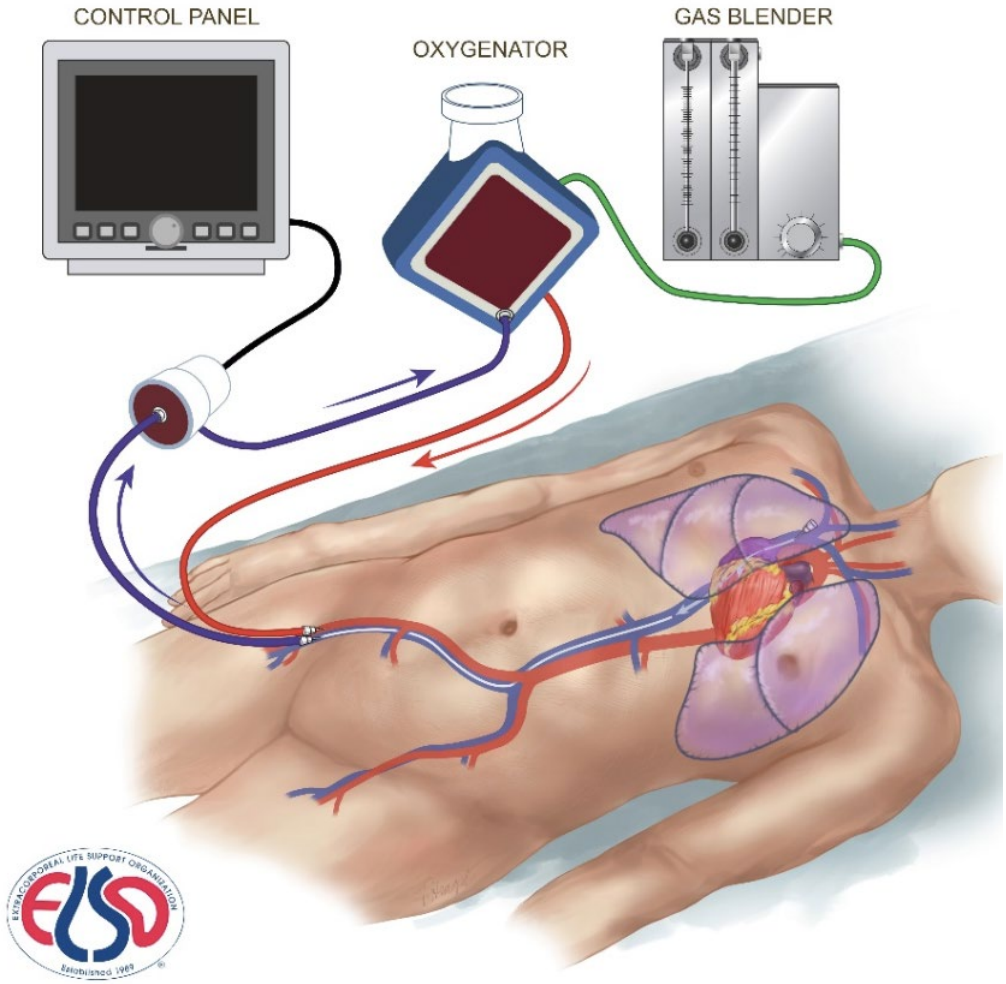
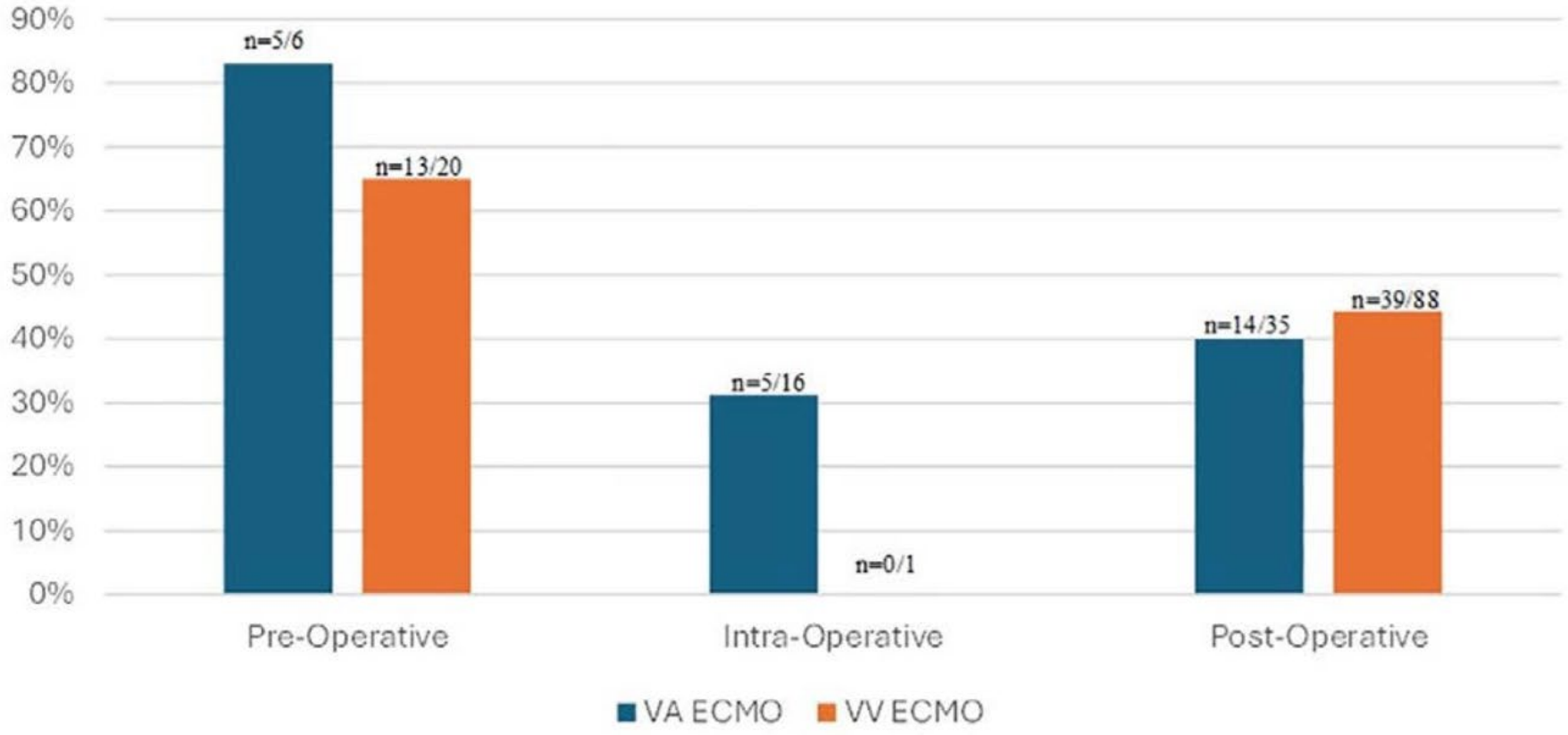






https://www.elso.org/extracorporeal-membrane-oxygenation.aspx

Survival Rate of LT Patients supported by ECMO based on Type of ECMO



ECMO for Postoperative Liver Transplant

MCS is rare, with poor evidence, largest study in North America from high volume center shows < 1% of patients required support (15/1559 patients required ECMO)

Only 0.4% required VV ECMO, mostly due to ARDS

VV ECMO post-op survival of 43% in pooled organs, contrast from 65% Medical ARDS ECMO.
22% difference in survival is almost always Clinically Significant.

ECMO in hepatic failure/transplant presents challenges: hemodynamics, immunosuppression, infection, coagulopathy, cardiomyopathy

No RCT/formal guidelines exist for this population. ? Time to consider

Other High Risk Immunocompromised Patients

Not all immunocompromised patients have worse outcomes

Pooled solid organ transplant patients do not have worse outcomes

HIV ARDS revealed 67% survival in literature

60% of patients with AIDS and PJP pneumonia survived to decannulation

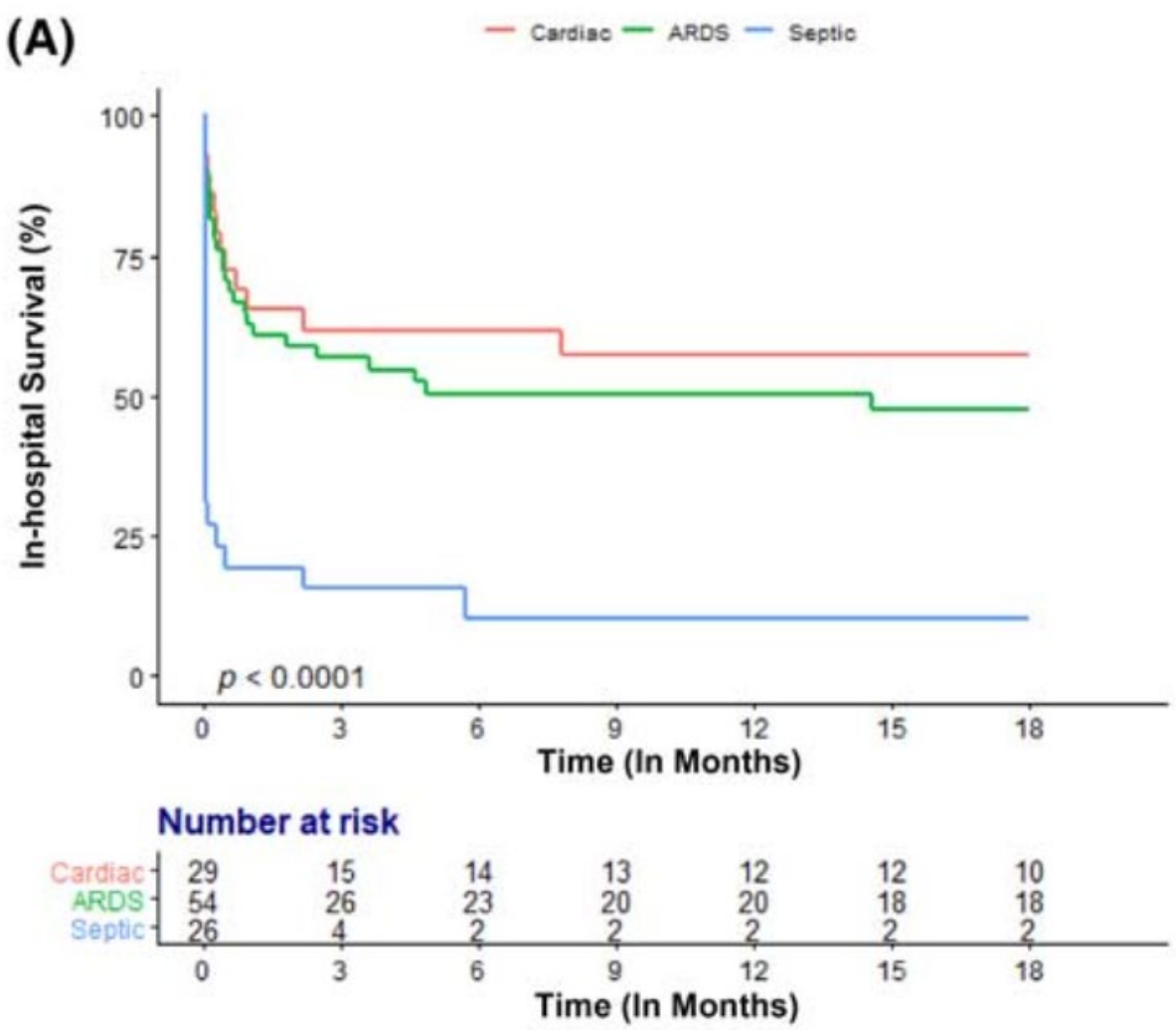
Postoperative Liver ECMO prognostication

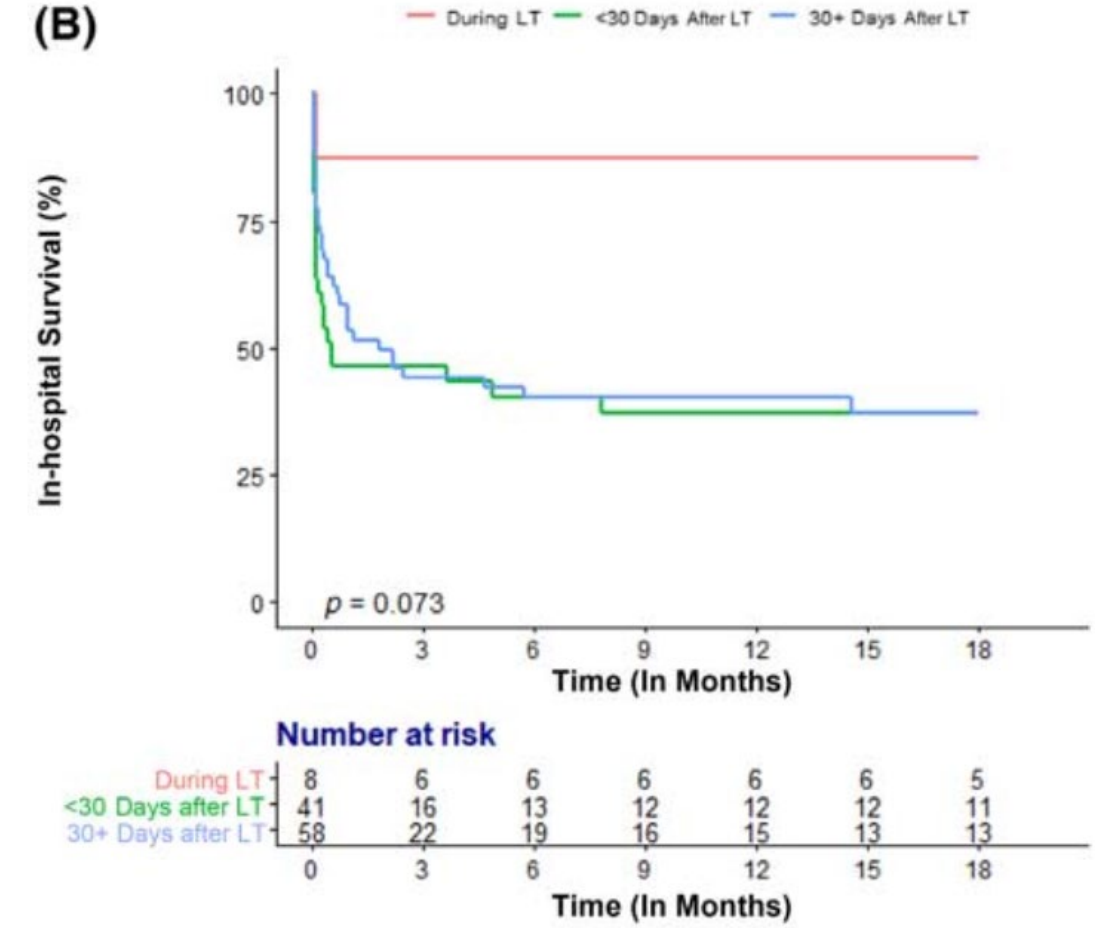
No validated risk calculators, RESP and Murray score not validated

PF ratio associated with worse outcome

Septic shock, prior ECMO treatment and bilirubin > 5 mg/dL associated with worse outcomes in perioperative period

Poor outcomes may be related to coagulopathy, immunosuppression, infection, hepatopulmonary syndrome, and coagulopathy





VA VV

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Postoperative Liver Transplant VV ECMO

ARDS management in post liver transplant is challenging and evidence is limited

ECMO for post liver transplant associated with suboptimal outcomes

Better patient selection is needed and clinicians are prone to bias, strong preference for ECLS overall, no patients declined for futility in single center study

Data is scant and limited to case series/reports

Formal guidelines do not exist and better evidence is needed for patient selection

Improving Decision-Making in Post Liver Transplant Venovenous ECMO Initiation

Gabriel Lowenhaar MD, Segun Olusanya Bsc BM, Vighnesh Venkatasamy MD, Pramod Guru MD, Jeffrey Scott DO MBA

Objectives:
ECMO is infrequently used after liver transplant, with post-transplant V-V ECMO seen in approximately 0.4% of liver transplant patients. Currently, no formal guidelines exist for decision making and evidence is limited. We aim to share our experience and discuss the various challenges and factors affecting postoperative ECLS.

Methods:
Case report and literature review.

Results:
A 65-year-old man with decompensated alcoholic cirrhosis, hepatorenal syndrome, hepatic hydrothorax, COPD, and diabetes underwent liver transplantation. Postoperatively, he experienced delayed fascial closure, a biliary leak, and worsening hypoxemia requiring mechanical ventilation. Suspecting ARDS from infection and hydrothorax, V-V ECMO was initiated on postoperative day 3. He unfortunately succumbed to his illness due to Klebsiella infection, presumed disseminated strongyloidiasis, and syphilis.

ECLS after liver transplantation presents unique challenges in selecting appropriate support and defining goals. Most data come from small studies or case reports. Key concerns are immunosuppression, infection risk, and coagulopathy. Survival is lower when ECMO is started post-transplant—about 43% for V-V ECMO, compared to 65% in ARDS patients. No validated decision tools exist for this group. Worse outcomes are linked with septic shock, prior ECMO, and bilirubin ≥5.0 mg/dL. Immunocompromised status increases mortality, but outcomes vary by cause; solid organ transplant recipients do not show significantly higher mortality. High-risk immunosuppressed groups can fare better than liver transplant recipients. For example, survival rates were 67% in HIV ARDS patients and 60% in AIDS/PJP pneumonia cases treated with V-V ECMO. Post-liver transplant patients face specific challenges not observed in other high-risk populations.

Conclusion:
Liver transplant patients pose distinct challenges. Postoperative ECMO leads to poorer outcomes. Careful patient selection is key for ECLS benefit, but perioperative bias may affect clinicians' decisions. In the absence of formal guidelines, involving an impartial third party could help reduce cognitive bias and improve candidate selection.

Innovative Use of VV ECMO in Multivisceral Transplantation for Cirrhotic Patients with Diffuse Portomesenteric Thrombosis: Technique Modification and Early Experience

Vighnesh Venkatasamy MD, Jeffrey Scott DO MBA, Gabriel Lowenhaar MD

Objectives:
Multivisceral transplantation(MVT) in cirrhotic patients with diffuse portomesenteric thrombosis (PMT) is among the most technically demanding abdominal procedures. It is often complicated by severe portal hypertension, diffuse varices, and massive intraoperative bleeding. Patients are at risk for ventilator-induced lung injury during large-volume resuscitation and fluid shifts. While extracorporeal membrane oxygenation (ECMO) is an established treatment option in cardiothoracic and critical care settings, its intraoperative role in abdominal transplantation remains poorly defined.

Methods:
We conducted a retrospective single center case series of four cirrhotic patients with diffuse PMT who underwent MVT supported by intraoperative veno-venous (VV) ECMO at a single institution between 2023-2024. We report outcomes of interest which include intraoperative and 1 year survival, thromboembolic complications, and intensive care unit(ICU) length of stay(LOS). Secondary outcomes include transfusion requirements, graft function, and acute rejection.

Results:
VV ECMO was initiated prior to laparotomy in all patients. To maintain operative access, we implemented a modified femoro-jugular cannulation strategy, positioning the femoral drainage cannula tip just superior to the renal veins rather than the conventional cavo-atrial positioning. VV ECMO maintained oxygenation and CO_2 clearance, mitigating ventilator-induced lung injury during large-volume resuscitation. No embolic or device-related bleeding occurred. All patients survived intraoperatively and > 1 year postoperatively. Average ICU LOS was 46 days. One patient required emergent decannulation for cannula thrombosis and later underwent repeat MVT for an unrelated early graft failure. The remaining grafts in the other patients functioned well. Average blood transfusion requirements was 218 units of blood products intraoperatively.

Conclusion:
To our knowledge this is the first and largest descriptive case series of this kind. In carefully selected, high-risk MVT recipients, intraoperative VV ECMO can safely provide gas exchange and hemodynamic buffering during reperfusion without compromising venous return. Modified positioning preserved surgical access of the retrohepatic IVC, facilitating complex caval control. Larger studies are warranted to refine indications and safety, but, our study illustrates promising outcomes for perioperative ECMO in this population.

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Journal of Intensive Care Article in Press

Inhaled nitric oxide for acute respiratory distress syndrome in adults: a systematic review and meta -analysis

02 January 2026

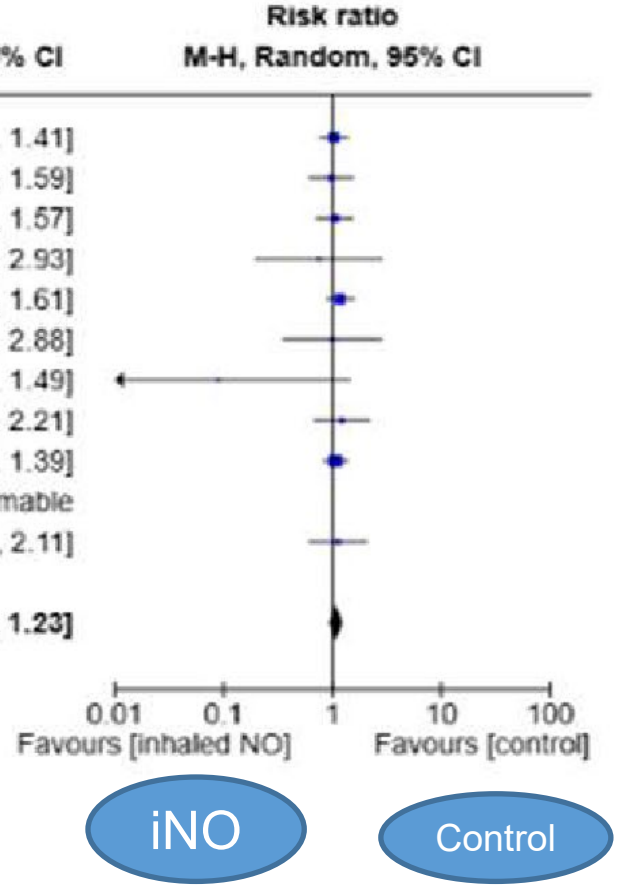
Yuta Nakamura et al.

11 RCTs comprising 1302 patients

Study or Subgroup	iNO Events	iNO Total	Control Events	Control Total	Weight	Risk ratio M-H, Random, 95% CI
Angus DC 2006	54	165	53	167	19.5%	1.03 [0.75 , 1.41]
Dellinger RP 1998	35	120	17	57	8.0%	0.98 [0.60 , 1.59]
Fenza R 2023	32	94	32	99	11.9%	1.05 [0.71 , 1.57]
Gerlach H 2003	3	20	4	20	1.0%	0.75 [0.19 , 2.93]
Lundin S 1999	48	93	38	87	19.9%	1.18 [0.87 , 1.61]
Mehta S 2001	4	8	3	6	1.7%	1.00 [0.35 , 2.88]
Merlin M 2022	0	14	4	11	0.2%	0.09 [0.01 , 1.49]
Michael JR 1998	11	18	9	18	5.4%	1.22 [0.68 , 2.21]
Payen D 1999	53	98	53	105	27.5%	1.07 [0.82 , 1.39]
Schwebel C 1997	0	9	0	10		Not estimable
Troncy E 1998	9	15	8	15	4.8%	1.13 [0.60 , 2.11]
Total (Wald[a])		**654**		**595**	**100.0%**	**1.07 [0.93 , 1.23]**
Total events:	249		221			

Test for overall effect: Z = 1.00 (P = 0.32)

Heterogeneity: Tau² (DL[b]) = 0.00; Chi² = 4.17, df = 9 (P = 0.90); I² = 0%



Footnotes

[a]CI calculated by Wald-type method.

[b]Tau² calculated by DerSimonian and Laird method.

Results:

- iNO therapy may result in no difference in mortality at the longest follow-up
- iNO may improve $PaO_2/FiO2$
- Uncertain about the effect on ECMO
- *iNO may increase the need for RRT*

In conclusion, although iNO may slightly improve oxygenation, it may not confer survival or other patient-centered benefits and may increase the need for RRT.

- **High-quality randomized evidence is needed to guide the optimal patient selection for this therapeutic option.**

[Critical Care Original Research]

CHEST

Inhaled Nitric Oxide vs Epoprostenol During Acute Respiratory Failure

An Observational Target Trial Emulation

Nicholas A. Bosch, MD; Anica C. Law, MD; Emily A. Vail, MD; Kari R. Gillmeyer, MD; Hayley B. Gershengorn, MD; Hannah Wunsch, MD; and Allan J. Walkey, MD

- Large U.S. multicenter retrospective cohort (Premier Healthcare Database).
- **11,200** ventilated adults with ARF/ARDS receiving an inhaled vasodilator.
- **Target trial emulation** using hospitals that **exclusively used either iNO or iEPO** to minimize confounding.
- Exposure = first inhaled vasodilator administered (iNO vs iEPO)

Bosch NA, Law AC, Vail EA, et al. Inhaled Nitric Oxide vs Epoprostenol During Acute Respiratory Failure: An Observational Target Trial Emulation. *Chest*. 2022;162(6):1287-1296. doi:10.1016/j.chest.2022.08.001

Main Findings

- **Effectiveness:**
  - No difference in successful extubation (**adjusted SHR 0.97; 95% CI 0.80–1.18**).
  - No difference in mortality, renal replacement therapy, ECMO use, or next-day oxygenation.
- **Costs:**
  - iNO associated with **significantly higher inhaled therapy cost** (median +$3,255).
  - **No difference** in total hospitalization cost.

Bosch NA, Law AC, Vail EA, et al. Inhaled Nitric Oxide vs Epoprostenol During Acute Respiratory Failure: An Observational Target Trial Emulation. *Chest*. 2022;162(6):1287-1296. doi:10.1016/j.chest.2022.08.001

Prostacyclins in Cardiac Surgery: Coming of Age

Seminars in Cardiothoracic and Vascular Anesthesia
1–18

DOI: 10.1177/1089253217749298
journals.sagepub.com/home/scv
SAGE

Seema P. Deshpande, MBBS[1], Michael A. Mazzeffi, MD, MPH[1], Erik Strauss, MD[1], Allison Hollis, PharmD[1], and Kenichi A. Tanaka, MD, MSc[1]

- Retrospective analysis using pharmacy billing data (January 2018–June 2020).
- Adult ICU patients who received **continuous iNO** or **continuous iEPO** were included.
- Primary and ONLY reported outcome: **total drug acquisition cost**.

Deshpande SP, Mazzeffi MA, Strauss E, Hollis A, Tanaka KA. Prostacyclins in Cardiac Surgery: Coming of Age. *Semin Cardiothorac Vasc Anesth*. 2018;22(3):306-323. doi:10.1177/1089253217749298

- Study reports **financial outcomes only** — no clinical outcomes (oxygenation, mortality, LOS) were included.

- Findings reinforce that:
  - iEPO is **clinically reasonable**
  - iEPO is **far more cost-effective**
  - iNO use should be **reserved for specific indications** (e.g., RV failure with poor response to iEPO).

Deshpande SP, Mazzeffi MA, Strauss E, Hollis A, Tanaka KA. Prostacyclins in Cardiac Surgery: Coming of Age. *Semin Cardiothorac Vasc Anesth*. 2018;22(3):306-323. doi:10.1177/1089253217749298

Circulation

ORIGINAL RESEARCH ARTICLE

Inhaled Epoprostenol Compared With Nitric Oxide for Right Ventricular Support After Major Cardiac Surgery

Kamrouz Ghadimi, MD, MHS; Jhaymie L. Cappiello, RRT; Mary Cooter Wright, MS; Jerrold H. Levy, MD; Benjamin S. Bryner, MD, MS; Adam D. DeVore, MD, MHS; Jacob N. Schroder, MD; Chetan B. Patel, MD; Sudarshan Rajagopal, MD, PhD; Svati H. Shah, MD, MS, MHS; Carmelo A. Milano, MD; for the INSPIRE-FLO Investigators

Primary Outcome:

RVR: **25.0% (iEPO) vs 22.5% (iNO)**

Risk difference: **2.5% (90% CI -6.6 to 11.6) → Met Criteria for equivalence.**

Secondary Outcomes

No significant differences in:

- Duration of mechanical ventilation
- ICU of hospital length of stay
- *Acute Kidney injury or need for dialysis*
- Tracheostomy
- Mortality at 30d, 90d or 1 year

Hemodynamic parameters similar between groups

Clinical interpretation:

iEPO is clinically equivalent to iNO for management of postoperative RV failure

Provides **similar outcomes** across all endpoints

Supports **iEPO as a cost-effectiveness** alternative without compromising patient safety

JAMA Surgery

RCT: Inhaled Pulmonary Vasodilator Therapy in Adult Lung Transplant

POPULATION

129 Men, 72 Women

Adult patients who underwent single or bilateral lung transplant

Median age, 64 y; IQR, 52-68 y

INTERVENTION

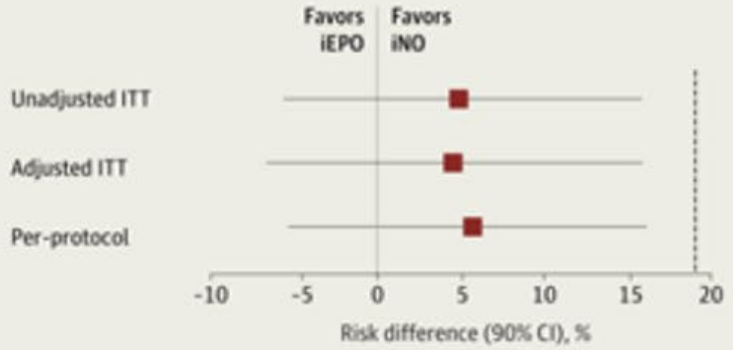
201 Participants randomized

98 Inhaled nitric oxide (iNO)
iNO given immediately before allograft reperfusion during lung transplant

103 Inhaled epoprostenol (iEPO)
iEPO given immediately before allograft reperfusion during lung transplant

FINDINGS

The between-group risk difference for PGD-3 was not significant between the 2 groups



iNO group

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Feature	iEPO (Inhaled Epoprostenol)	iNO (Inhaled Nitric Oxide)
Cost	Very low cost (80–90% cheaper)	Extremely expensive
Availability	Widely available; simple delivery	Requires proprietary delivery systems
Mechanism	↑ cAMP via IP receptor agonist	↑ cGMP via NO donation
Pulmonary Selectivity	High selective vasodilation	Excellent (gold standard)
Onset	Rapid	Immediate
Oxygenation Effect	Improves O2; similar to iNO	Improves O2; no superiority
Platelet Effects	Inhibits platelet aggregation	Minimal platelet effects
Rebound Risk	Low	Higher—risk of rebound PH
Use in PAH Testing	Alternative	Gold standard
Device Needs	Nebulizer-based	Proprietary NO system

Ghadimi K, Cappiello J, Cooter-Wright M, et al. Inhaled Pulmonary Vasodilator Therapy in Adult Lung Transplant: A Randomized Clinical Trial. *JAMA Surg.* 2022;157(1):e215856. doi:10.1001/jamasurg.2021.5856

Comparison Considerations

-iNO and iEpo have comparable physiologic and clinical effects across:

- Acute respiratory failure / ARDS
- Lung and heart transplantation
- Cardiac surgery with RV dysfunction

-Randomized trials and high-quality observational studies show no superiority of iNO over iEPO for major clinical outcomes:

- Mortality
- PGD severity
- Ventilator-free days
- RV failure or need for mechanical support

-iEPO is consistently more cost-effective with similar efficacy

-Persistent dependence on inhaled vasodilators (particularly iNO) identifies **high-risk physiology**, rather than therapeutic benefit

Daily Cost

EPOPROSTENOL 1.5 MG/50MLNS	$61.83
NITRIC OXIDE	$1156.00

ISHLT Consensus Statement on the Perioperative use of ECLS in Lung Transplantation:
Part I: Preoperative Considerations:

January 2026.

Volume 45, Issue 1

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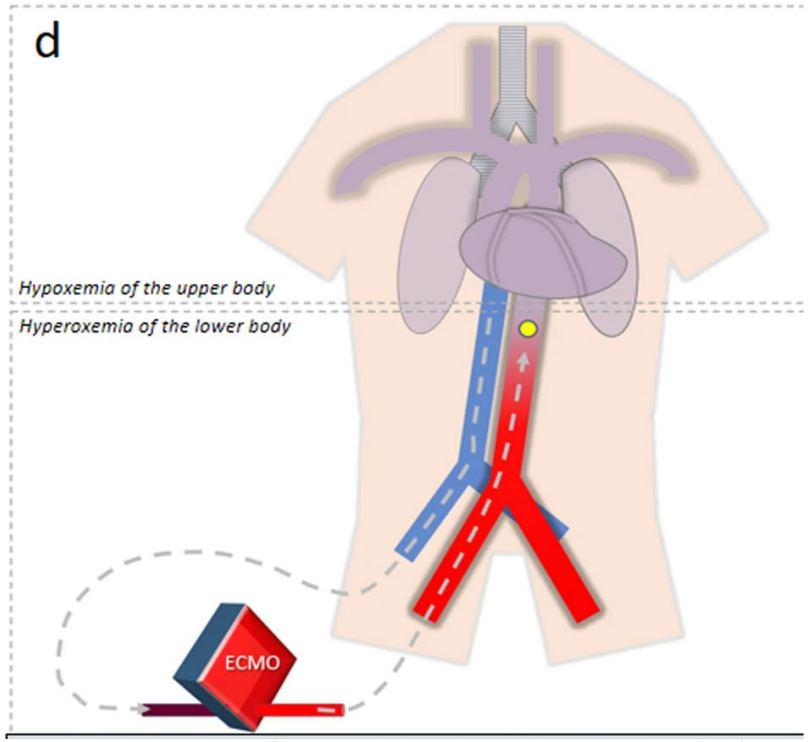
Differential Hypoxemia / Harlequin Syndrome / North-South Syndrome

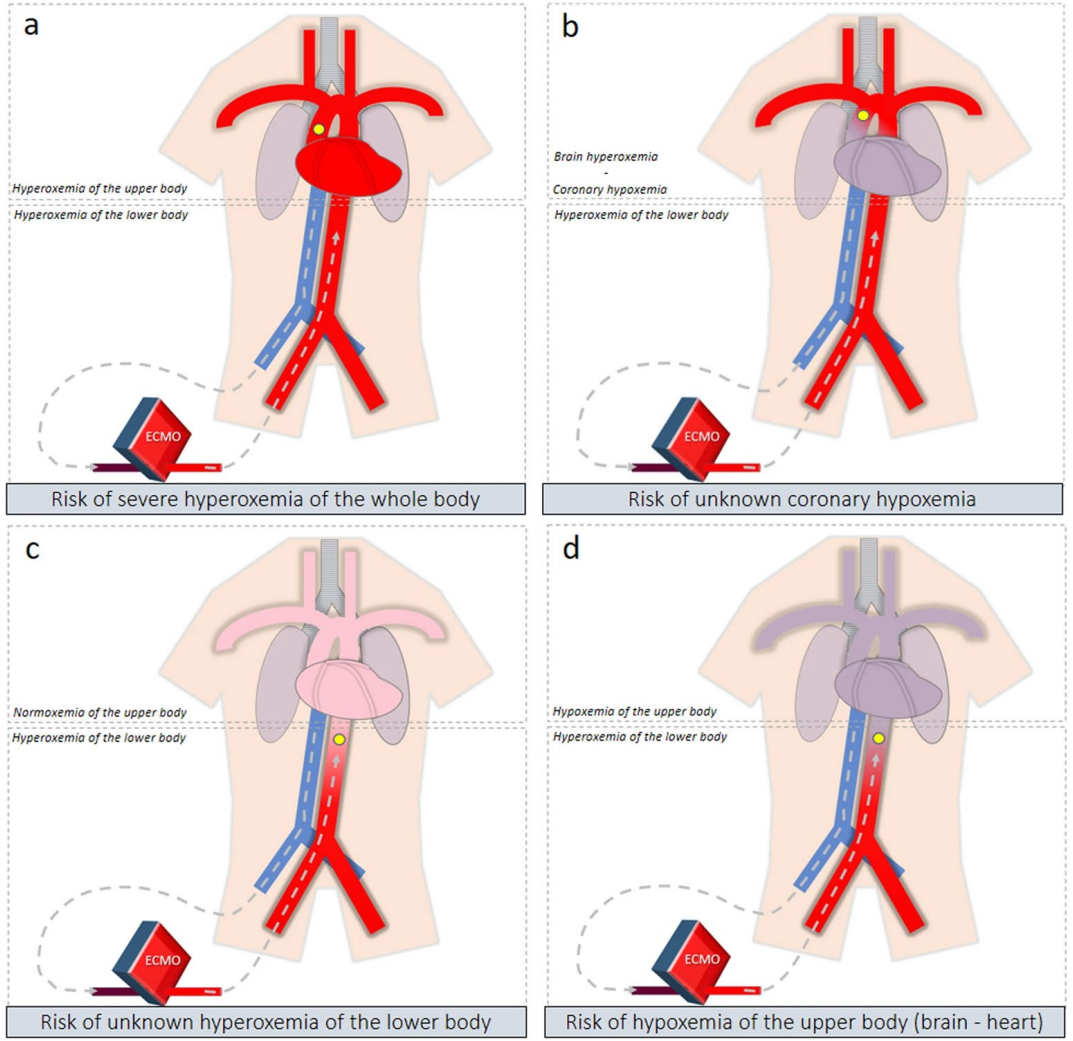
- **Peripheral V-A ECMO when cardiac output improves in association with hypoxemia.**
- MCS or native recovery
- "*Mixing Point*" location is 🔑 to explain physiology
- RUE and Right Cerebrum vs. Left Cerebrum and LUE-lower body
- Initially attempt medical optimization (PEEP, Afterload and Volume)
- Often requires V-AV limb added to Right IJV / central recannulation



Winiszewski, H., Guinot, PG., Schmidt, M. *et al.* Optimizing PO_2 during peripheral veno-arterial ECMO: a narrative review. *Crit Care* **26**, 226 (2022). https://doi.org/10.1186/s13054-022-04102-0

Mixing Point

- The **location of the mixing point**, depends upon the relative strengths of the native and ECMO Circuit.
- The **mixing point** will determine which regions of the body are perfused with **blood ejected from the left ventricle** by reinfused **blood from the ECMO circuit**, effectively establishing *dual circulations*.
- The **degree of O2 and CO2 differential** between the circulations will depend of the patients lung function, not the ecmo circuit.



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Circulation

Volume 151, Issue 4, 28
January 2025
https://doi.org/10.1161/CIRCULATIONAHA.124.071524

ON MY MIND

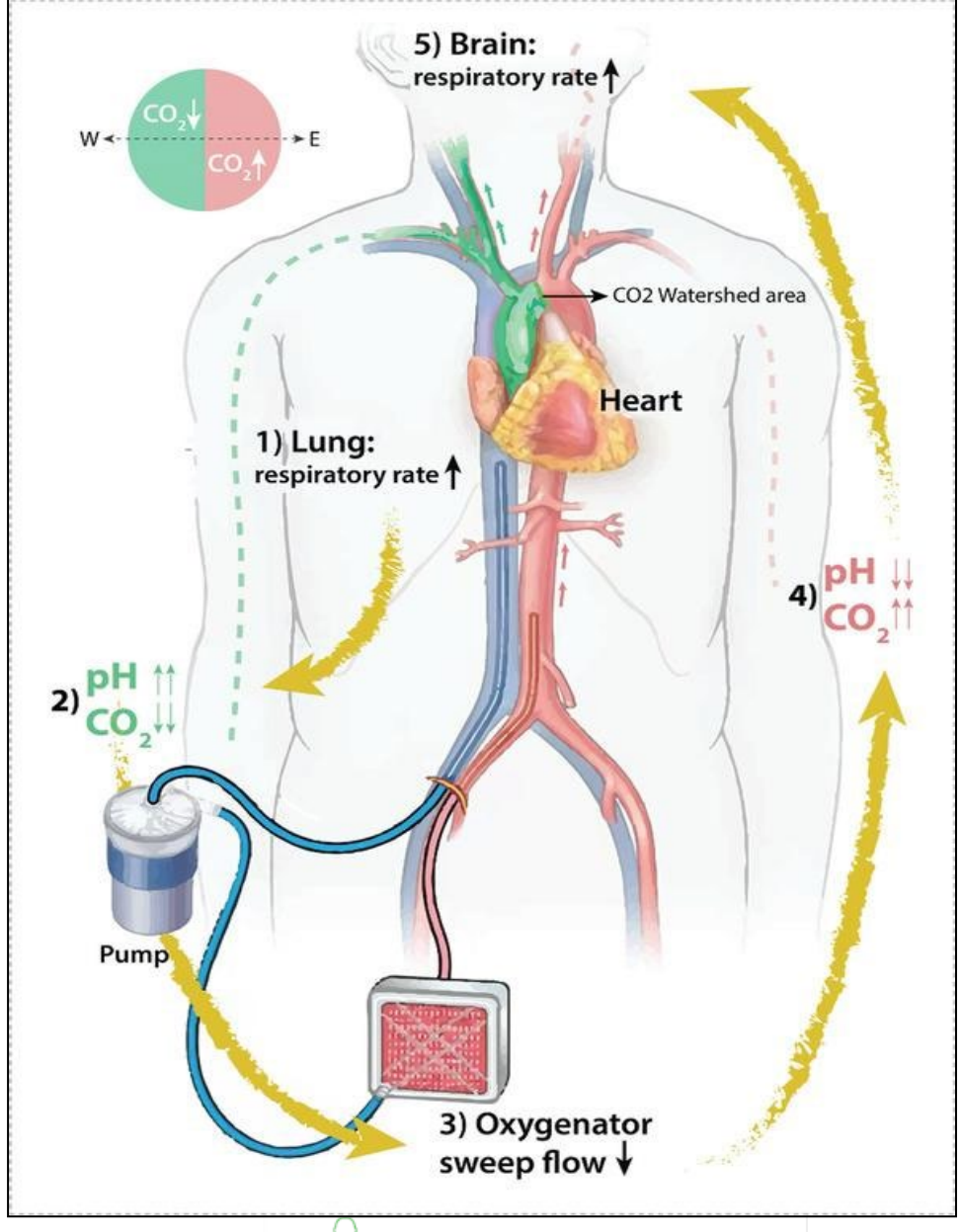
Relatively Increased CO_2 Delivered to the Brain From the Descending Aorta Leading to an Elevated Respiratory Rate Causing Differential Hypocapnia (RIDDLER or East-West Syndrome): New Pitfalls in *Awake* Peripheral V-A ECMO

Alex Rosenberg MBBS MRCP PGDipCU FCICM

The RIDDLER Syndrome: A New Twist on Differential Gas Exchange in V-A ECMO

Why RIDDLER Syndrome Matters?

In awake, spontaneously breathing patients on peripheral V-A ECMO, we can inadvertently create a CO_2 imbalance across the brain—one hemisphere receiving DECARBOXYLATED blood from the lungs, the other hypercapnic blood from the circuit. This can trick us into making the wrong adjustments.



How RIDDLER happens

1. **Tachypnea** develops (pain, exertion, sepsis, etc.), which increases native lung CO_2 clearance.

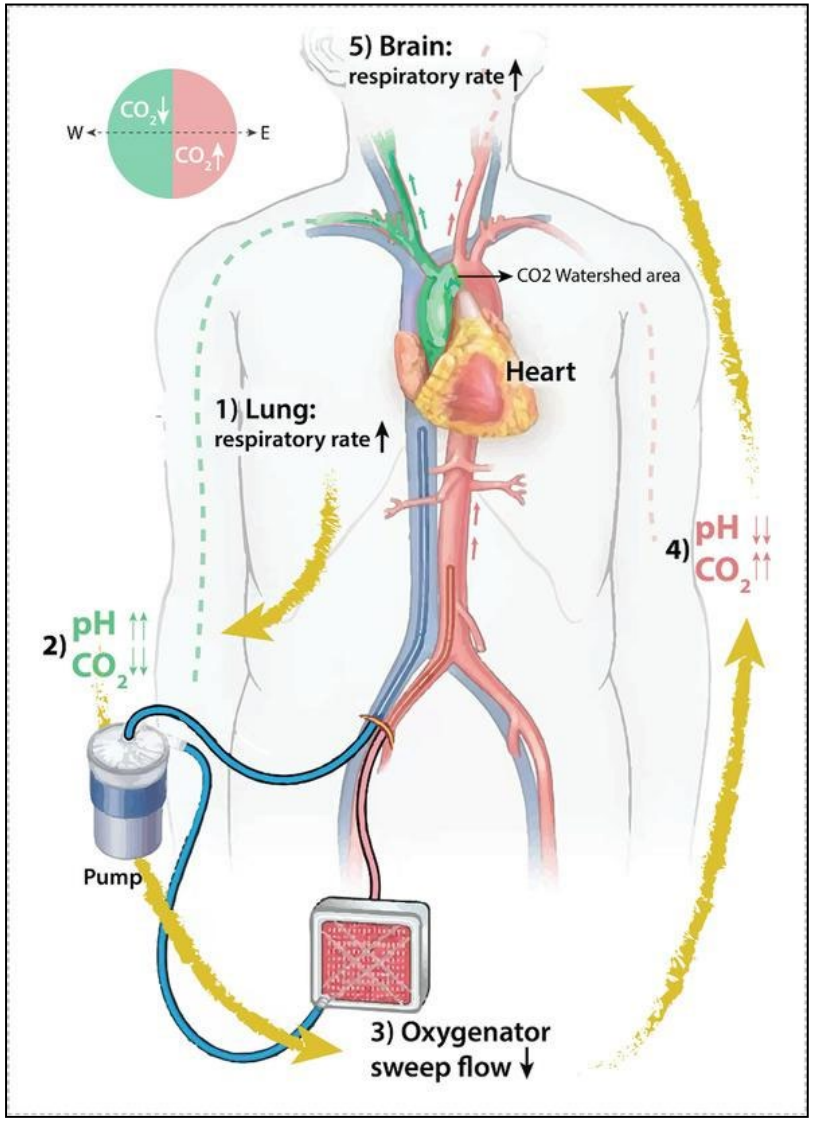
2. Right arm ABG shows a low $PaCO_2$ and high pH—looks like we're over-sweeping.

3. Clinicians **reduce ECMO sweep**, expecting less CO_2 clearance.

4. But **retrograde ECMO blood becomes more hypercapnic**, perfusing the *left brain* via the left carotid artery.

5. Brainstem chemoreceptors detect rising CO_2 → further increase in respiratory drive → worsening tachypnea.

6. We respond to the *wrong signal*—the low $PaCO_2$ in the right radial artery—and drop the sweep even more.



How to avoid the trap

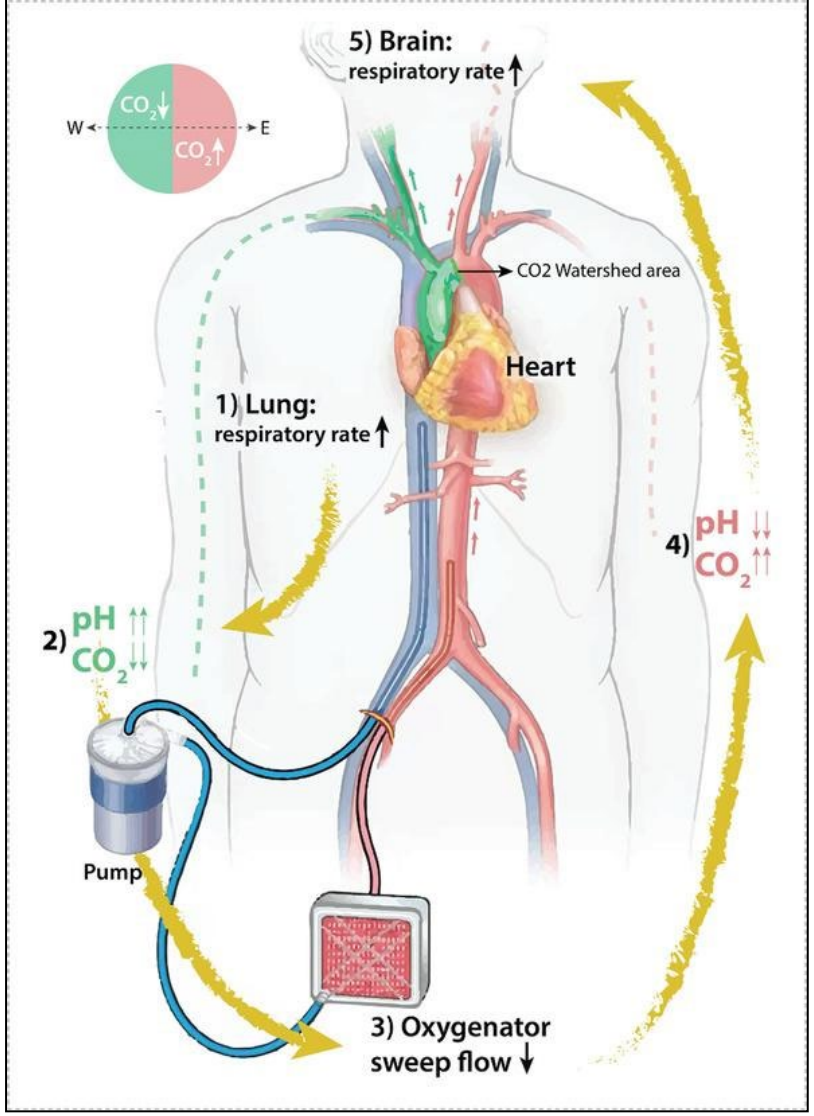
Don’t rely solely on the right radial ABG—it’s giving you only half the story.

Check post-oxygenator CO_2 to verify circuit decarboxylation.

Consider left radial or central venous gas sampling for a more complete picture.

Watch for inappropriate tachypnea that doesn’t respond to sedation or pain control.

Don’t reflexively reduce sweep gas just because of low $PaCO_2$ in the right arm—context is key.



How to break this cycle

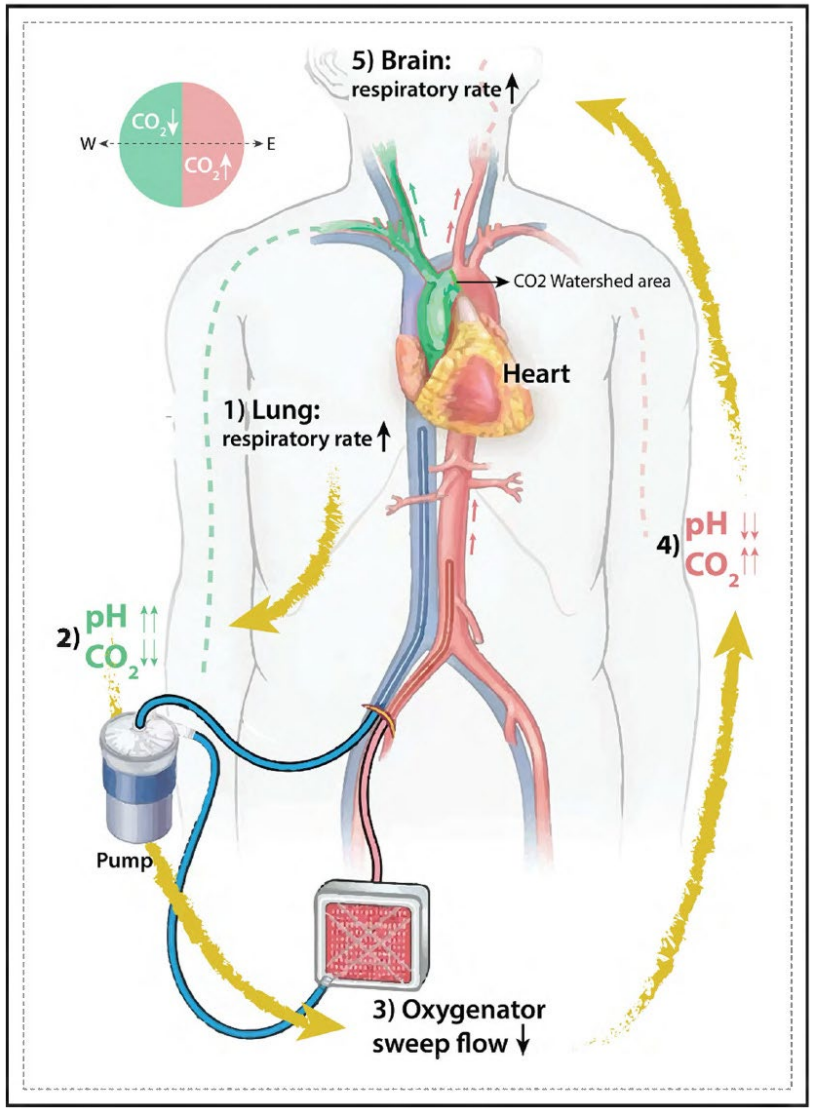
- Match sweep to blood flow (e.g., 1:1 ratio) once stable.
- Aim for physiologic post-oxygenator pH and CO_2 targets.
- Treat underlying causes of tachypnea: pain, anxiety, sepsis.
- Consider gentle re-sedation, noninvasive support, or even reintubation in severe cases.

RIDDLER Syndrome is **differential decarboxylation**, requiring a shift in our thinking—especially in awake, peripheral V-A ECMO patients.

Don’t be fooled by the right radial blood gas.

🔑 Key Points

- **RIDDLER** Syndrome refers to a CO_2 mismatch @ awake peripheral V-A ECMO—when CO_2-rich ECMO blood perfuses the brainstem, causing tachypnea even though ABGs may look “normal.”
- **The right radial ABG can mislead you**—showing low $PaCO_2$ while the brainstem is actually seeing high CO_2 from the ECMO circuit.
- **RIDDLER** underscores the importance of **post-oxygenator** ABGs and **considering regional aspects of gas delivery**, rather than focusing solely on systemic approaches.



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Clinical management of the Impella 5.5 pump

Alexander M. Bernhardt, MD, Vanessa Blumer, MD, Christophe Vandenbriele, MD, Benedikt Schrage, MD PhD, Kanika Mody, MD, Federico Pappalardo, MD, Scott Silvestry, MD, Mark Anderson, MD, Jacob Abraham, MD, Ann Gage, MD, Daniel Goldstein, MD, Michael Grant, MD, Ilija Klipa, Thomas Schlöglhofer, Sern Lim, MD, Jacob Moller, MD, Bernd Panholzer, MD, Ezequiel Molina, MD, Julia Riebandt, MD, Nir Uriel, MD, Anthony Carnicelli, MD, Evgenij Potapov, MD, Manreet Kanwar, MD

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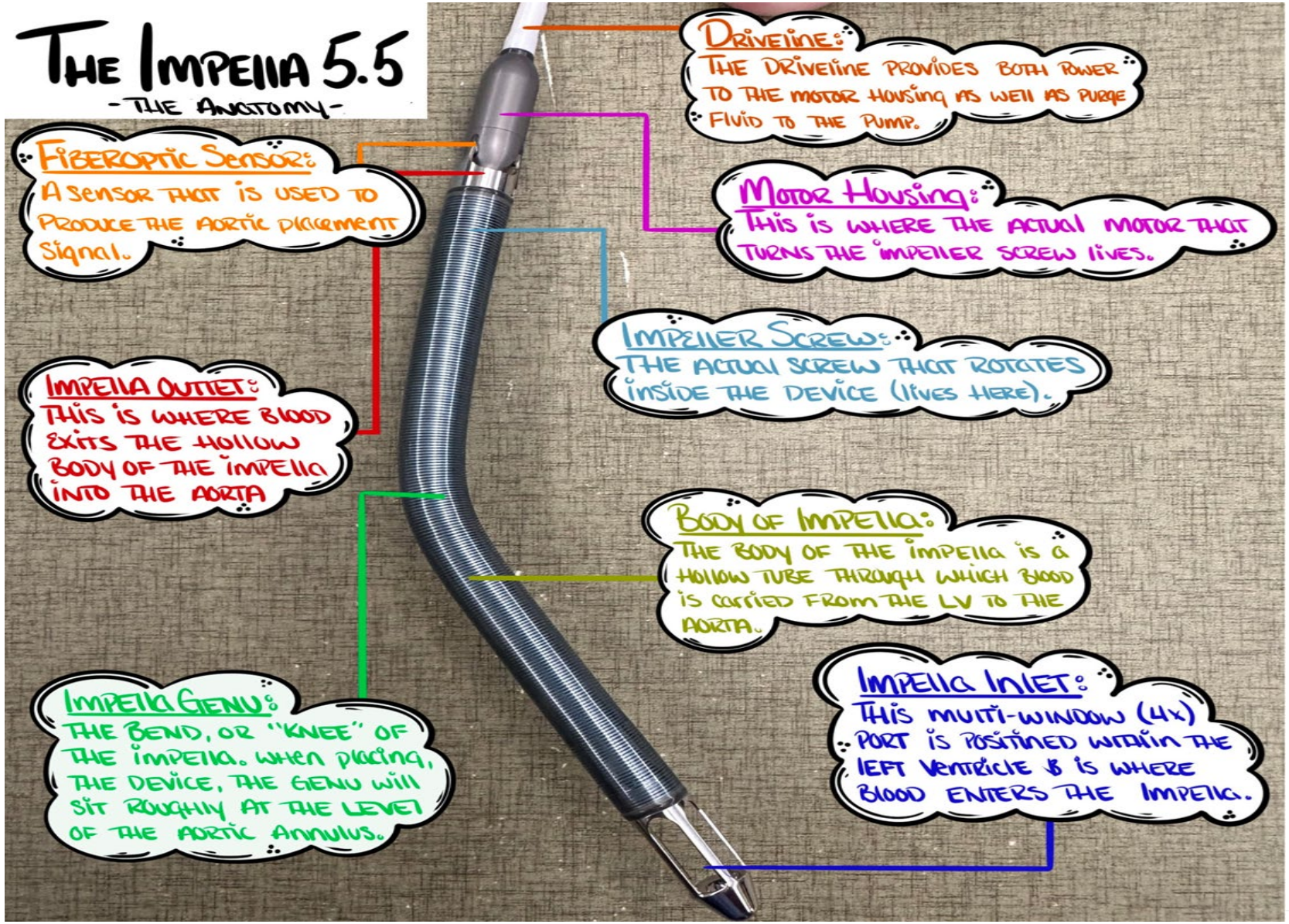
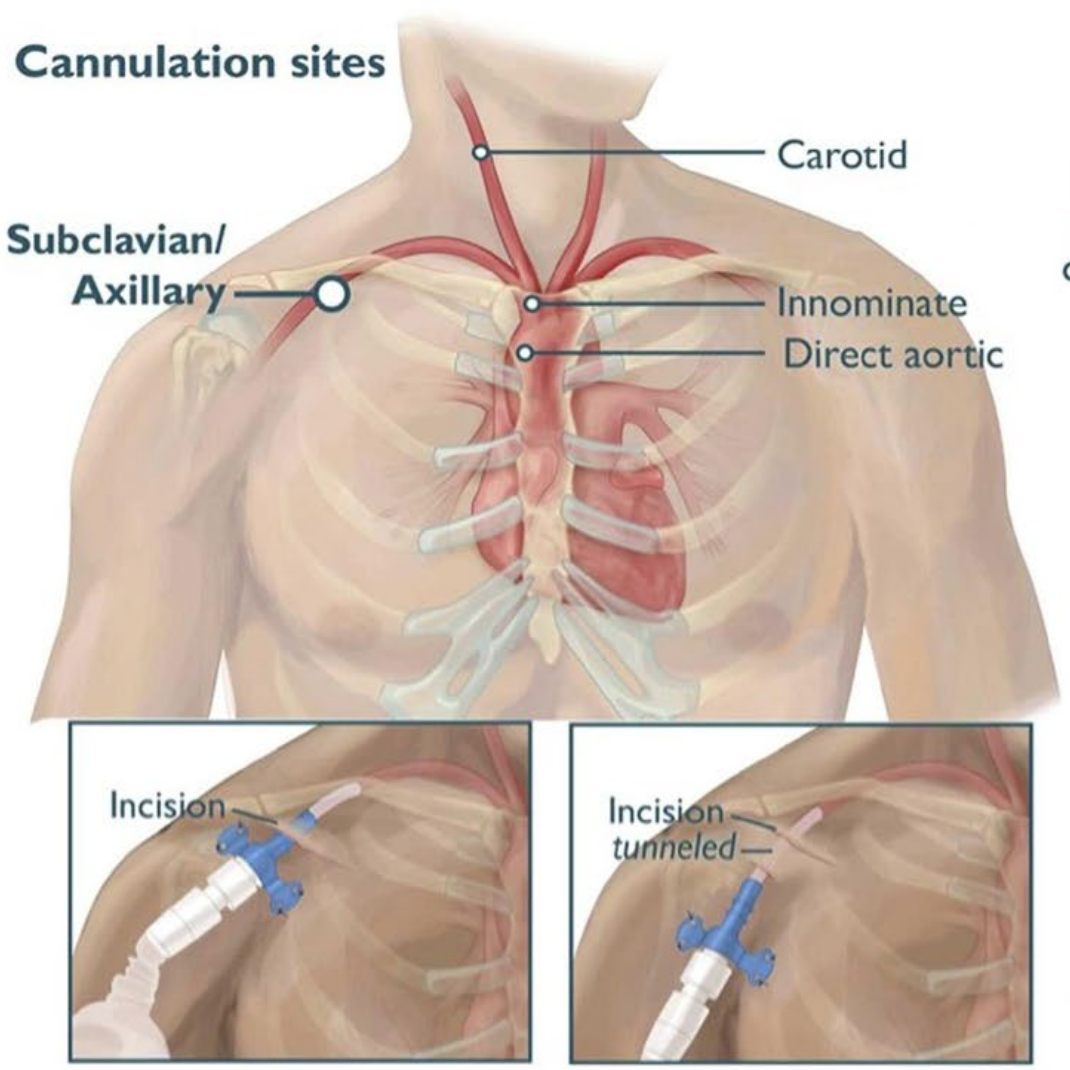
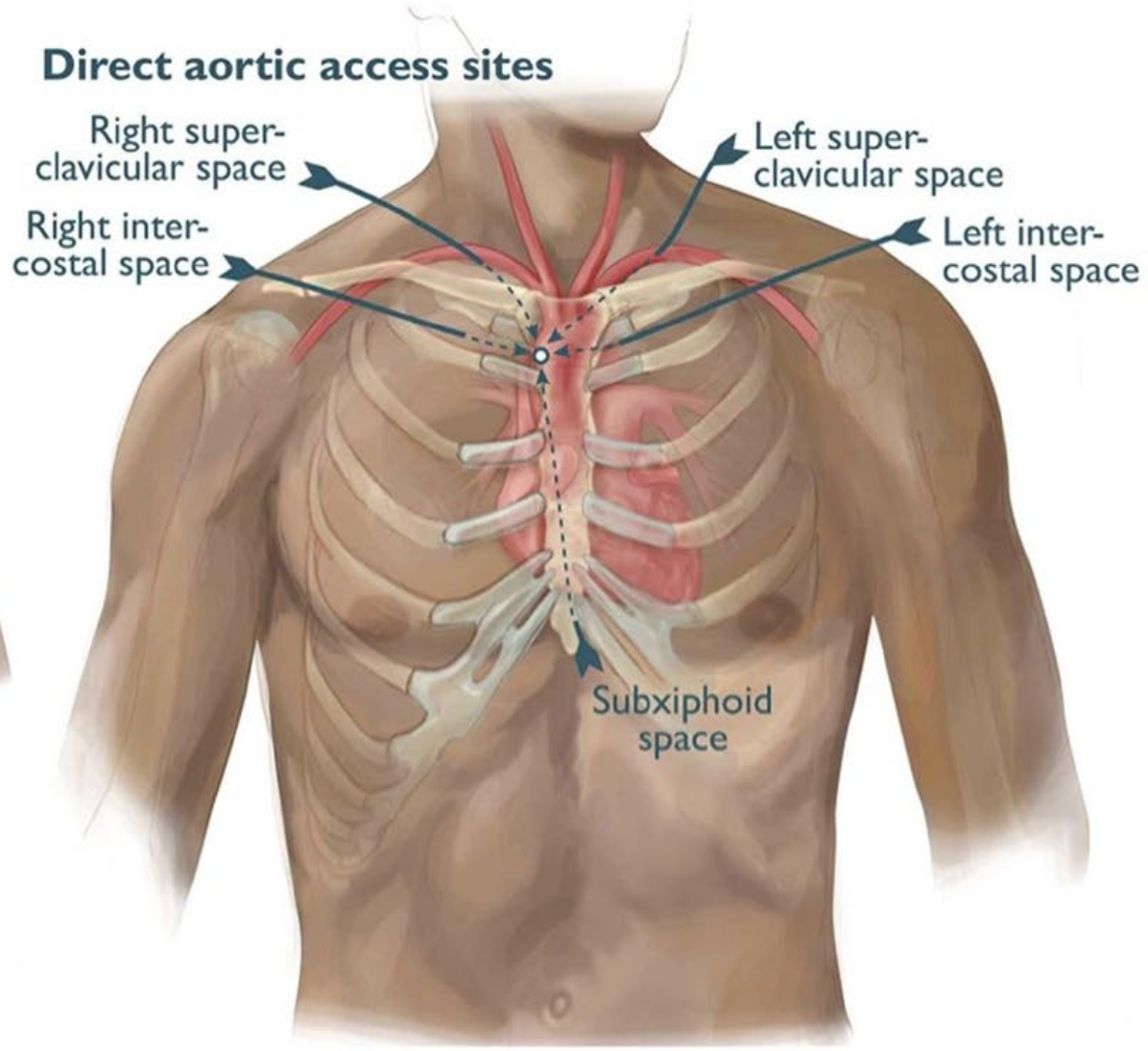
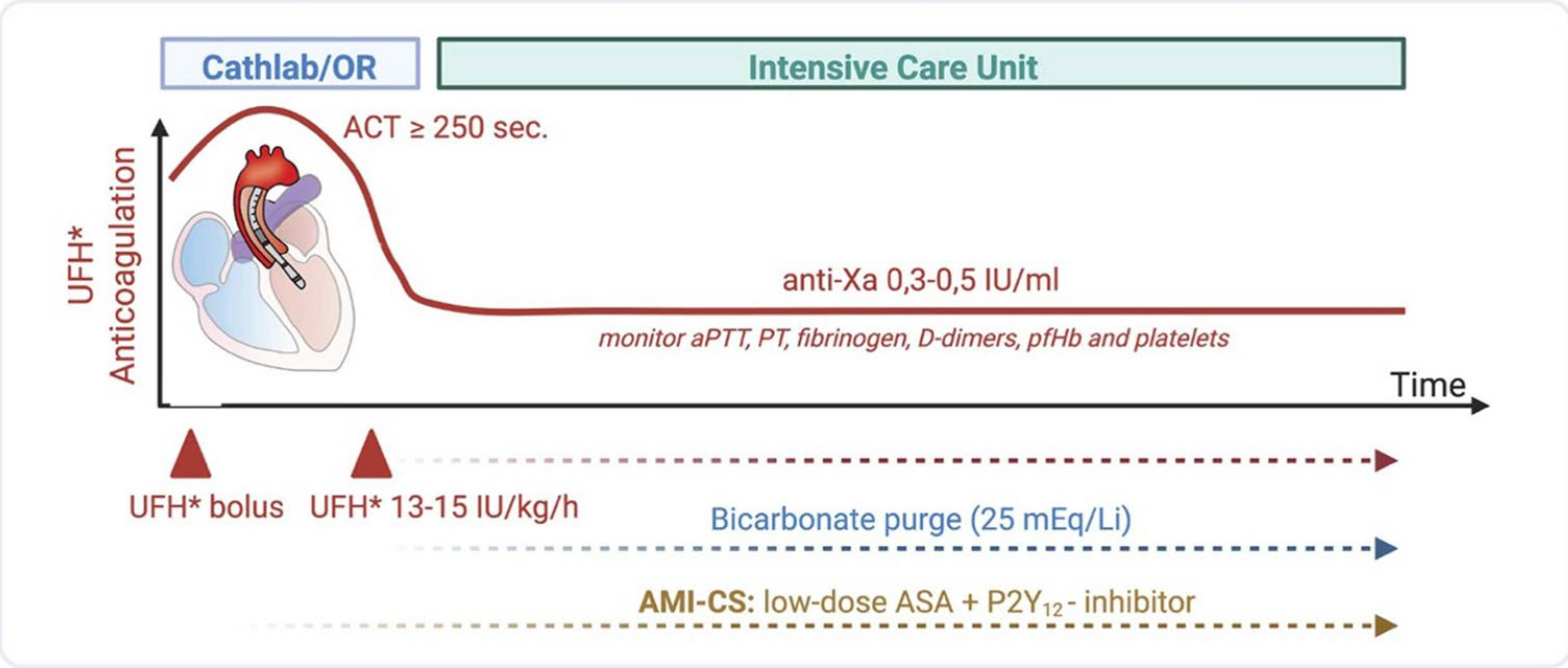
The Impella 5.5

-The Anatomy-




Cannulation sites
Carotid
Subclavian/
Axillary
Innominate
Direct aortic
Incision
Incision
tunneled


Direct aortic access sites
Right super-
clavicular space
Left super-
clavicular space
Right inter-
costal space
Left inter-
costal space
Subxiphoid
space

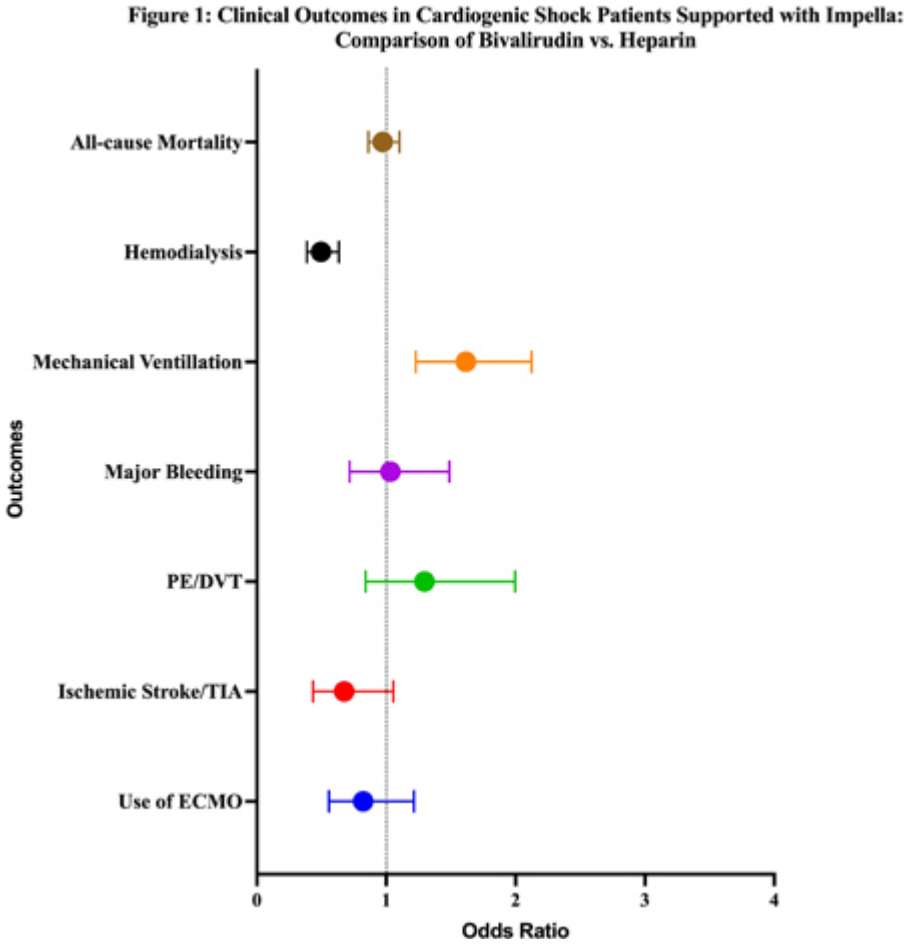


The Journal of Heart and Lung Transplantation 2025 441688-1702DOI: (10.1016/j.healun.2025.06.008)

Circulation

Comparative Outcomes of Bivalirudin Versus Heparin in Cardiogenic Shock Patients Supported with Impella Device: A Propensity -Matched Multi -centers Analysis

November 3, 2025



- "In Impella-supported cardiogenic shock, Bivalirudin was associated with less renal replacement therapy, possibly due to lower thrombotic burden, while Heparin was linked to lower mechanical ventilation rates, perhaps reflecting milder illness severity"

.

- Despite these differences, survival was similar between groups. These findings highlight the need for randomized trials to clarify optimal anticoagulant strategies.

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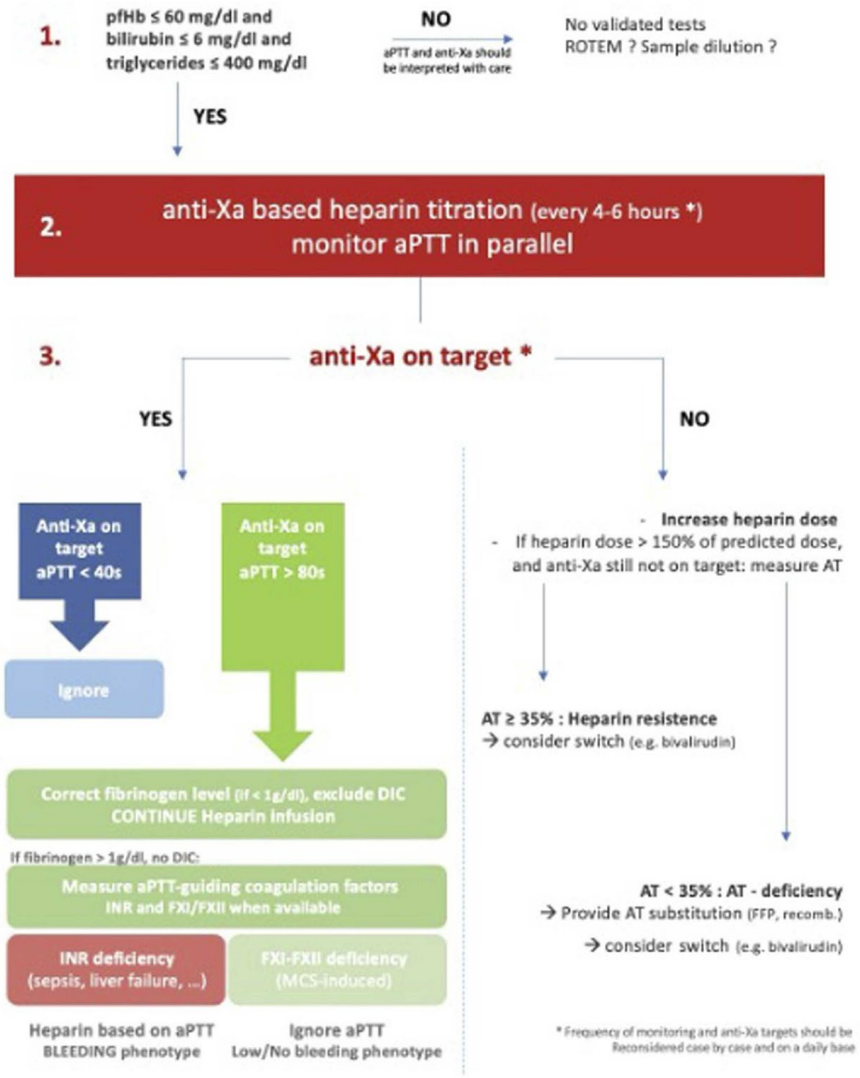

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Cheers from

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Thank you!