Building an ECMO Program and Fundamentals

October 10, 2024

AREP

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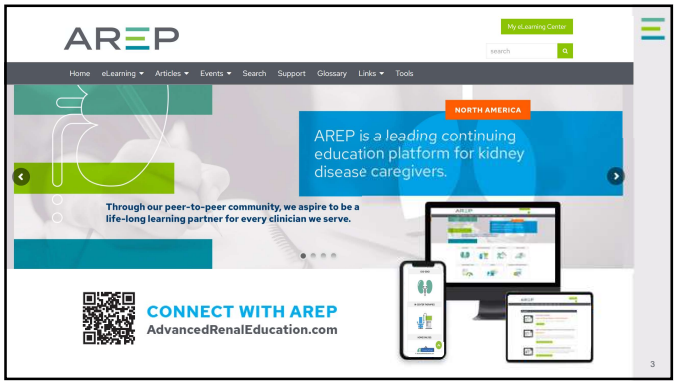

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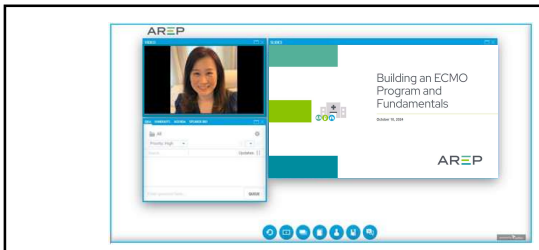

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Upcoming Events

ACCME **credits available*

https://advancedrenaleducation.com/wparep/events/

October 28	Understanding the Essentials and Application of Online Hemodiafiltration
November 14	HDF Spotlight: Global Epidemiology and Real-World Data on High-Volume Hemodiafiltration
December 5	HDF Spotlight: Shifting from High-Flux HD to High-Volume HDF

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Course Disclosure

- This educational program has been developed by the Fresenius Medical Care Global Medical Office.
- It is intended to provide pertinent data to assist health care professionals in forming their own conclusions and making decisions.
- Published treatment recommendations and best practice guidelines discussed in this course may include off-label use of drugs or medical devices.
- Any such use of drug or devices should not be considered an endorsement of any indication, dosage or other claim that is not covered, if applicable, in the FDA-approved label.
- The treatment prescription is the sole responsibility of the attending physician.
- Extracorporeal membrane oxygenation (ECMO) is used for acute severe cardiac or pulmonary failure that is potentially reversible and unresponsive to conventional management (1).
- Although ECMO may address important clinical problems, it is important to consider common adverse events associated with this therapeutic option, including, but not limited to, bleeding, thromboembolism, neurologic impairment, cannulation-related complications, and heparin-induced thrombocytopenia.
- The presenters are external AREP faculty under speaker contract with the Fresenius Medical Care Renal Therapies Group, LLC.

1. Brogan TV, et al., eds. The ELSO Red Book. 5th ed. Extracorporeal Life Support Organization; 2017.

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Meet the Faculty

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Disclosures

- JW Awori Hayanga, MD MPH MHL FACS FRCS FCCP
  - Paid speaker, consultant, and member of Medical Advisory Board for Fresenius Medical Care
- Jeffrey DellaVolpe, MD, MH
  - Paid speaker, consultant, and member of Medical Advisory Board for Fresenius Medical Care
- Rachel Sterling, MSN, APRN
  - Paid speaker for Fresenius Medical Care

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Disclosures cont.

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Learning Objectives

1. Review the primary reasons for building an ECMO program
2. Explain the basic components of what makes a great ECMO team for an ECMO program
3. Review training, education and quality requirements for an ECMO program
4. Review ECLS criteria and finding the "Sweet Spot" for patient selection for treatment

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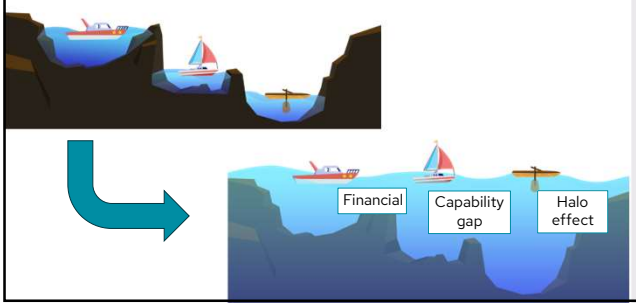
Why build a program?



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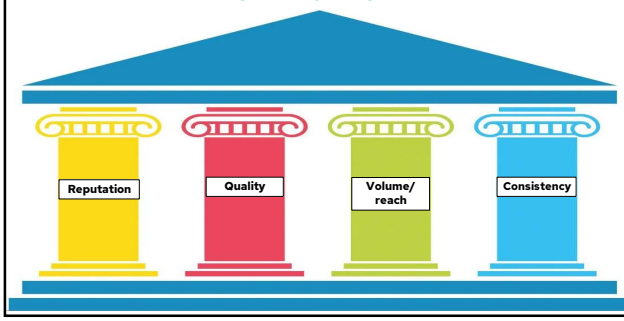
What makes a great program?



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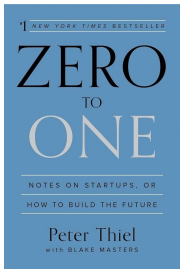
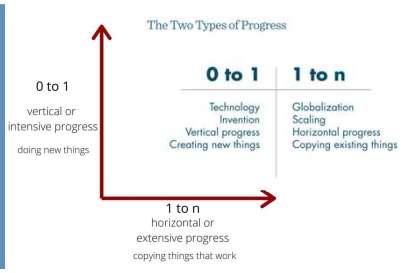
What are you building?





Thiel, P., & Masters, B. I. (2014). *Zero to one: notes on startups, or how to build the future*. First edition. New York, Crown Business.

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Fundamentals for building an ECMO program

1. Team
2. Education/Training
3. Selection
4. Culture of quality

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Fundamentals for building an ECMO program

1. **Team**
2. Education/Training
3. Selection
4. Culture of quality

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Team: what kind of team does ECMO require?

Image source: Be Thankful This Year For The San Antonio Spurs : NPR

Image source: Lakers retain NBA title with win over Celtics - CNN.com

Image source: How many rings does Tim Duncan have? (firstsportz.com)

Image source: How Many Rings Does Kobe Bryant Have? (firstsportz.com)

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What Is Unique?

Operating room

- Consistent roles and responsibilities
- Vertical control
- Consolidation of responsibilities

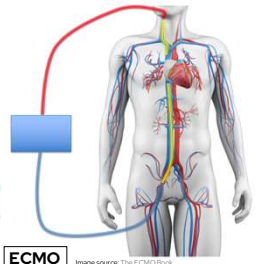

Image source: The ECMO Book

ECMO

- Inconsistent roles and responsibilities
- Horizontal control
- Dispersion of responsibilities

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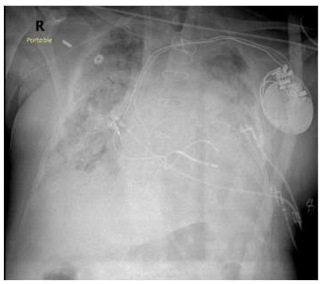
Multidisciplinary team in action



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Rachel's corner

- ECMO works best as a team sport
- "Buy in" is necessary
- Adaptability is critical- never accepting "this is the way we do it" as the answer.
- Consistency in training

Image Source 1

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Challenges of multidisciplinary care

Operating room

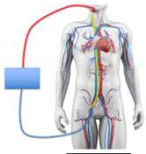

Image source: The ECMO Book

ECMO

- When does multidisciplinary care break down?
- How do you balance inclusion/big tent philosophy with consolidation of expertise?
- What does "right" look like?

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Fundamentals for building an ECMO program

1. Team
2. **Education/Training**
3. Selection
4. Culture of quality

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Addressing Clinical and Professional Needs*

Clinical Needs

- Increased volume
- Higher complexity
- Quality

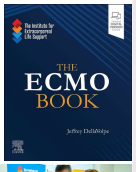
Professional Challenges

- High turnover
- Less training time
- Less experience

Our Approach

- Efficiency
- Safety
- Consistency

- Establish baseline
- Progressive skills development



*Based on Presenters' Experience

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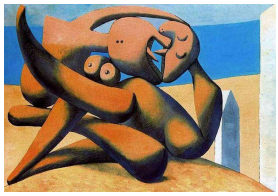
Consistency v. adaptability



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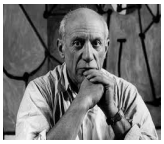

Image source: https://www.gktoday.in/cubism-picassos-revolutionary-art-movement/

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Image source: https://www.pbs.org/treasuresoftheworld/guernica/glevel_1/2_process.html

Image source: https://www.pbs.org/treasuresoftheworld/guernica/glevel_1/2_process.html

Images source: https://www.museoreinasofia.es/en/collection/artwork/guernica

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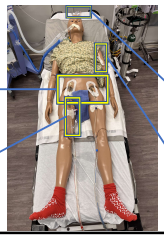
Fostering consistency and adaptability through training*



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Consistency vs. adaptability

"In theory, consistency is about being disciplined, determined, and unwavering.
In practice, consistency is about being adaptable. Let your habits change shape to meet the demands of the day.
Adaptability is the way of consistency."

Fictious Case example:

- 35-year-old man with massive PE, cannulated for VA ECMO at remote hospital in anticipation of transport
- Shortly after initiation, rapid rise in delta P with dropping blood flow
- What would you do?

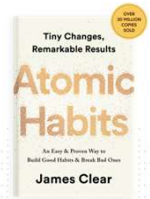

Image source: https://jamesclear.com/best-books/self-help

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Rachel's corner/discussion

Education and training

Image Source 2

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ECMO Team Simulation

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Simulation Library*

Sim #	ECMO Type	Patient finding	Trigger	Scenario	Response	Interventions	Debrief	
1	VV	Hypoxia	Decreased flow (Limitations)	insufficient flow	increase RPMs	↑ RPMs= ↑ Sats	Flow as a fraction of CO	
2	VV	Hypoxia	Decreased flow(Limitations)	recirculation	decrease RPMS	↑ RPMs= ↓ sats. ↓ RPM, ↑ sats	CXR to show cannula position	RV
3	VV	hypoxia	Decreased flow (Limitations)	volume depletion	give volume or 2	↑ flow = ↑ chatter. ↓ flow= worse sats. Volume = improvement in flow and sa	preload dependent, CXR cannula position	Vol
4	VV	Hypoxia	Decreased flow (Limitations)	chatter (not volume responsive)	RPM adjustment	↑ RPM = ↑ chatter. If volume ≠improvement in flow, then ↓ RPM= stabilzed fl	preload dependent, CXR cannula positon	
5	VV	Hypoxia	Decreased flow (limitations)	cannula position	reposition cannula	↑ RPM = ↑ membrane pressures w/o improved flow. Volume≠improvement in	Cannula positions on CXR	
6	VV	hypoxia	Decreased flow (Limitations)	pnemothorax	xray, chest tube	↑ RPM = ↑ chatter. ↓ RPM= worse sats. Volume≠improvement in flow. CXR: p	Intrathoracic pressure	
7	VV	Hypoxia	Decreased flow (Limitations)	agitation	sedation	↑ RPM = slight improvement in sats but high membrane pressures, still hypoxic.	Flow as a fraction of CO, afterload of the patient and the impac	
8	VV	Hypoxia	Decreased flow (Limitations)	RP bleed	CT, labs, hold anticoagulation	↑ RPM = ↑ chatter. ↓ RPM= worse sats. Volume with some improvement in fl	Flow limitiation by volume (bleeding), oxygneation limitatic	Hol
9	VV	Hypoxia	Decreased flow (Limitations)	pain (agonal breathing)	medication	High -pvenous. ↑ RPMs = lower pvenous and ↓ flow. ↓ RPM= worse sats. Volu	Agonal breathing generates negative pressure which limits	Bre
10	VV	Hypoxia	Decreased flow (Limitations)	more negative pressire -insufficient drainage	add drain	High -pvenous. ↑ RPMs = lower pvenous and ↓ flow. ↓ RPM= worse sats. Volu	Flow limited by drainage cannula. Increase delivery of oxy	Op
11	VV	Hypoxia	SaO2 oxygenator	oxygenator failure (thrombus)	circuit change/oxy change	Sudden ↑ Δp. ↑RPMs to maintain flow until circuit change	Membrane pressures chart	
12	VV	hypoxia	SaO2 oxygenator	oxygenator dysfunction - green hose disconnection	circuit check	Sudden ↓ sats, flow stable, no color change. Circuit check, green hose disconnec	Circuit check, sudden drop in oxygenation likely a hose problem	
13	VV	hypoxia	SaO2 oxygenator	oxygenator dysfunction - wall source	circuit check/switch to tank	Sudden ↓ sats, flow stable, no color change. Green hose connected to the blend	Circuit check, sudden drop in oxygenation likely an O2 source p	
14	VV	Hypoxia	increased cardiac output	insufficient flow	increase RPMs	↑ RPMs= ↑ Sats	Flow as a fraction of CO	
15	VV	Hypoxia	increased cardiac output	fever	tylenol/ turn off heater cooler	↑ RPMs= some ↑ Sats. Limit of SvO2	Increasing flow will increase oxygen delivery but only if its grea	
16	VV	Hypoxia	increased cardiac output	pain	medication, increase RPMs	↑ RPMs= some ↑ Sats. Limitation of pvenous with negative pressure if agonally	Flow as a fraction of CO, afterload of the patient and the impac	
17	VV	Hypoxia	increased cardiac output	agitation	sedation , increase RPMs	↑ RPM = ↑ saturation but limited by circuit pressures. Volume help some with in	Increase in flow will work to a degree before limits of circuit pre	
18	VV	Hypoxia	increase cardiac output	serotonin syndrome	wean antipsychotics	↑ RPM = ↑ saturation but limited by circuit pressures. Volume help some with in	High CO state. Need to decrease CO by treating agitation. Flow	
19	VV	Hypoxia	increased cardiac output	sepsis	increase RPMs, optimize ABGs, treat acidosis	↑ RPM = ↑ saturation but limited by chatter d/t vasodilation. Volume = ↑ flow	Decreased flows both due to increased cardiac output as well a	
20	VV	Hypoxia	DO2: VO2	insufficient Hgb	give PRBCs, increase RPMS	↑ RPM with minimal improvement. Give 1u PRBC, ↑ oxygenation despite the sa	Increasing flow may not be enough, still needs hgb to more eff	
21	VV	Hypoxia	DO2: VO2	pain	medication, increase RPMs	↑ RPMs = ↑ Sats to apoint. Limited by circuit pressures eventually unless VO2 ↓	Increasing flow will be helpful to apoint until limited by circuit p	
22	VV	Hypoxia	DO2: VO2	agitation	sedation, increase RPMs	↑ RPMs = ↑ Sats to apoint. Limited by circuit pressures eventually unless VO2 ↓	Increasing flow will be helpful to apoint until limited by circuit p	
23	VV	Hypoxia	Native lungs	vent optimization	maintain ECMO flow, optimize vent	Sats ↓ despite optimal ECMO flow. No chatter but high pressures. Increase vent	balance between reducing harm from coonventional care v	If s
24	VA	hypoxia	Native Heart - increased CO	increased CO competitive flow				
25	VA	hypoxia	Native Lungs	optimize vent	No ECMO flow changes	Optimize vent settings, maintain current ECMO flow if hemodynamics are stable	balance between reducing harm from coonventional care but i	
26	VA	hypoxia	Native Lungs	VAV conversion	Add venous return	Hypoxic despite vent optimized and adequate arterial flow, add venous return	If hypoxic despite flow and vent optimization, may require ven	
26	VA	hypoxia	SaO2 oxygenator	oxygenator failure (thrombus)	circuit/oxy change	Sudden ↑ Δp. ↑RPMs to maintain flow until circuit change	Membrane pressures chart. Consequence of stangnant blo	Cau
27	VA	hypoxia	SaO2 oxygenator	oxygenator dysfunction - green hose disconnection	circuit check	Sudden ↓ sats, hemodynamic collapse, flow stable, no color change. Circuit chec	Off sweep in a VA ECMO vs VV. VA not only supporting CO but	
28	VA	hypoxia	SaO2 oxygenator	oxygenator dysfunction -wall source	circuit check/switch to tank	Sudden ↓ sats, heodynamic collapse, flow stable, no color change. Green hose c	Off sweep in a VA ECMO vs VV. VA not only supporting CO but	
29	VA	hypoxia	SaO2 oxygenator	FIO2	Increase FiO2 on ECMO	Increase FiO2 on ECMO	Optimize ECMO first before vent	
31	VA	hypoxia	ECMO Flow, Decreased SVO2	Insufficient flow	Increase flow, optimize vent if no improvement	Hypoxia with decreased SvO2, ↑ RPM for DO2	If hypoxic due to inadequate flow and low venous return, increa	
32	VV	hypotension	decreased flow	RVAD	Increase flow through the RVAD	↑ RPMs= ↑ BP	RV vs LV (pg 29 & 155) response	
33	VV	hypotension	decreased flow	hypoxia/hypercapnia	increase RPMs, optimize ABGs, treat acidosis	↑ RPMs/sweep = ↑Oxygen sats and reduce CO2= ↑ BP	Hypoxia/hypercapnia leads to increased vasoconstriction caus	
34	VV	hypotension	Vasodilation	sepsis	increase RPMs, optimize ABGs, treat acidosis. Fi	↑ sweep if hypercapnic, ↑ RPM if hypoxic and/or SvO2 low to optimze. ↑ flow	No direct impact on hypotension, however, if hypoxic or hyperc	
35	VV	hypotension	volume	Bleeding, overdiuresis	Give volume/blood	Give volume, if chatter due to hypovolemia then decrease RPMs as long as oxyg	If hypotensive due to hypovolemia, manage	
36	VV	hypotension	RV dysfunction	opitmize RV	Inotopes, diuretics	Optimize ABG, ↓ flows if able, diuresis and intropic support	RV dysfunction as a result of lung disease and high PA. Do not g	
37	VV	hypotension	RV Failure	VAV	Adding an arterial return	Add an arterial return, adjust hoffman to optimize RV unloading and improve MA	Arterial return now added to CO and offloads the RV since it is n	
38	VA	hypotension	Decreased flow (Limitations)	Native CO, decrease preload- Vasodilation	Increase ECMO blood flow	↑ RPM = ↑ BP but limited by chatter d/t vasodilation. Volume = ↑ flow and ↓ c	Treat cause of vasodilation, give volume to maintain flow	
39	VA	hypotension	Decreased flow (Limitations)	Native CO, decrease preload- SVR	Wean pressors, optimize drainage	Low -pvenous. ↑ RPMs = lower pvenous and ↓ flow. ↓ RPM= worse BP. Volum	Preload limited. Improving draining strategies: cannula positio	
40	VA	hypotension	Decreased flow (Limitations)	Native CO, decrease preload- Volume	Give volume, ↑ BP	↑ flow = ↑ chatter. ↓ flow= worse sats. Volume = improvement in flow and sa	preload dependent, CXR cannula position- ensure no other reve	
41	VA	hypotension	Decreased flow (Limitations)	Native CO, decrease contractility- Left heart	↑RPMs, ↑ BP	↑ RPMs= ↑ MAP	If native CO down and MAP low, increae ECMO flow	
42	VA	hypotension	Decreased flow (Limitations)	Native CO, decrease contractility- Right heart	↑RPMs, ↑ BP	↑ RPMs= ↑ MAP by ↑ drainage from the RV to offload	If RV contractility reduced, increase ECMO blood flow to inc	ECM
43	VA	hypotension	Decreased flow (Limitations)	ECMO, preload- Volume	Give volume/blood	Give volume, if chatter due to hypovolemia then decrease RPMs as long as oxyg	preload dependent, CXR cannula position- ensure no other reve	
44	VA	hypotension	Decreased flow (Limitations)	ECMO, preload- Vasodilation	pressors, reverse cause of vasodilation (infectior	↑ flow = ↑ chatter. ↓ flow= worse sats. Volume = improvement in flow and sa	Treat cause of vasodilation, give volume to maintain flow	
48	VA	hypotension	Decreased flow (Limitations)	ECMO, afterload- oxygenator failure (thrombus)	circuit/oxy change	Sudden ↑ Δp. ↑RPMs to maintain flow until circuit change	Membrane pressures chart	
49	VA	hypotension	Decreased flow (Limitations)	ECMO, afterload- circuit occlusion	Tip-to-tip inspection	Unable to increase flow. ↑ membrane pressures	Membrane pressures chart	

*Based on Presenters' Experience

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Fundamentals for building an ECMO program

1. Team
2. Education/Training
3. **Selection**
4. Culture of quality

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ECLS Criteria

Not sick enough to need ECLS

Disease severity

Too sick for ECLS to be of benefit

Sweet spot: likely to do poorly without ECLS and will improve with ECLS

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Selecting to hit the sweet spot

Rule 1: ***Reversible*** etiology of cardiac or respiratory failure

Rule 2: Conventional therapy is harming the patient more than helping

Rule 3: Cardiac/respiratory failure has to be severe enough to justify the risks of ECLS

Rule 4: Patient is not too far gone so that ECLS will not be of benefit

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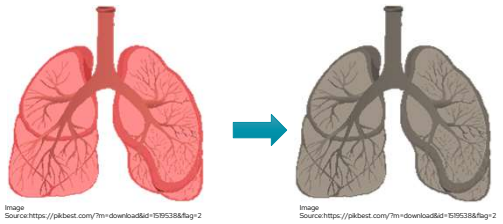
Respiratory failure



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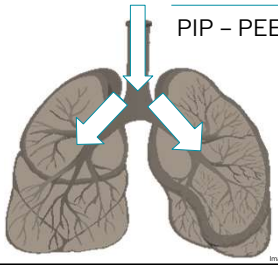
Respiratory Failure Measures

Compliance = $\frac{V_T}{PIP - PEEP}$

V_T

P_{IP}

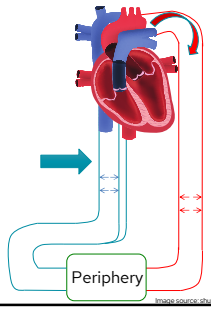


"Barotrauma"

"Volutrauma"

38

Adverse effects of fluid for shock



Hydrostatic pressure

Pressure

Blood vessel

Interstitium

Edema

Periphery

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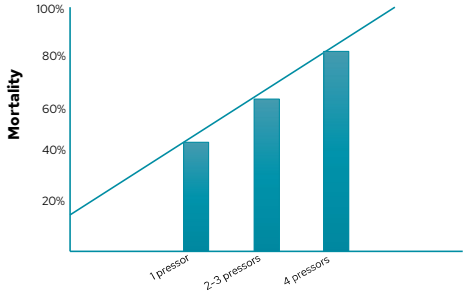
Mortality and vasopressor requirement in cardiogenic shock



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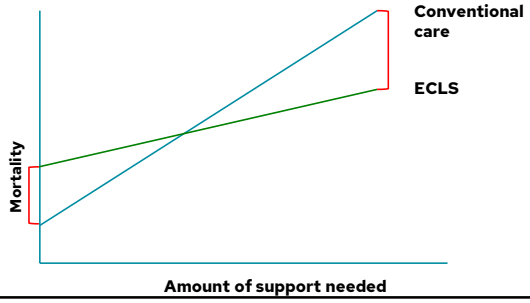
Mortality and support needed



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Selecting to hit the sweet spot

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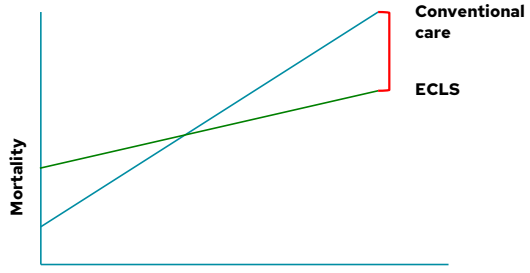
Mortality and support needed



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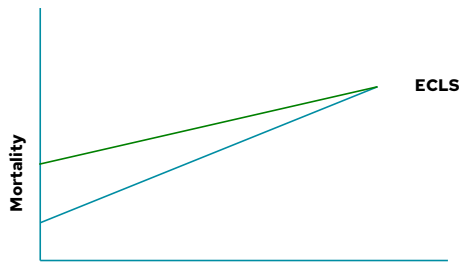
Mortality and support needed



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Worsening Respiratory Values

- Oxygenation (provides P:F < 100
- Ventilation (removes pH <7.25

Image Source:https://pikbest.com/?m=download&id=15195388&flag=2

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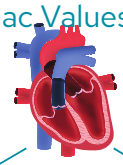
Worsening Cardiac Values



- Maintain MAP
  - 2 or more pressors
- Perfuse end organ
  - Lactate>4
  - UOP <30mL/hour
  - CVP > 16

Image source: shutterstock_1381420736.jpg

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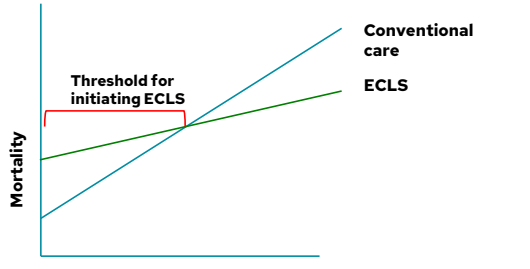
ECLS Risk-Benefit Analysis



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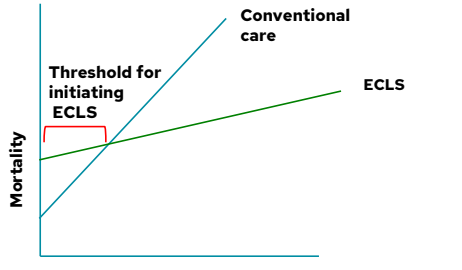
ECLS Risk-Benefit Analysis



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Selecting to hit the sweet spot

Rule 1: ***Reversible*** etiology of cardiac or respiratory failure

Rule 2: Conventional therapy is harming the patient more than helping

Rule 3: Cardiac/respiratory failure has to be severe enough to justify the risks of ECLS

Rule 4: Patient is not too far gone so that ECLS will not be of benefit

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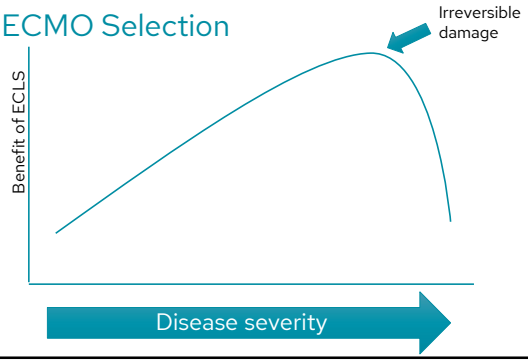
ECMO Selection



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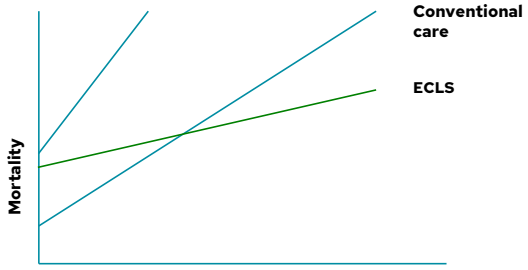
Mortality and support needed



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Rachel's corner: applying principles of selection

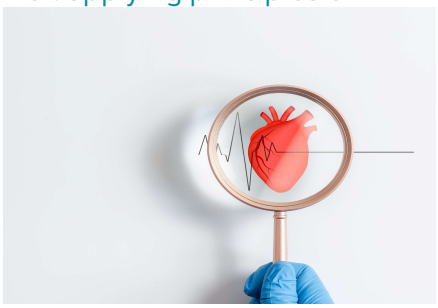

Image Source 7

Image Source 7: Shutterstock_2385158097.jpg

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Inclusion criteria

ORIGINAL ARTICLE

Extracorporeal Life Support in Infarct-Related Cardiogenic Shock

- Adults > 18 years of age
- Acute myocardial infarction with planned revascularization (PCI or CABG)
- Systolic blood pressure < 90mmHg for >30 mins or catecholamines to maintain SBP > 90mmHg
- Signs of impaired organ perfusion
- Arterial lactate > 3mmol/L

The NEW ENGLAND JOURNAL of MEDICINE

ORIGINAL ARTICLE

Extracorporeal Membrane Oxygenation for Severe Acute Respiratory Distress Syndrome

- ARDS
- Endotracheal intubation of <7 days and
- PaO2:FIO2 ratio <50 mmHg for >3 hours; or,
- PaO2:FIO2 <80 mmHg for >6 hours; or,
- Arterial blood pH <7.25/PaCO2 >60 mmHg for >6 hours

Thiele, H. et al. (2023) *Extracorporeal life support in infarct-related cardiogenic shock.* New England Journal of Medicine. Combes, A. et al. (2018) *Extracorporeal membrane oxygenation for severe acute respiratory distress syndrome.* The New England Journal of Medicine.

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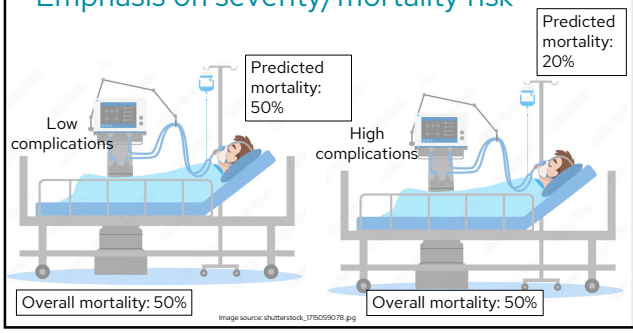
Emphasis on severity/mortality risk



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Who would derive the most benefit from ECMO?

- 55 year old with respiratory failure due to COVID-19, satting 85% on maximal ventilator settings
- 70 year old post knee repair with brief cardiac arrest found to have large pulmonary embolism on three pressors
- 65 year old with NSTEMI with LAD lesion s/p PCI/IABP placement now with cardiogenic shock
- 40 year old OHCA with persistent V fib and 50 minutes CPR

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Who would derive the most benefit from ECMO? Cont.

- 55 year old with respiratory failure due to COVID-19, satting 85% on maximal ventilator settings
- **70 year old post knee repair with brief cardiac arrest found to have large pulmonary embolism on three pressors**
- 65 year old with NSTEMI with LAD lesion s/p PCI/IABP placement now with cardiogenic shock
- 40 year old OHCA with persistent V fib and 50 minutes CPR

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Case 1

- 22-year-old college student with cardiac arrest at airport
- Prior to arrest was reportedly having palpitations, called family who called medic at the airport.
- History of Wolfe-Parkinson-White (2014) with no recurrent episodes
- Active at baseline/runs cross-country
- EMS transported to hospital, unable to get return of spontaneous circulation. Initially awake with chest compressions, pulled out airway
- On arrival to hospital was in refractory ventricular fibrillation (~45 minutes of continuous chest compressions)
  - Initial ABG: 6.87/25/108/4.5/-28/93.6%, lactic acid 19

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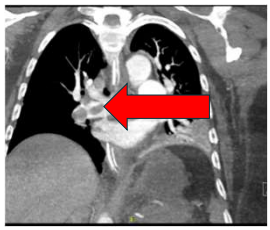
Case 2

- 65-year-old female with chronic pancreatitis with pseudocyst presenting with complaints of abdominal pain
- CT scan of the abdomen pelvis as well as showed of large bilobed pancreatic pseudocyst and cholelithiasis
- Admitted to telemetry but became abruptly hypotensive, hypoxic, tachycardic, and lightheaded
- Placed on BiPAP
- Cardiac arrest



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Fundamentals for building an ECMO program

1. Team
2. Education/Training
3. Selection
4. **Culture of quality**

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What is quality as it relates to a great ECMO program?

Patient centered

Ability to adapt to changing environment

Commitment to continuous improvement

Measurable metrics

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Patient centered

Disclosure: Personal professional images. Waivers on file. Pictures property of Institute for ECMO Development, LLC

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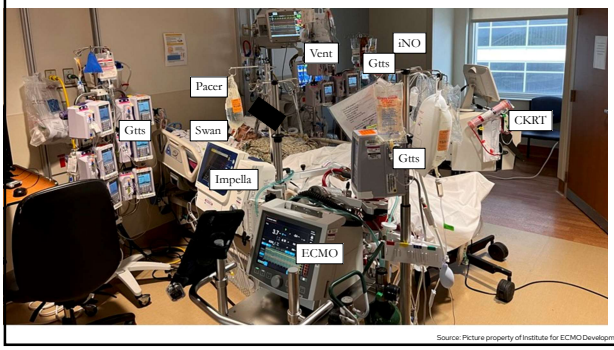
Care Giver Model



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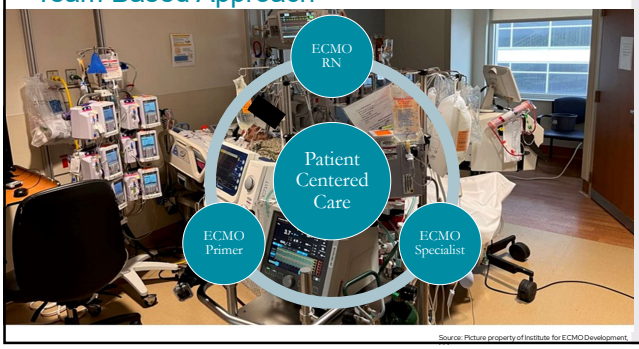
Team Based Approach



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Ability to adapt to changing environments

Adapt to COVID-19
Multiple ICUs
Separation of resources
Build capacity

Shifted focus
Developed research
Built out identity
While maintaining lung rescue concept

2019 — 2020 — 2021 — 2022 — 2023

Growth and development
Program growth
Predominantly cardiac
Single ICU

Continued growth
Continued lung rescue growth
Buildup of cardiac capabilities

Consolidation and pivot
Merge staff resources
Focus on outreach and transport
Ancillary program development

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Ability to adapt to changing environments

Adapt to COVID-19
Developed efficient model
Improved fidelity with simulation

Shifted focus
Handled increasing skills and complexity
Maintained currency

2019 — 2020 — 2021 — 2022 — 2023

Growth and development
Developed specialist identity
Built up capacity

Continued growth
Turnover
Maximized efficiencies

Consolidation and pivot
Train for new capabilities
Expand footprint

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Commitment to continuous improvement

- How we do it?
- Triggers for improvement
- Review
- Environment for improvement/criticism

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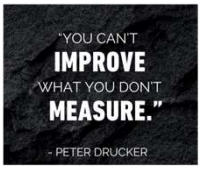
Measurable metrics

- Identify root cause
- Empower entire team
- Communicate measurable goals



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Rachel's corner

Image Source 8

Image Source 8: Shutterstock_1799530594.jpg

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Why we build this?

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Thank you!

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Upcoming Events

ACCME **credits available*

https://advancedrenaleducation.com/wparep/events/

October 28	Understanding the Essentials and Application of Online Hemodiafiltration
November 14	HDF Spotlight: Global Epidemiology and Real-World Data on High-Volume Hemodiafiltration
December 5	HDF Spotlight: Shifting from High-Flux HD to High-Volume HDF

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