CARDIOGENIC SHOCK

ECMO management in the ICU: status 2020

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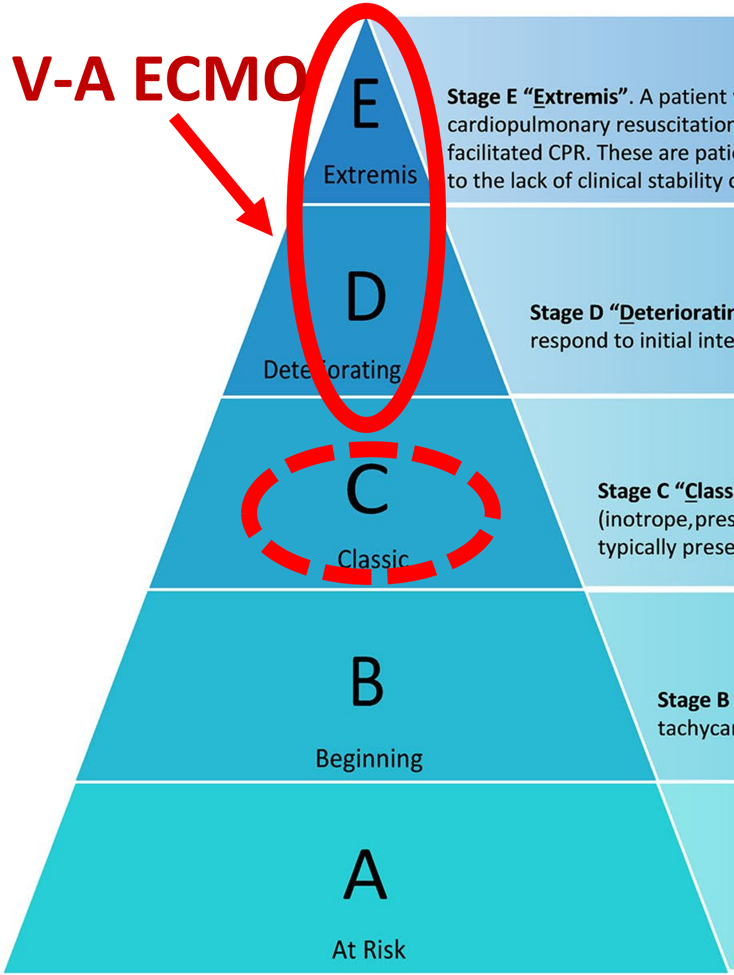


Stage E "Extremis". A patient with circulatory collapse, frequently (but not always) in refractory cardiac arrest with ongoing cardiopulmonary resuscitation (CPR) or are being supported by multiple simultaneous acute interventions including ECMO-facilitated CPR. These are patients with multiple clinicians at bedside laboring to address multiple simultaneous issues related to the lack of clinical stability of the patient.

Stage D "Deteriorating or Doom". A patient that is similar to category C but is getting worse. They have failure to respond to initial interventions.

Stage C "Classic" Cardiogenic Shock. A patient that manifests with hypoperfusion that requires intervention (inotrope, pressor or mechanical support, ECMO) beyond volume resuscitation to restore perfusion. These patients typically present with relative hypotension.

Stage B "Beginning" Cardiogenic Shock. A patient who has clinical evidence of relative hypotension or tachycardia without hypoperfusion.

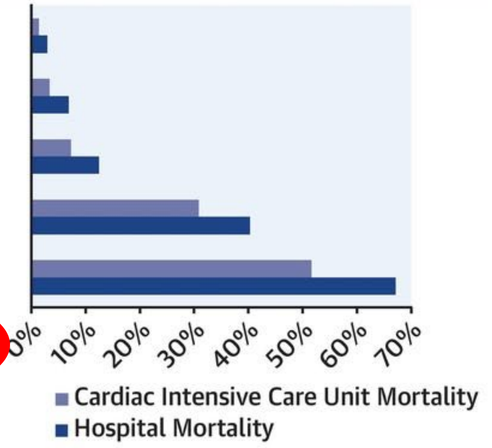
Stage A "At Risk". A patient who is not currently experiencing signs or symptoms of cardiogenic shock, but is at risk for its development. These patients may include those with acute myocardial infarction, acute and/or acute on chronic heart failure symptoms.

Baran Det al. Catheter Cardiovasc Interv, 2019, 94;29-37

CENTRAL ILLUSTRATION: Definitions of SCAI Shock Stages A Through E, With Associated Cardiac Intensive Care Unit and Hospital Mortality in Each SCAI Shock Stage

Cardiogenic Shock Stage	Study Definition
Stage A ("At risk")	Neither hypotension/tachycardia nor hypoperfusion
Stage B ("Beginning")	Hypotension/tachycardia WITHOUT hypoperfusion
Stage C ("Classic")	Hypoperfusion WITHOUT deterioration
Stage D ("Deteriorating)"	Hypoperfusion WITH deterioration NOT refractory shock
Stage E ("Extremis")	Hypoperfusion WITH deterioration AND refractory shock

Observed Mortality in Overall Cohort



Jentzer, J.C. et al. J Am Coll Cardiol. 2019;74(17):2117-28.

V-A ECMO

Biventricular support
Oxygenation benefit
cave: afterload ↑

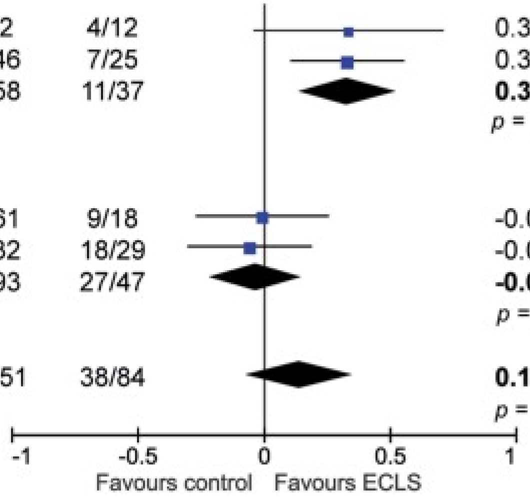
Cardiogenic shock & MCS: the challenge

- ***GOAL*** = restore end-organ perfusion asap
- pair the right patient with the right device at the right time
- **V-A ECMO**
  - biventricular support
    - ↓ preload
    - ↑ MAP
    - ↑ cardiac output (3-7 l/min)
  - pulmonary support
    - secures oxygenation
- **Impella CP/5.0**
  - LV support
    - ↓ preload
    - ↓MAP
    - ↑ cardiac output (3-5 l/min)
  - no pulmonary support

ECLS in cardiac arrest and cardiogenic shock

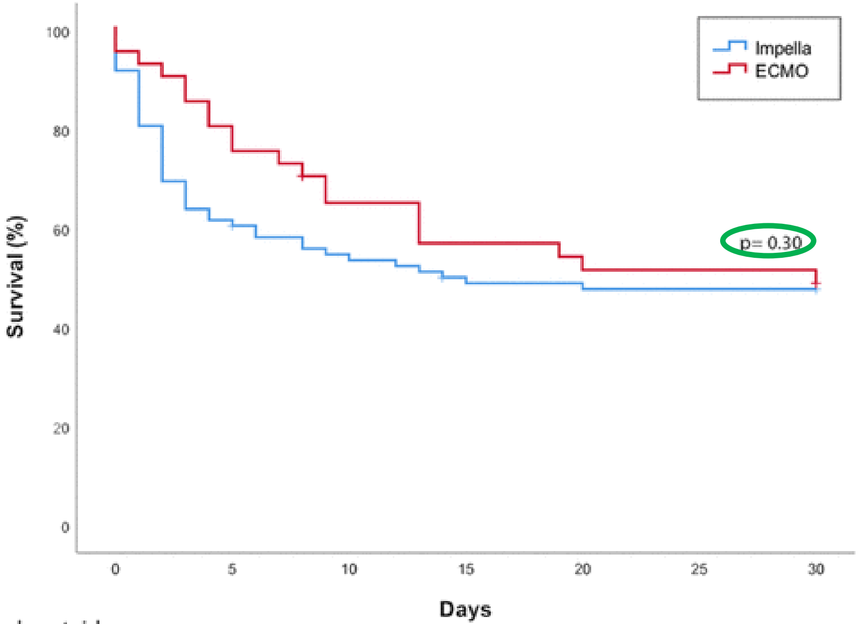
Cardiogenic shock - 30-day survival

	ECLS n/N	Control n/N	Absolute risk difference		
ECLS versus IABP					
Settler 2014	8/12	4/12	0.33 (-0.04 - 0.71)	*p* (heterogeneity) = 0.98
Sheu 2010	28/46	7/25	0.33 (0.10 - 0.55)	I^2 = 0%
Pooled	36/58	11/37	**0.33 (0.14 - 0.52)** *p = 0.0008*	
ECLS versus Impella/TandemHeart					
Chamogeorgakis 2013	30/61	9/18	-0.01 (-0.27 - 0.25)	*p* (heterogeneity) = 0.79
Lamarche 2010	18/32	18/29	-0.06 (-0.30 - 0.19)	I^2 = 0%
Pooled	48/93	27/47	**-0.03 (-0.21 - 0.14)** *p = 0.70*	
Pooled	84/151	38/84	**0.14 (-0.08 - 0.35)** *p = 0.20*	*p* (heterogeneity) = 0.06, I^2 = 60%

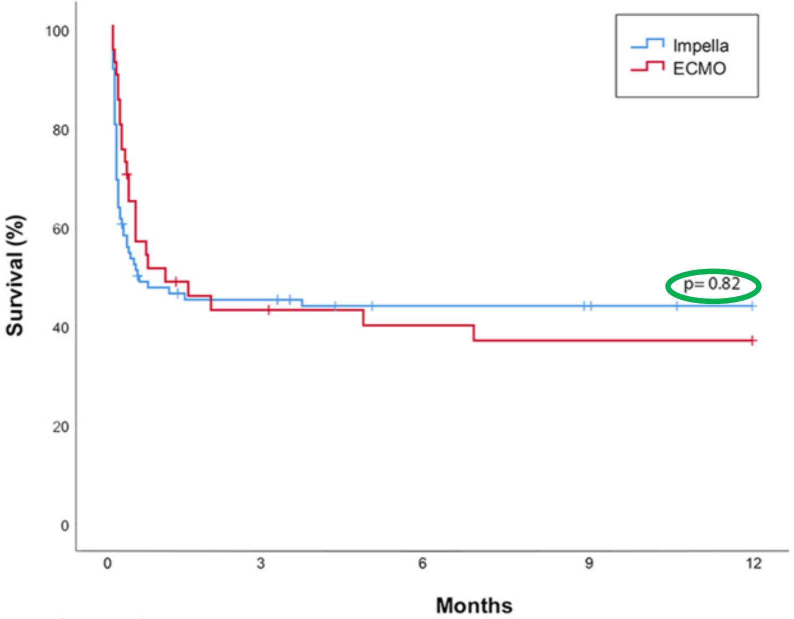


Ouweneel et al, Intensive Care Med 2016; 42(12):1922-1934

30-day and 1 year survival in Impella CP/5.0 and ECMO supported AMI-patients: retrospective analysis



Number at risk				
Impella	90	47	41	40
ECMO	38	24	20	19



Number at risk					
Impella	90	37	32	31	29
ECMO	38	14	13	12	12

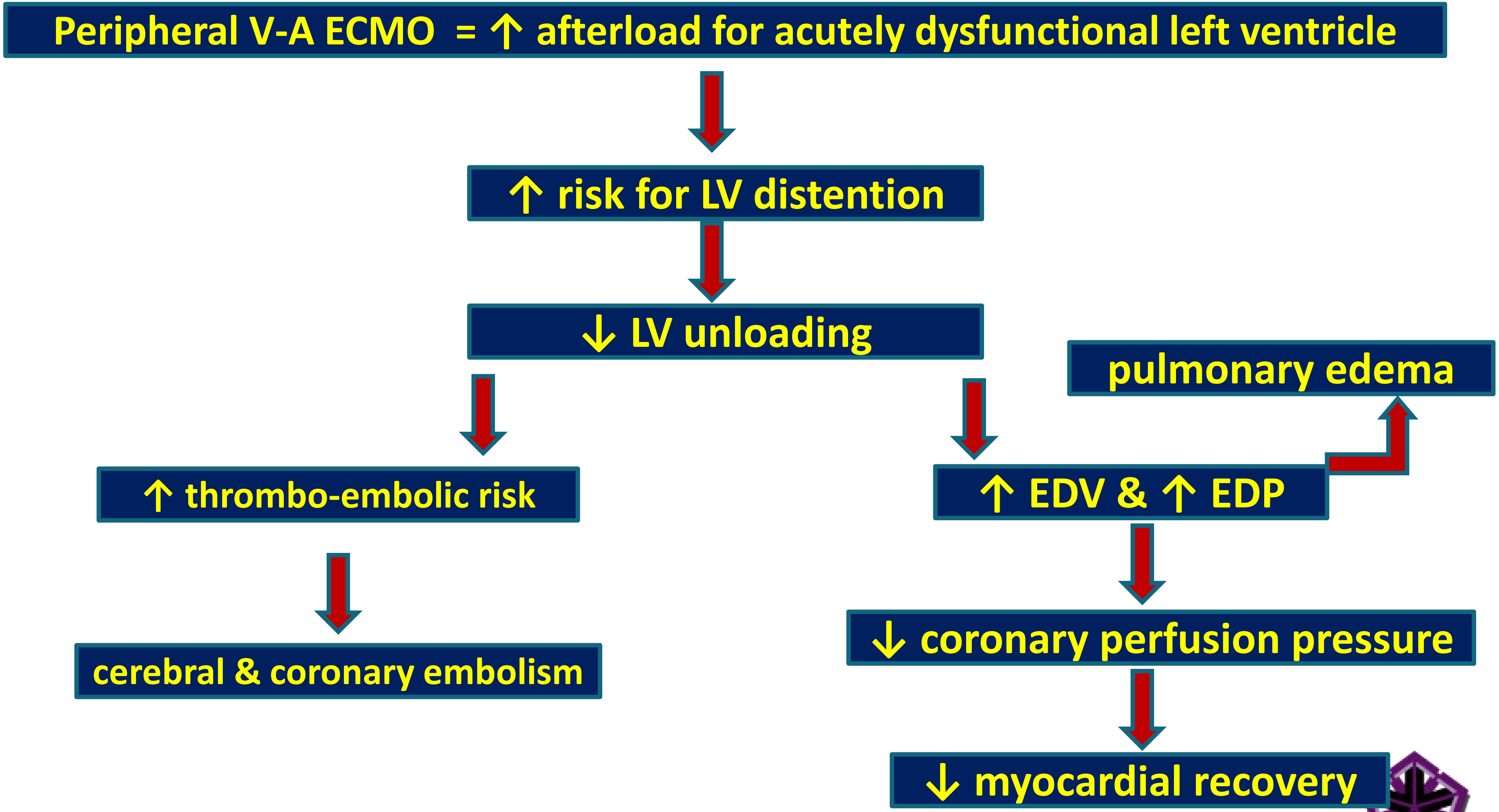
Karami et al. Eur Heart J Acute Cardiovasc Care 2020; 9(2):164-172

V-A ECMO: advantages & risks

- Easy access / cannulation @ the **bedside**
  - percutaneous/surgical
- **Biventricular** support
- **Oxygenation** benefit: pulmonary support
  - ↓ ventilator-induced heart-lung interactions

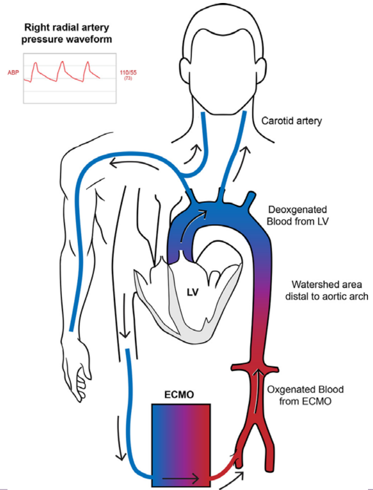
} ↑ organ perfusion & function

- inter-hospital **transport** in controlled conditions
- ***cave: LV-afterload* ↑** & *unloading LV :*
  - ↑ myocardial wall stress, pulmonary edema & risk intracardiac thrombosis


Peripheral V-A ECMO = ↑ afterload for acutely dysfunctional left ventricle
↑ risk for LV distention
↓ LV unloading
↑ thrombo-embolic risk
cerebral & coronary embolism
↑ EDV & ↑ EDP
pulmonary edema
↓ coronary perfusion pressure
↓ myocardial recovery

V-A ECMO: management issues

- Early phase : inter-hospital **transport**
  - LV-unloading?!
    - pharmacologic venting
  - volume-status
    - bleeding ?
  - differential hypoxemia (watershed-zone)
    - Harlequin syndrome / North-South syndrome
    - ventilatory & flow management



V-A ECMO: management issues

- Early phase in **ICU**
  - LV-unloading?!
    - pharmacologic and/or mechanical venting
  - differential hypoxemia (Harlequin syndrome / North-South syndrome)
  - vascular problems: limb ischemia; compartment syndrome
  - hemodynamic monitoring:
    - ABP(right), NIRS[4], SaO_2(right), SvO_2, Swan-Ganz, TTE/TOE
  - bleeding ← **anticoagulation** → thrombosis: 

V-A ECMO: management issues

- **Weaning** phase
  - hemodynamic assessment: echocardiography !
  - strategies
    - pharmacologic support
    - ECMELLA-concept
    - ventilatory management
  - anticoagulation
  - bridge to …

VA-ECMO Management ICU

CAPITA SELECTA

HARLEQUIN

Recognize
Differential Hypoxemia

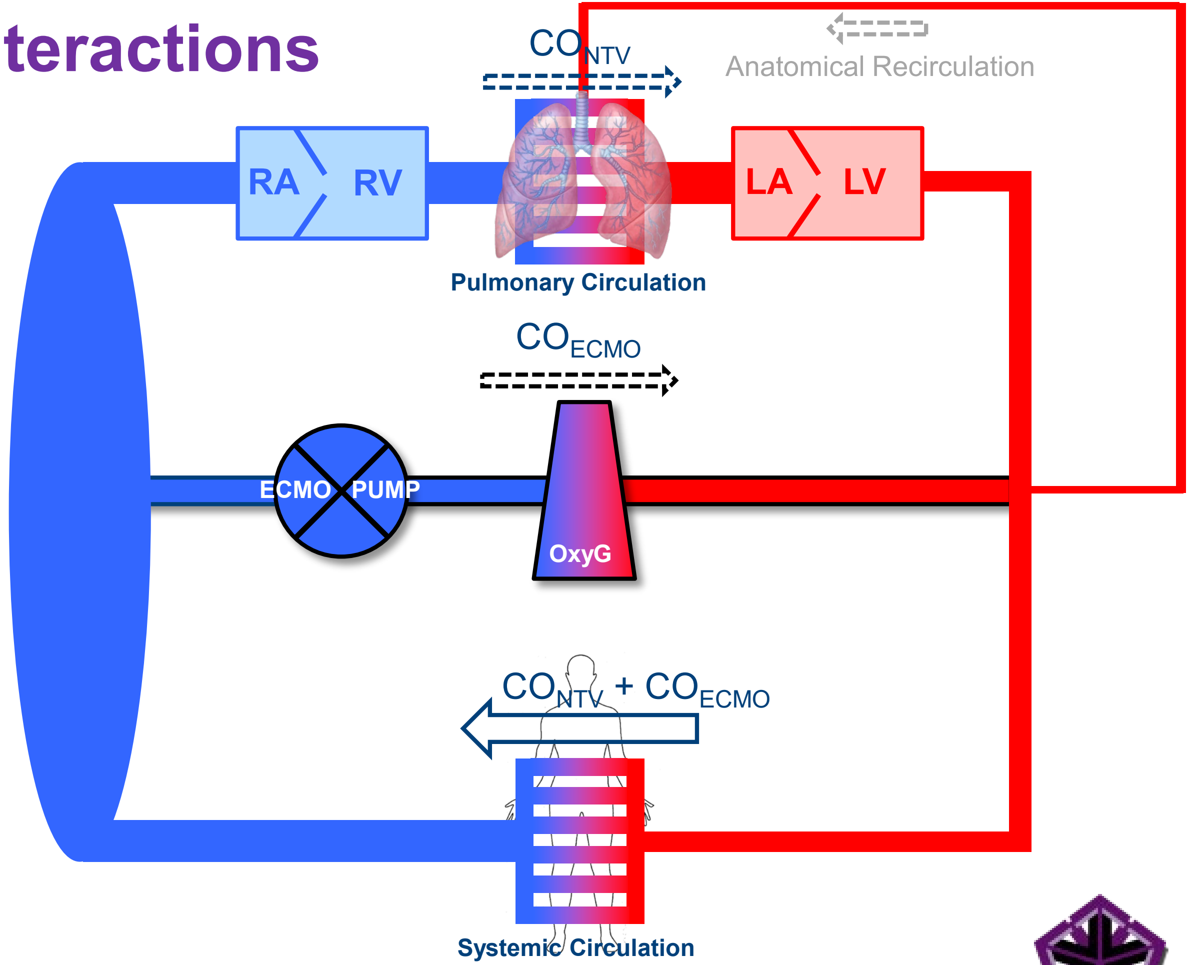
UNLOADING

Medical
Management

WEANING

Medical
Management

VA-ECMO - Patient Interactions

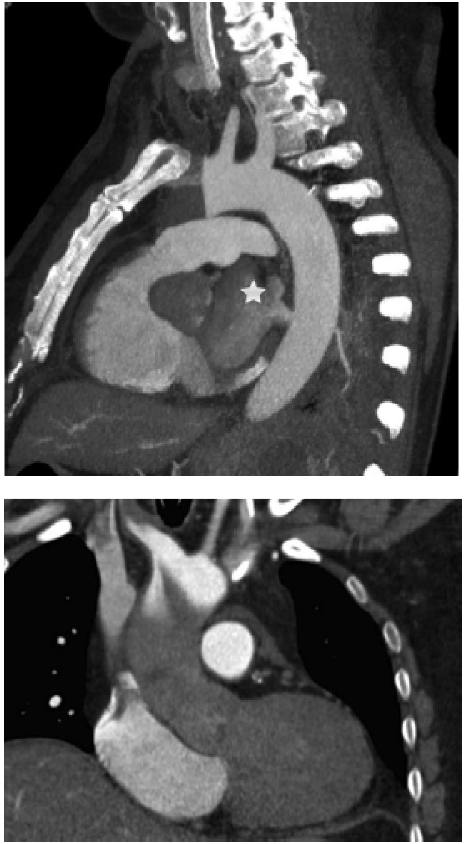


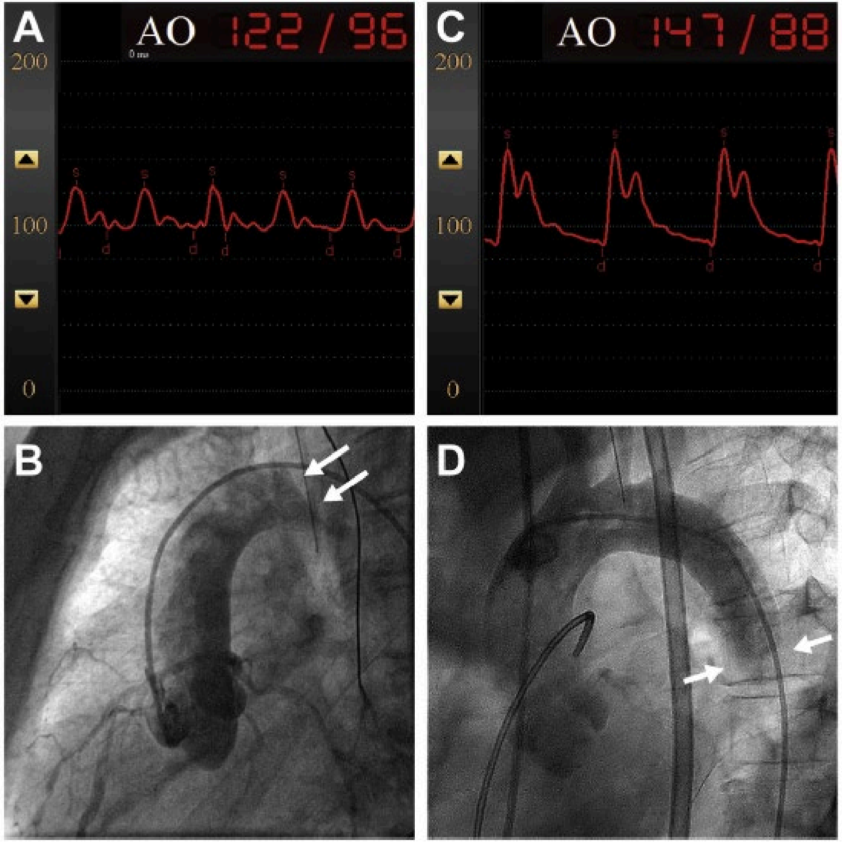
PARTIAL BYPASS

Hemodynamic Support
Unloading (Right) Heart
Unloading Pulmonary Circulation

Gas Exchange

Dynamic Flow Competition

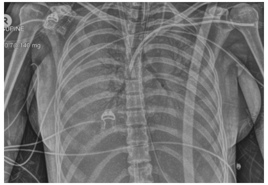


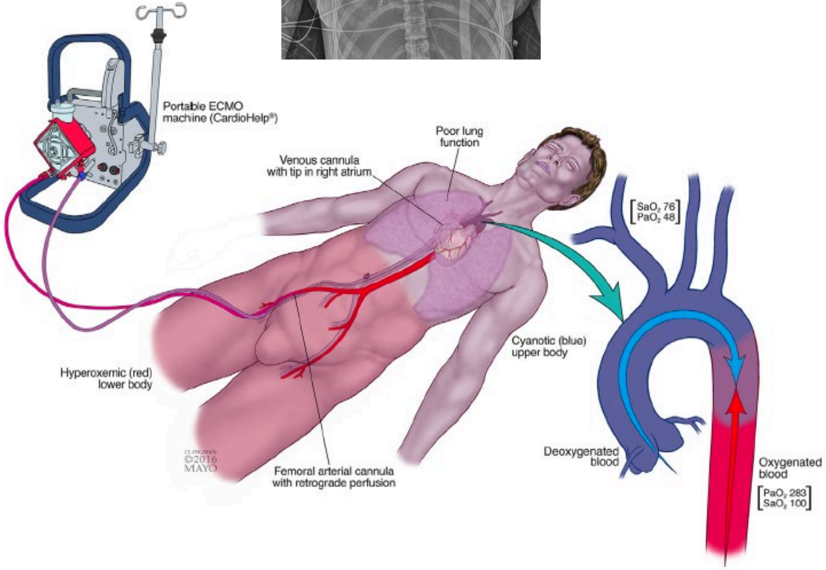


CT

Aortogram Cathlab

Recognize Differential Hypoxemia





“CONDITIO SINE QUA NON”:

- Peripheral Fem-Fem VA-ECMO
- ‘RECOVERY’ HEART
- Respiratory Failure

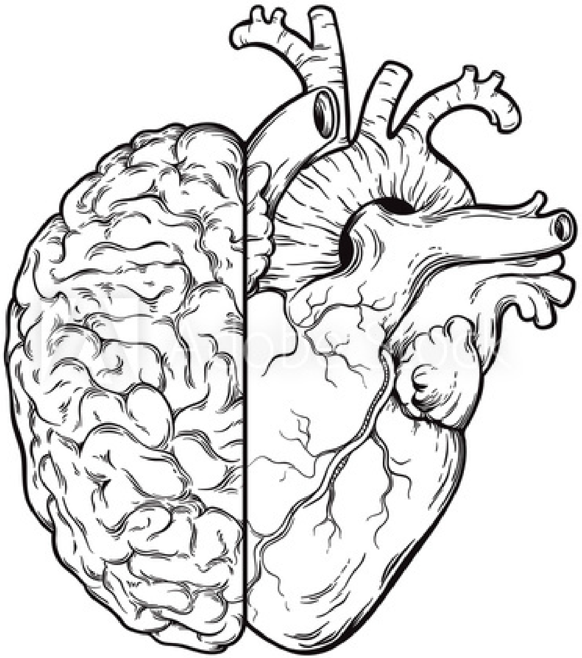
RECOGNIZE:

- ABG/POx right arm
- NIRS[4]

MANAGE:

- Increase ventilatory support
- ECMO reconfiguration / mode switch
- …

Recognize Differential Hypoxemia



PRESERVE

"CONDITIO SINE QUA NON":

- Peripheral Fem-Fem VA-ECMO
- 'RECOVERY' HEART
- Respiratory Failure

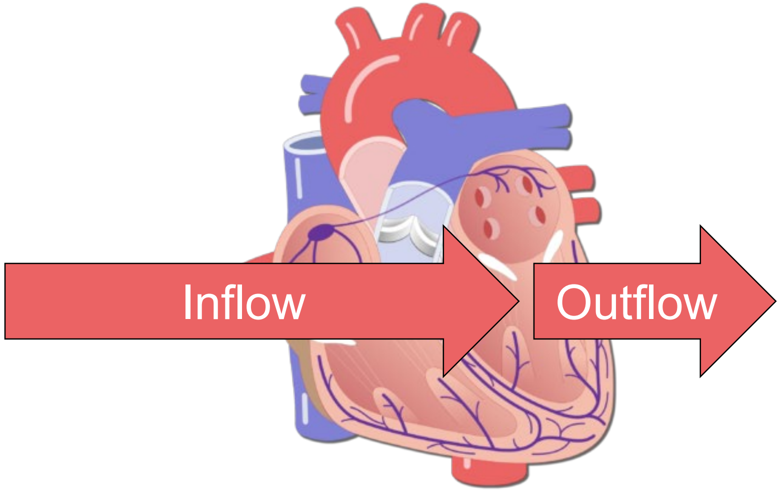
RECOGNIZE:

- ABG/POx right arm
- NIRS[4]

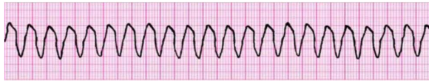
MANAGE:

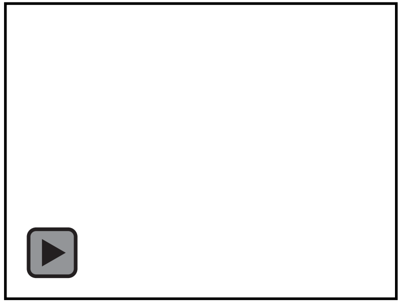
- Increase ventilatory support
- ECMO reconfiguration / mode switch
- …

"Medical" Unloading Strategies

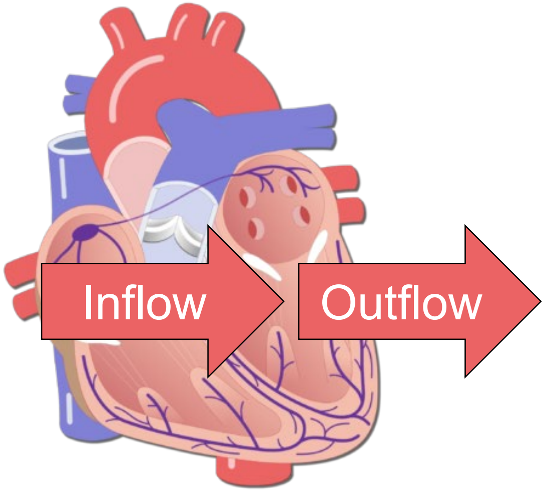


Left Heart Inflow-Outflow Imbalance





"Medical" Unloading Strategies



Restoring Left Heart Inflow-Outflow Balance

CONSIDER TOTAL SYSTEMIC FLOW (CO_{NTV}+CO_{ECMO})
- Reduce '*SUPRAPHYSIOLOGIC*' ECMO-flow

CARDIOPULMONARY INTERACTIONS
- High PEEP strategy

PHARMACOLOGICAL AFTERLOAD OPTIMIZATION
- Optimize SVR

PHARMACOLOGICAL 'VENTING'
- MILD inotropic 'kick'

+ INCREASE ANTICOAGULATION TARGETS

Weaning VA-ECMO

TIMING IS CRUCIAL

(Elective vs accelerated “push off”)

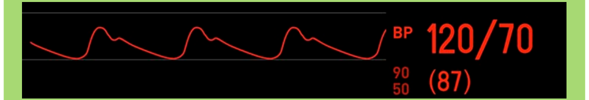
Weaning VA-ECMO

Incentives for an "Official Weaning Trial" - Assess q24h

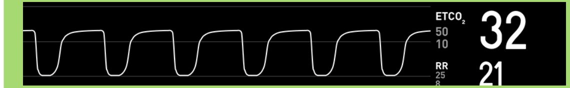
Resolution of Shock

Resolution of Major Metabolic Disturbances

Augmentation > 24h



$ETCO_2$ ⇧



Sustained Hemodynamics at Partial ECMO-support with 'reasonable' # pressors

Echocardio Contractility ⇧

Weaning VA-ECMO

The heart is preload 'starved' during VA-ECMO support
(partial bypass)

"Crude" and "static" eyeballing during support
contains limited prognostic information

More advanced and **DYNAMIC** assessment needed
LOAD DEPENDENT CONTRACTILE RESERVE
(Preload ⇧ and Afterload ⇩ Recruitability)
"Official VA-ECMO Weaning Trial"

Weaning VA-ECMO

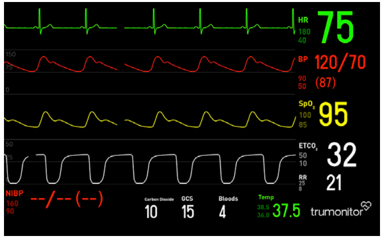
PREPARE:

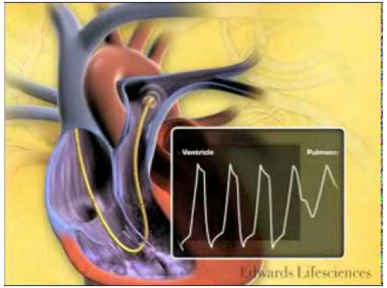
Ensure optimal volume state
Increase/initiate inotropic support
Increase lung protective ventilation
Ensure optimal anticoagulation

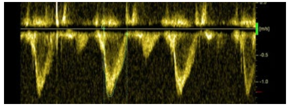
Gradual step-down ECMO blood flow
NEVER switch of FGF

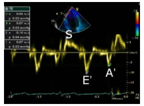
MONITOR:

Hemodynamics
Echocardiography
Gas exchange
Differential hypoxemia ?









DECIDE
HAVE A FAILURE PLAN

Weaning VA-ECMO

PAUCITY OF DATA

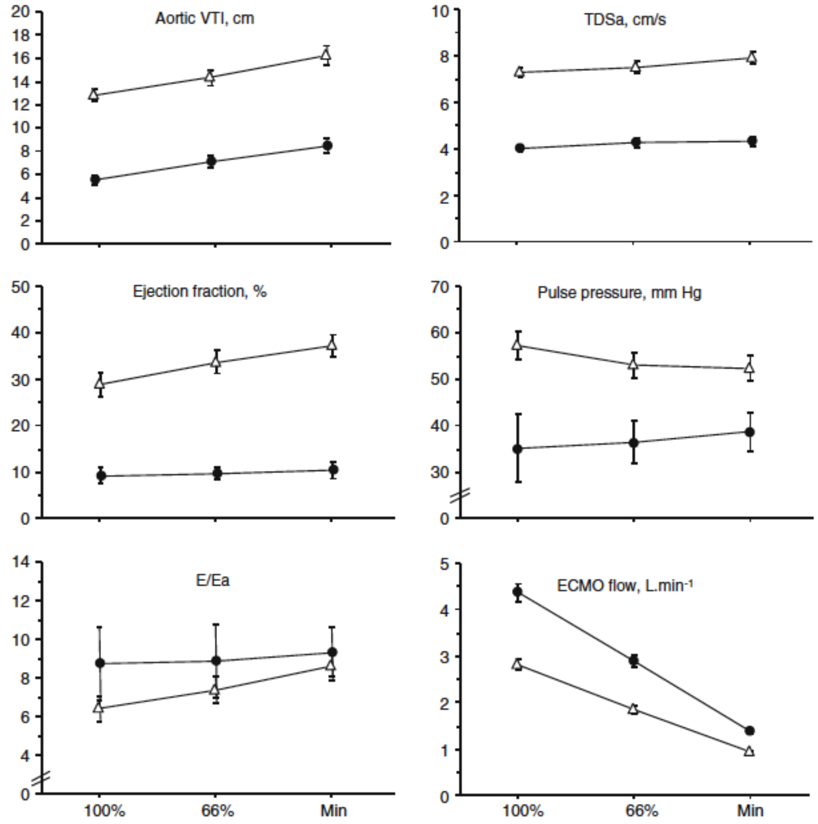
Intensive Care Med (2011) 37:1738–1745
DOI 10.1007/s00134-011-2358-2

ORIGINAL

Nadia Aissaoui
Charles-Edouard Luyt
Pascal Leprince
Jean-Louis Trouillet
Philippe Léger
Alain Pavie
Benoit Diebold
Jean Chastre
Alain Combes

Predictors of successful extracorporeal membrane oxygenation (ECMO) weaning after assistance for refractory cardiogenic shock

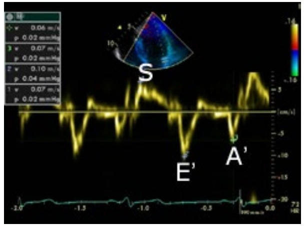
Weaning VA-ECMO

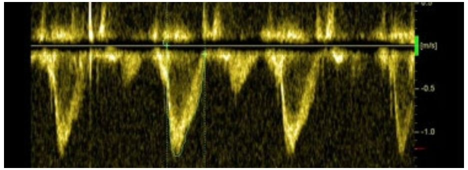


DYNAMIC Echo Assessment

At 1-1.5 L/min ECMO blood flow:

- LVOT VTI ≥ 10-12 cm
- TDSa MV ≥ 6 cm/s
- LVEF ≥ 20-25%
- NO ventricular Interdependence





Weaning VA-ECMO

Levosimendan ?

Effects of Levosimendan on Endothelial Function and Hemodynamics During Weaning From Veno-Arterial Extracorporeal Life Support

Fabio Sangalli, MD,* Leonello Avalli, MD,* Matteo Laratta, MD,*‖ Francesco Formica, MD,§‖ Elena Maggioni, MD,* Rosa Caruso, CPT,‡ Maria Cristina Costa, CPT,‡ Marco Guazzi, MD, PhD,† and Roberto Fumagalli, MD, PhD‖¶

Review — *Perfusion*

Perfusion 2020, Vol. 35(6) 484–491 © The Author(s) 2020 DOI: 10.1177/0267659120918473 SAGE

Effects of levosimendan on weaning and survival in adult cardiogenic shock patients with veno-arterial extracorporeal membrane oxygenation: systematic review and meta-analysis

Lucrecia María Burgos,[1] Leonardo Seoane,[2] Juan Francisco Furmento,[2] Juan Pablo Costabel,[2] Mirta Diez,[1] Mariano Vrancic,[3] Nadia Aissaoui,[4] Mariano Noel Benzadón[2] and Daniel Navia[3]

Vally et al. Ann. Intensive Care (2019) 9:24 https://doi.org/10.1186/s13613-019-0503-1 — Annals of Intensive Care

RESEARCH — Open Access

Impact of levosimendan on weaning from peripheral venoarterial extracorporeal membrane oxygenation in intensive care unit

Shamir Vally[1], Cyril Ferdynus[2,3], Romain Persichini[1], Bruno Bouchet[1], Eric Braunberger[4], Hugo Lo Pinto[1], Olivier Martinet[1], David Vandroux[1], Thomas Aujoulat[1], Jérôme Allyn[1] and Nicolas Allou[1,5*]

Guilherme et al. Critical Care (2020) 24:442 https://doi.org/10.1186/s13054-020-03122-y — Critical Care

RESEARCH — Open Access

Can levosimendan reduce ECMO weaning failure in cardiogenic shock?: a cohort study with propensity score analysis

Enrique Guilherme[1], Matthias Jacquet-Lagrèze[1,2*], Matteo Pozzi[3], Felix Achana[4], Xavier Armoiry[5,6] and Jean-Luc Fellahi[1,2]

ASAIO Journal 2013

Adult Circulatory Support

Levosimendan May Improve Weaning Outcomes in Venoarterial ECMO Patients

Alessandro Affronti, Isidoro di Bella, Davide Carino, and Temistocle Ragni

BJA — British Journal of Anaesthesia, 117 (1): 52–8 (2016) doi: 10.1093/bja/aew151 Cardiovascular

Beneficial effects of levosimendan on survival in patients undergoing extracorporeal membrane oxygenation after cardiovascular surgery

K. Distelmaier[1], C. Roth[1], L. Schrutka[1], C. Binder[1], B. Steinlechner[2], G. Heinz[1], I. M. Lang[1], G. Maurer[1], H. Koinig[3], A. Niessner[1], M. Hülsmann[1], W. Speidl[1] and G. Goliasch[1,*]

CONFLICTING LOW QUALITY EVIDENCE

HOWEVER

- Majority positive
- Pharmaco-dynamics/kinetics
- Non-ECLS data

LOW THRESHOLD

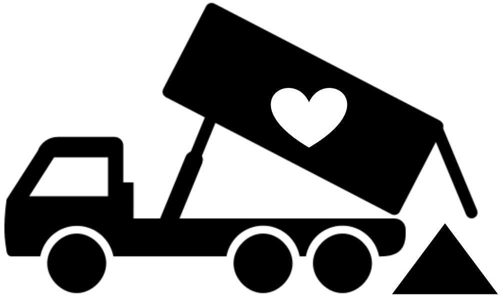
- Consider early
- Especially: cardiac surgery, β-blockers, arrhythmias, …

VA-ECMO Management ICU

CAPITA SELECTA

HARLEQUIN

Understand Pathophysiology
And Recognize
Differential Hypoxemia



UNLOADING

Fully Exploit
"Medical" Options

WEANING

Expert
Multimodal
Assessment
Timing is Crucial