Patient Selection for VA ECMO

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Cardiac Surgery ICU, Madinah Cardiac Centre

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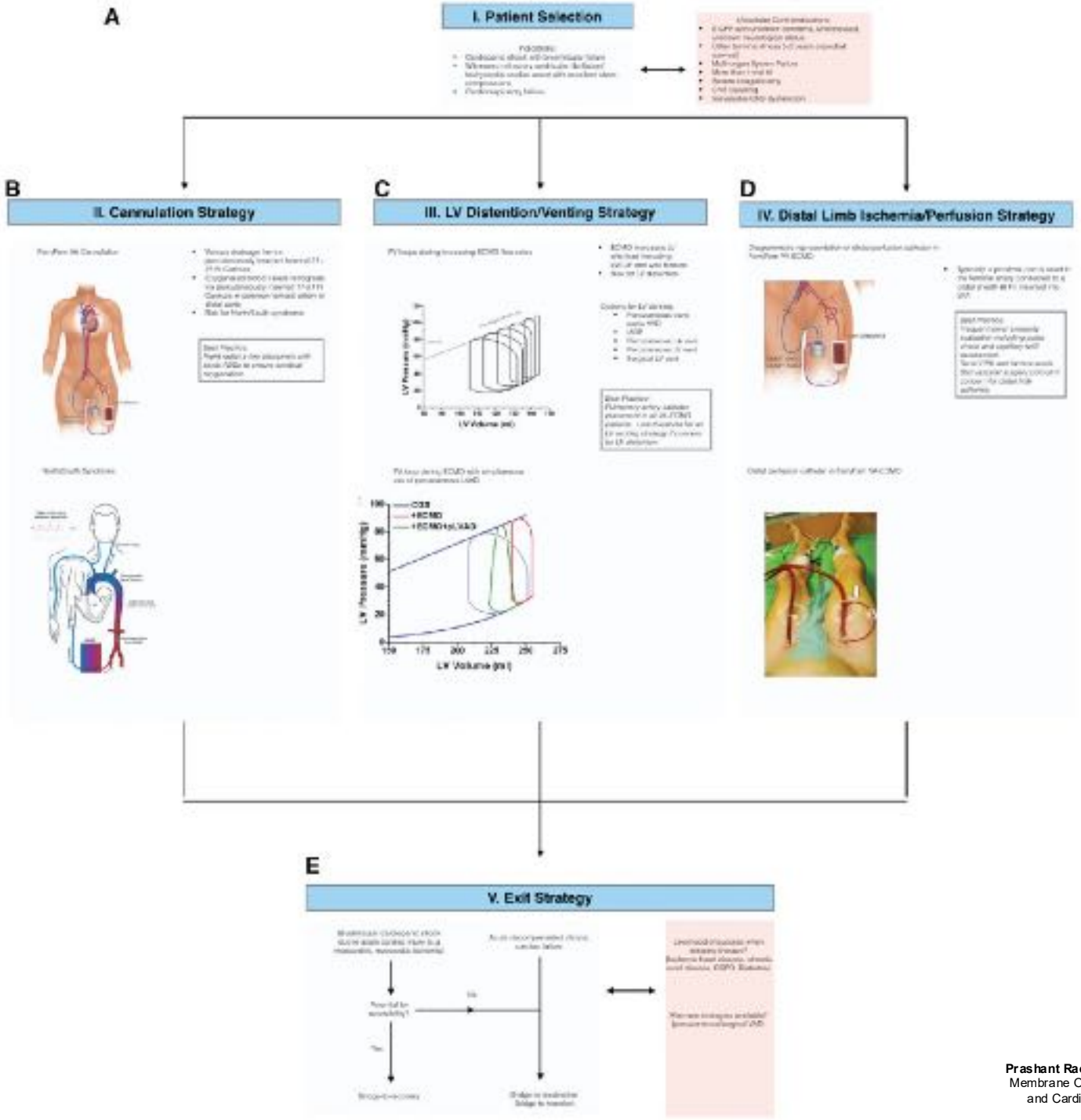
University of Western Ontario, London, Ontario, Canada

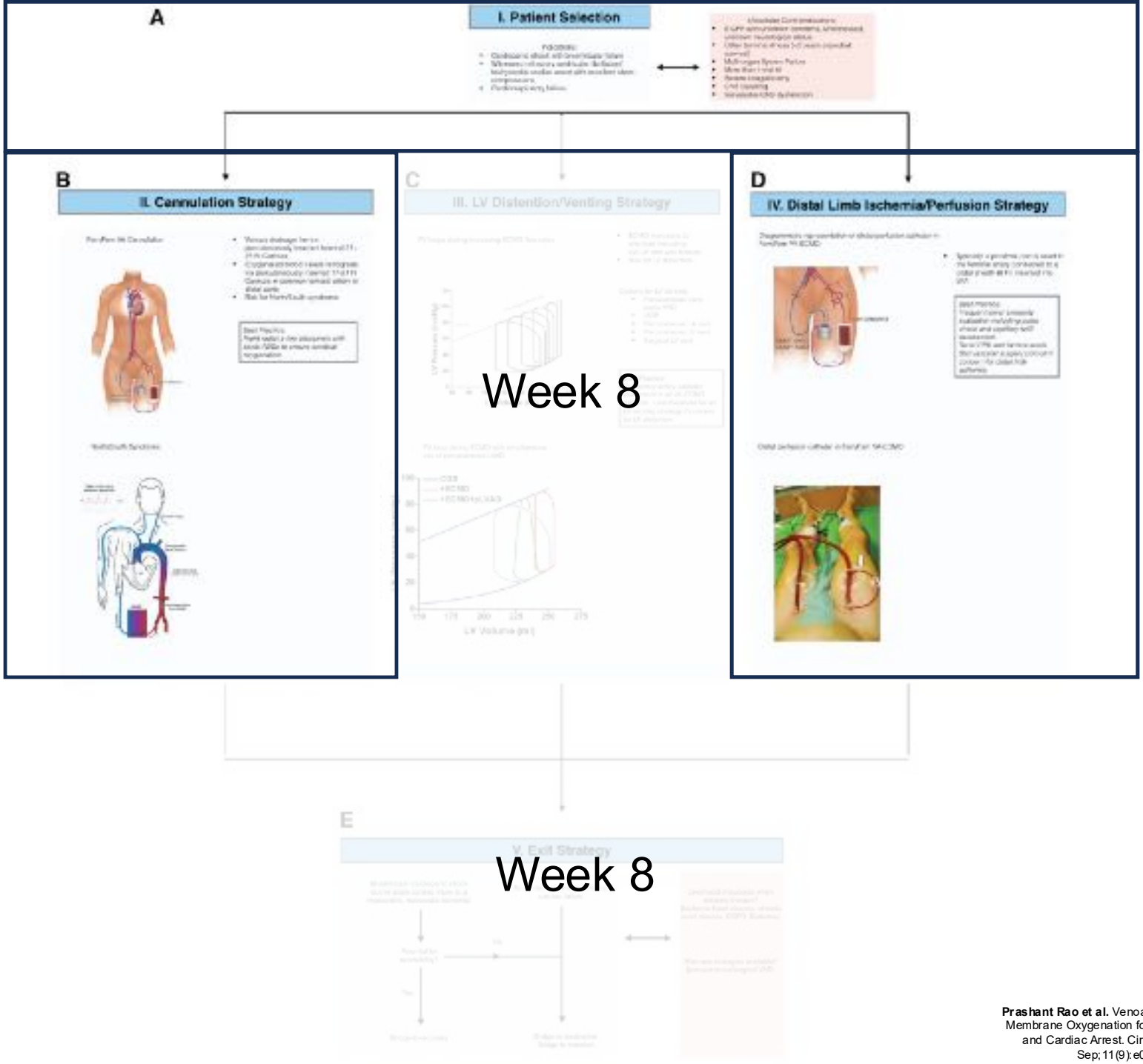
Saving Lives Academy

Outline

- Patient Selection
- VA ECMO Initiation
- VA ECMO Goals



Prashant Rao et al. Venoarterial Extracorporeal Membrane Oxygenation for Cardiogenic Shock and Cardiac Arrest. Circ Heart Fail. 2018 Sep; 11(9): e004905.



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Saving Lives Academy

Outline

- **Patient Selection**
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Case Presentation

ID

- 26-year-old female

PMHx

- Hypothyroidism on replacement therapy

Case Presentation

ID

- 26-year-old female

PMHx

- Hypothyroidism on replacement therapy

HPI

- Viral prodrome 5 days ago
- Feeling very weak 2 days ago
- Presented to peripheral hospital

Case Presentation

O/E

- Cold clammy extremities
- BP: 78/49, HR: 136 (sinus), SpO_2 89% on RA

Labs

- Creatinine 138 mmol/L, BUN 14
- Lactate: 6.2 mmol/L, pH 7.21, HCO_3 15

Case Presentation

O/E

- Cold clammy extremities
- BP: 78/49, HR: 136 (sinus), SpO_2 89% on RA

Labs

- Creatinine 138 mmol/L, BUN 14
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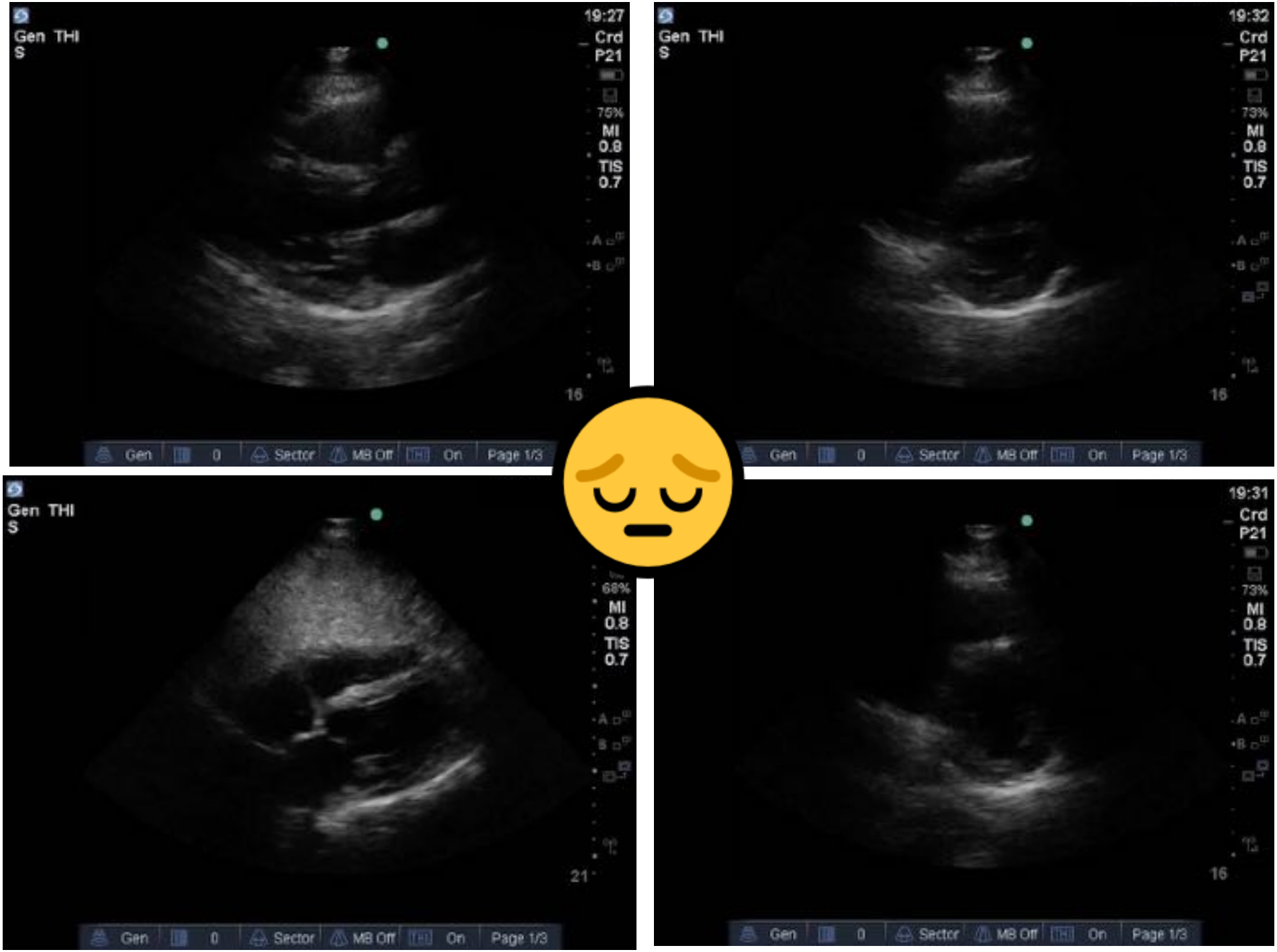
Next Steps

- Started on norepinephrine infusion
- POCUS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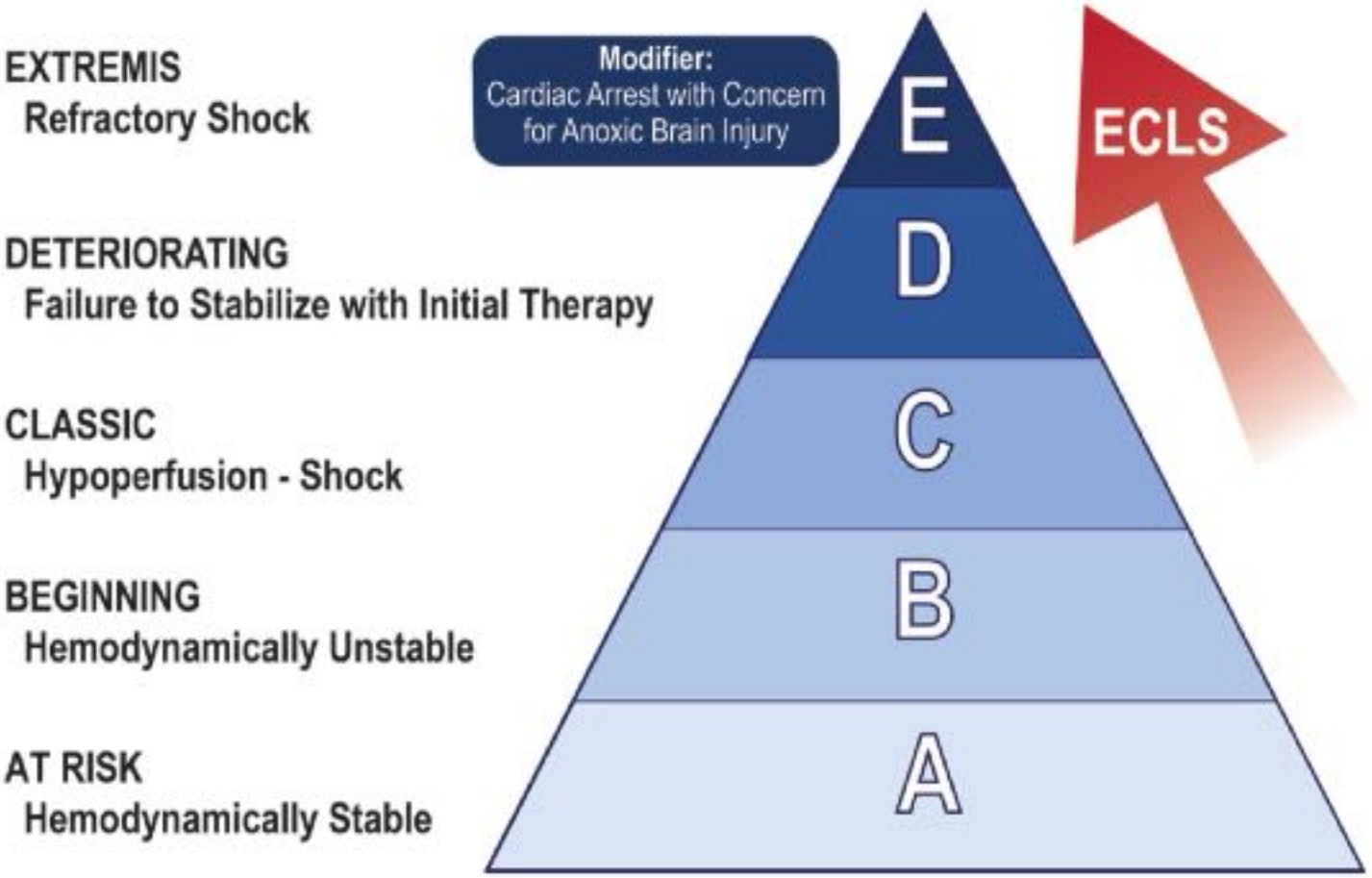
Question 1

Which **SCAI** class of cardiogenic shock is she in?

A. Class A
B. Class B
C. Class C
D. Class D
E. Class E

Society of Cardiovascular Angiography & Interventions (SCAI) Staging for Cardiogenic Shock



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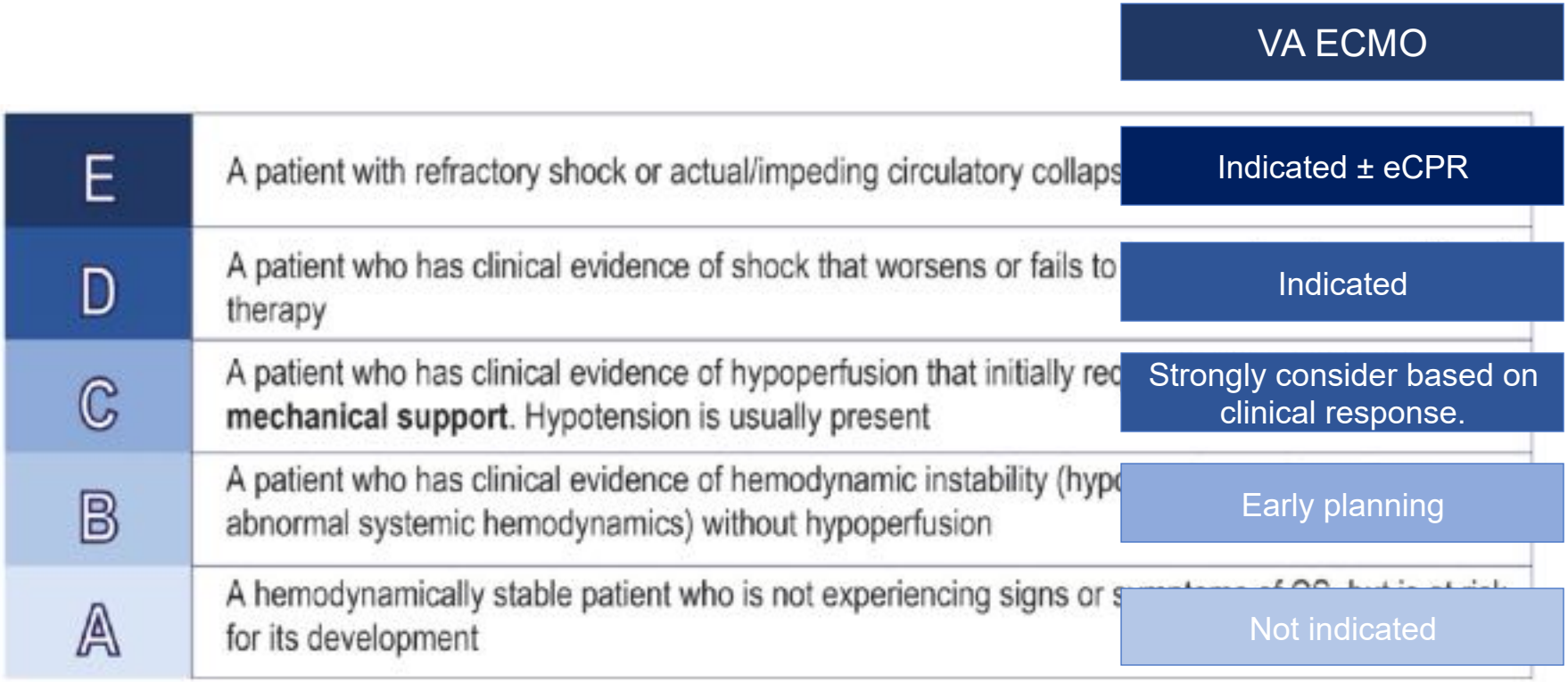

Steven P Keller et al. Temporary Mechanical Circulatory Support after Cardiac Surgery. J Cardiothorac Vasc Anesth. 2024 Sep;38(9):2080-2088.

Question 1

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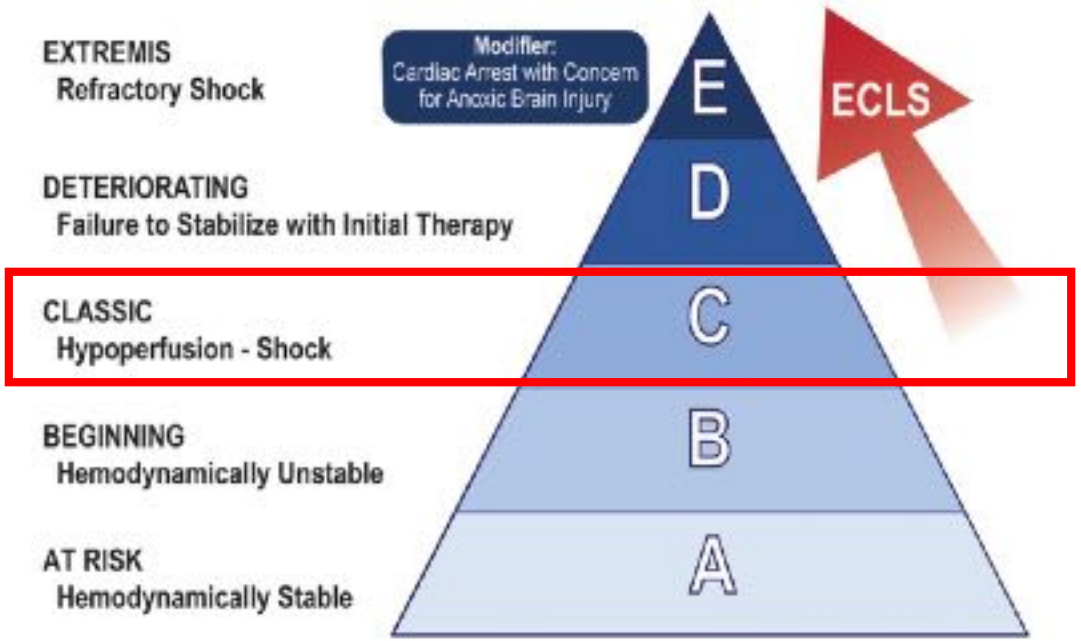
B. Class B

C. <u>Class C</u>

D. Class D

E. Class E



Cardiogenic Shock Diagnosis

Symptoms/Signs	Altered mental status, confusion, chest pain or pressure, cold and clammy extremities, rapid pulse, low pulse pressure (<25% of SBP), elevated jugular venous pressure, crackles, rales, orthopnea, paroxysmal nocturnal dyspnea, lower extremity edema
Urine output	Oliguria or anuria, <30 mL/h (<0.5 mL/[kg·h])
Sustained hypotension	SBP <90 mm Hg, MAP <65 mm Hg for >30 min or a >30-mm Hg decrease from baseline, or the need for pharmacological or mechanical support to maintain SBP >90 mm Hg
Perfusion	Evaluate markers of end-organ malperfusion, including lactic acid >2 mmol/L, ALT >200 U/L or >3× upper limit of normal, creatinine ≥2× upper limit of normal, pH <7.2, metabolic acidosis without another known cause

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Shashank S Sinha, et al. 2025 Concise Clinical Guidance: An ACC Expert Consensus Statement on Cardiogenic Shock. J Am Coll Cardiol. 2025 Apr 29;85(16):1618-1641.

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ECG/Echocardiogram	Evaluate acute ischemia, including ECG and sonographic evidence of STEMI (regional wall motion abnormalities); evidence of LV or RV dilation and systolic dysfunction; valvular pathology
Congestion	Presence or absence of congestion based on physical signs and hemodynamics; elucidation of ventricular involvement (LV vs RV vs BiV)

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Triage	Appropriate triage/shock team activation or possible transfer to a higher level of care

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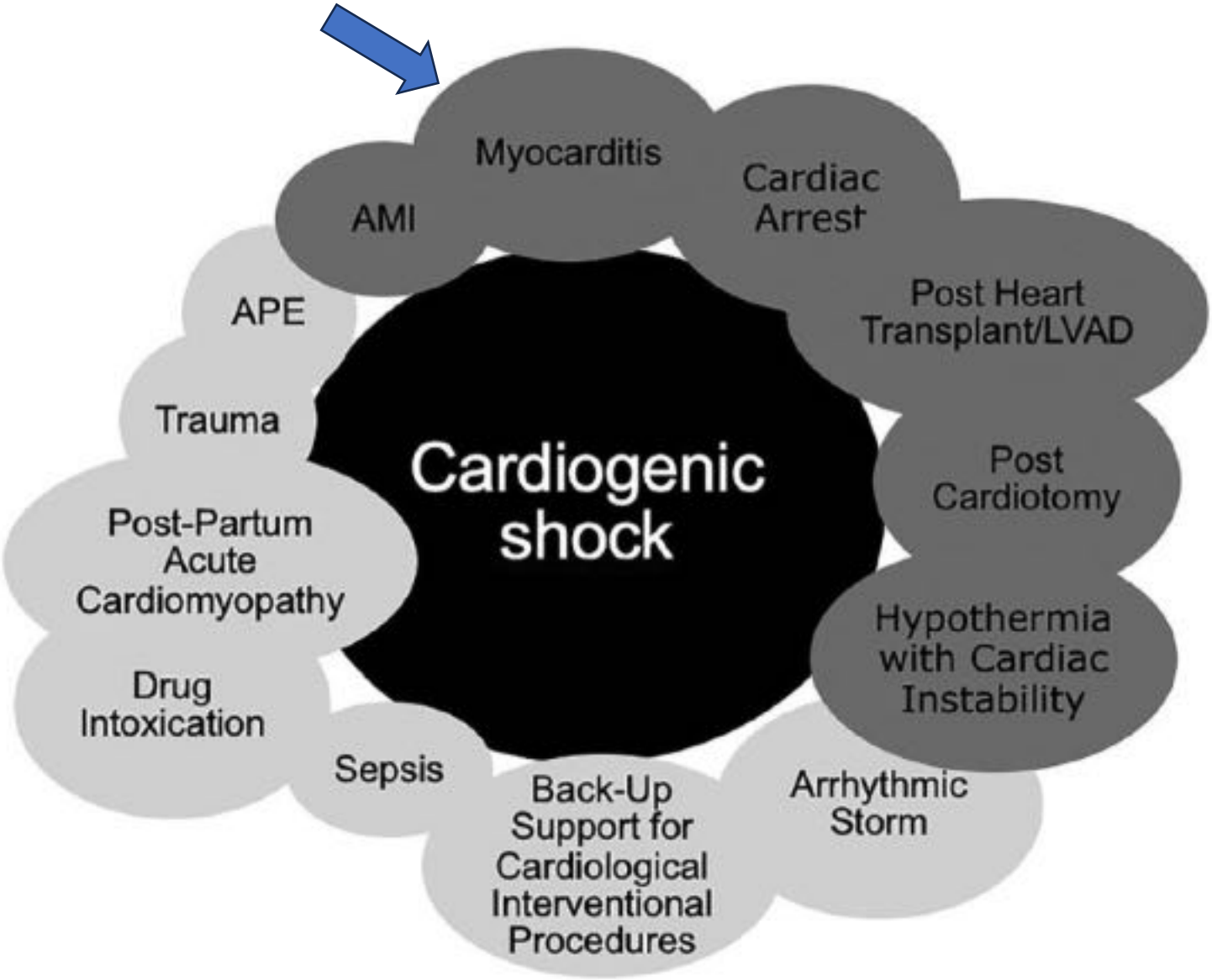


"Protected Procedures"

Lorusso R, et al. ELSO Interim Guidelines. ASAIO J. 2021

Case Presentation

Steps

- Central line & art line inserted
- Norepi escalated to 0.3 mcg/kg/min
- Dobutamine started at 5 mcg/kg/min

Vitals

- New vitals:
  BP 92/51, HR 141, SpO_2 92% on FMO_2 6 L/m

Labs

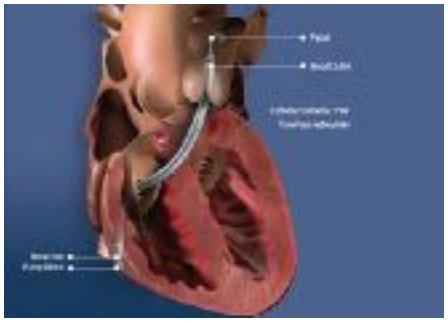
- Creatinine 138 mmol/L, BUN 14
- Lactate 6.9 mmol/L (from 6.2 mmol/L)
  pH 7.20, HCO_3 14

You call your CS Team
(or ECMO Team)

MCS Choices

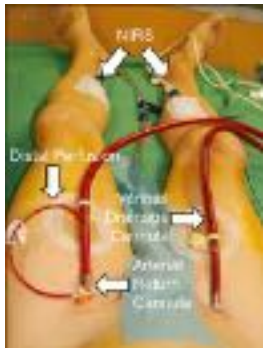
IABP

Impella



Impella RP

Protek Duo



VA ECMO

Durable LVAD
(Heart Mate 3)

Question 2

What would be the most appropriate MCS device choice for this patient?

A. Intra-aortic balloon pump
B. Impella CP
C. Protek Duo
D. VA ECMO
E. Durable LVAD

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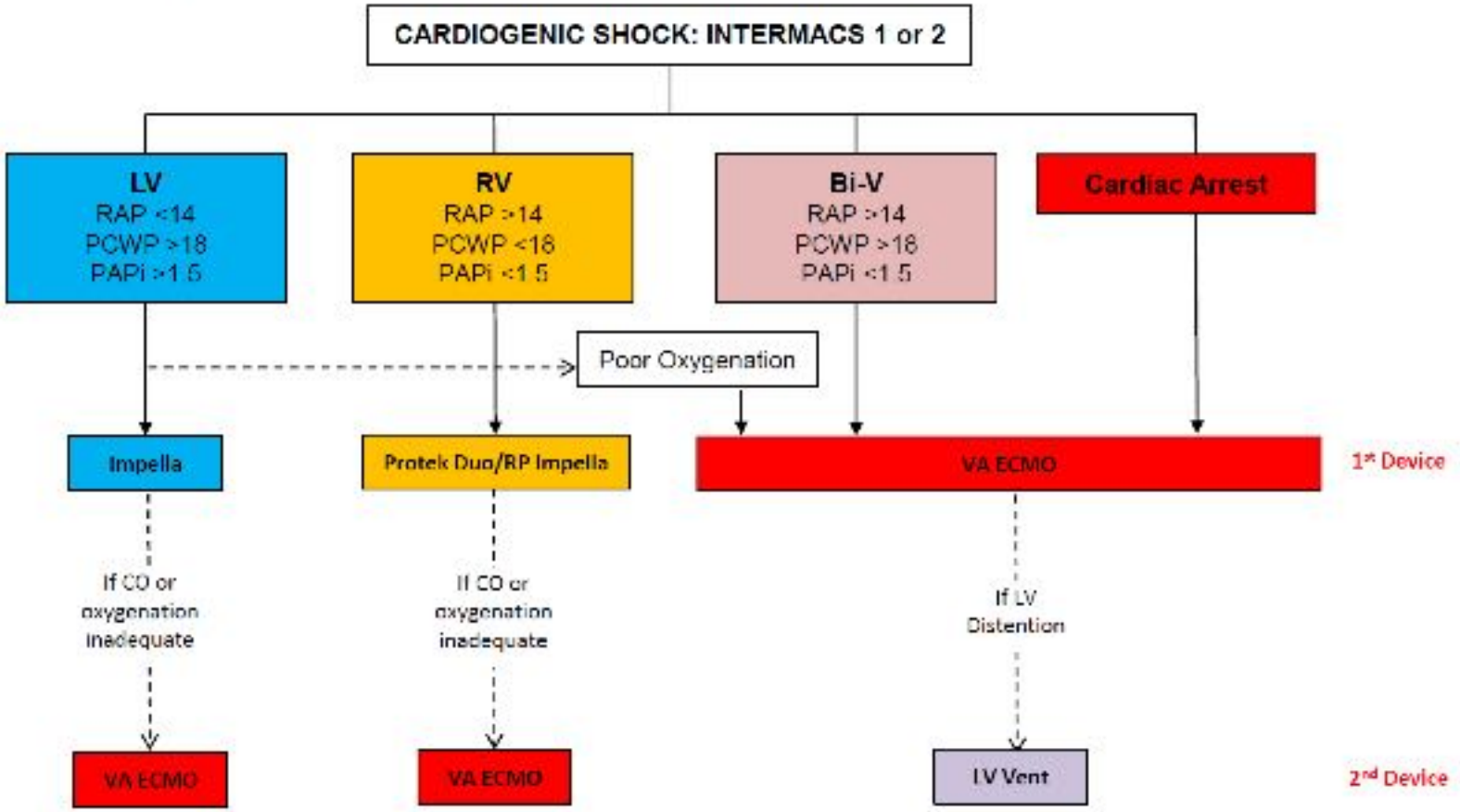
INSTITUT DE CARDIOLOGIE
DE L'UNIVERSITÉ D'OTTAWA

Short-Term MCS Decision Algorithm



Additional Considerations:
Concomitant profound respiratory failure → VA ECMO
Profound hemodynamic compromise outside cardiac cath lab or OR → VA ECMO
Impella contraindicated with mechanical AVR, LV thrombus

Options for LV Vent
1) Impella
2) IABP
3) LV Cannulation

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$$PAPi = (PASP - PADP)/RAP$$

Short-Term MCS Decision Algorithm

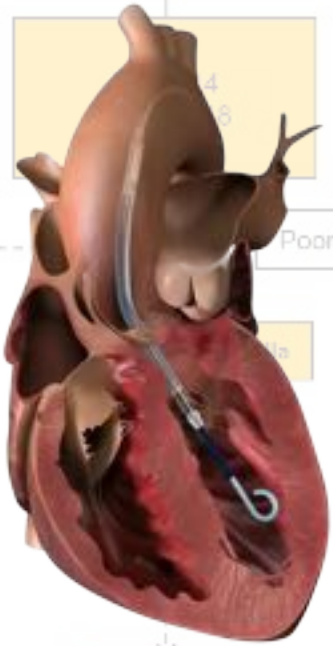
CARDIOGENIC SHOCK: INTERMACS 1 or 2

LV
RAP <14
PCWP >18
PAPi >1.5

Impella

If CO or oxygenation inadequate

VA ECMO



Poor Oxygenation

Bi-V
RAP >14
PCWP >18
PAPi <1.5

Cardiac Arrest

VA ECMO

1st Device

If LV Distention

LV Vent

2nd Device

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Cardiac Arrest

Poor Ox

Impella

Protek Duo/RP Impella

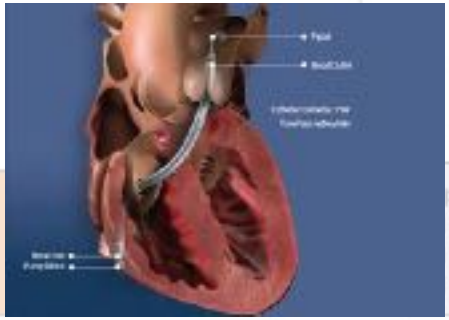
If CO or oxygenation inadequate

If CO or oxygenation inadequate

VA ECMO

VA ECMO

1st Device



2nd Device

Additional Considerations:
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ptions for LV Vent
Impella
IABP
LV Cannulation

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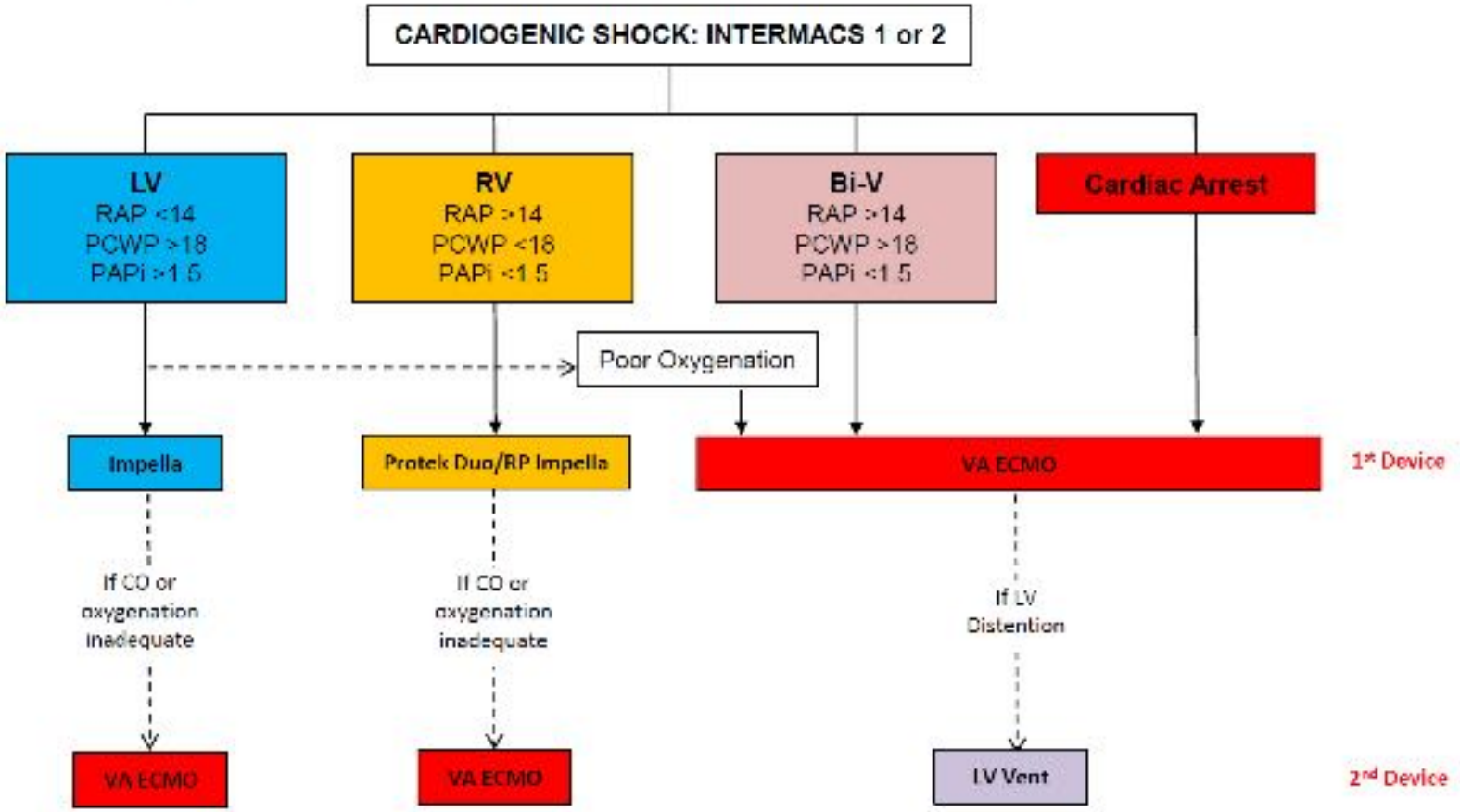

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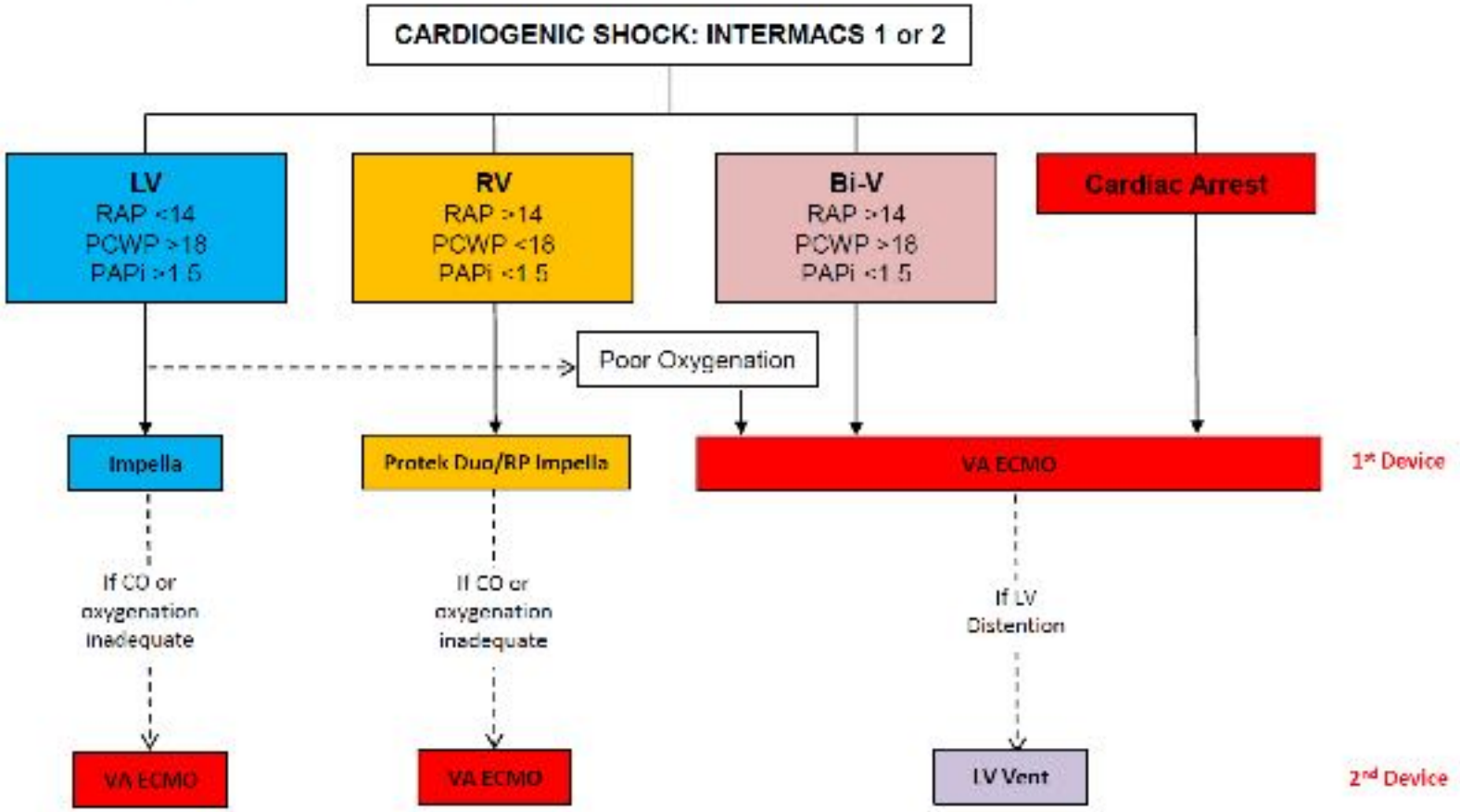

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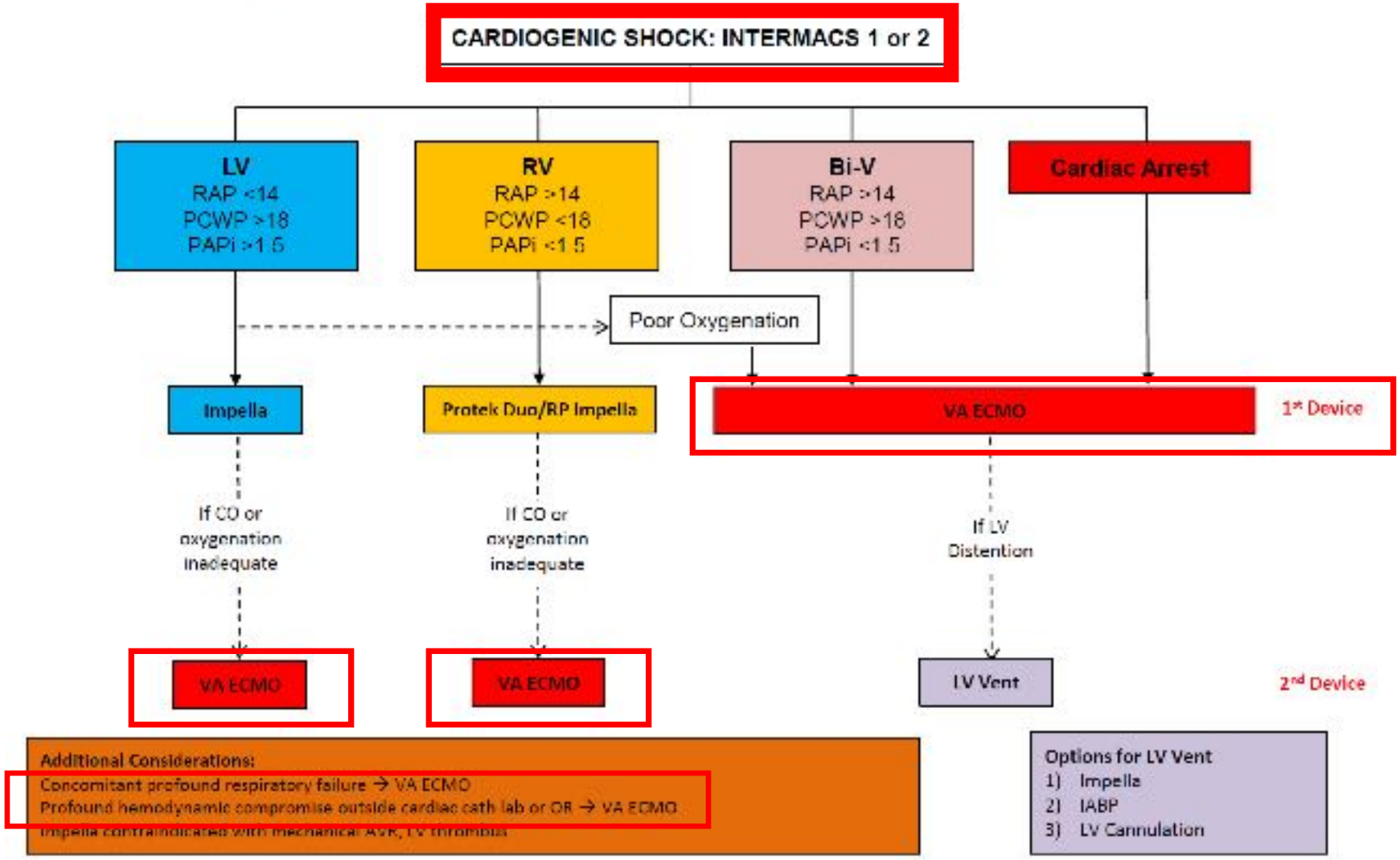
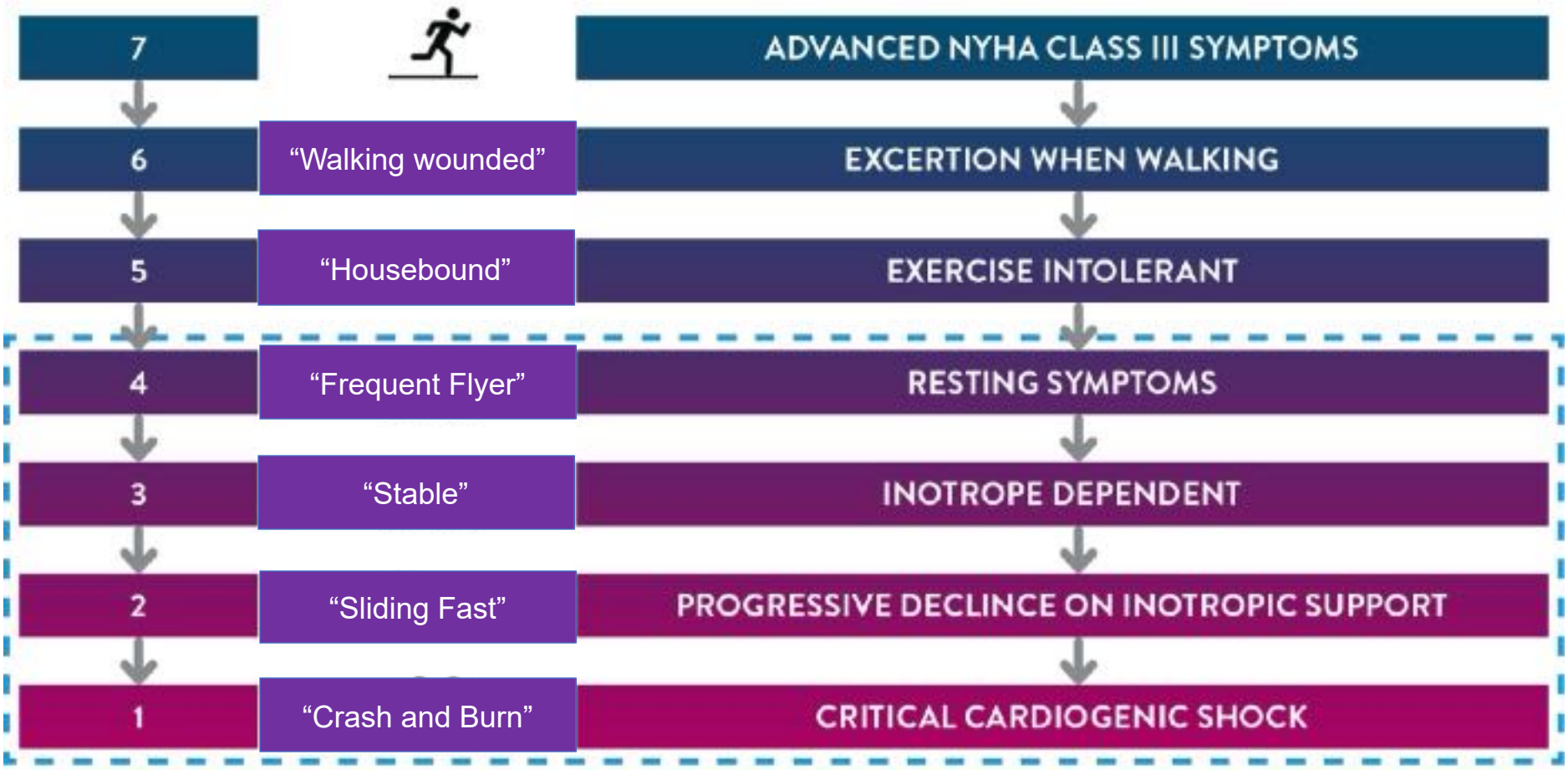


Intermacs Classification



https://www.my-connext.com/heart-failure/heart-failure-disease/heart-failure/classification

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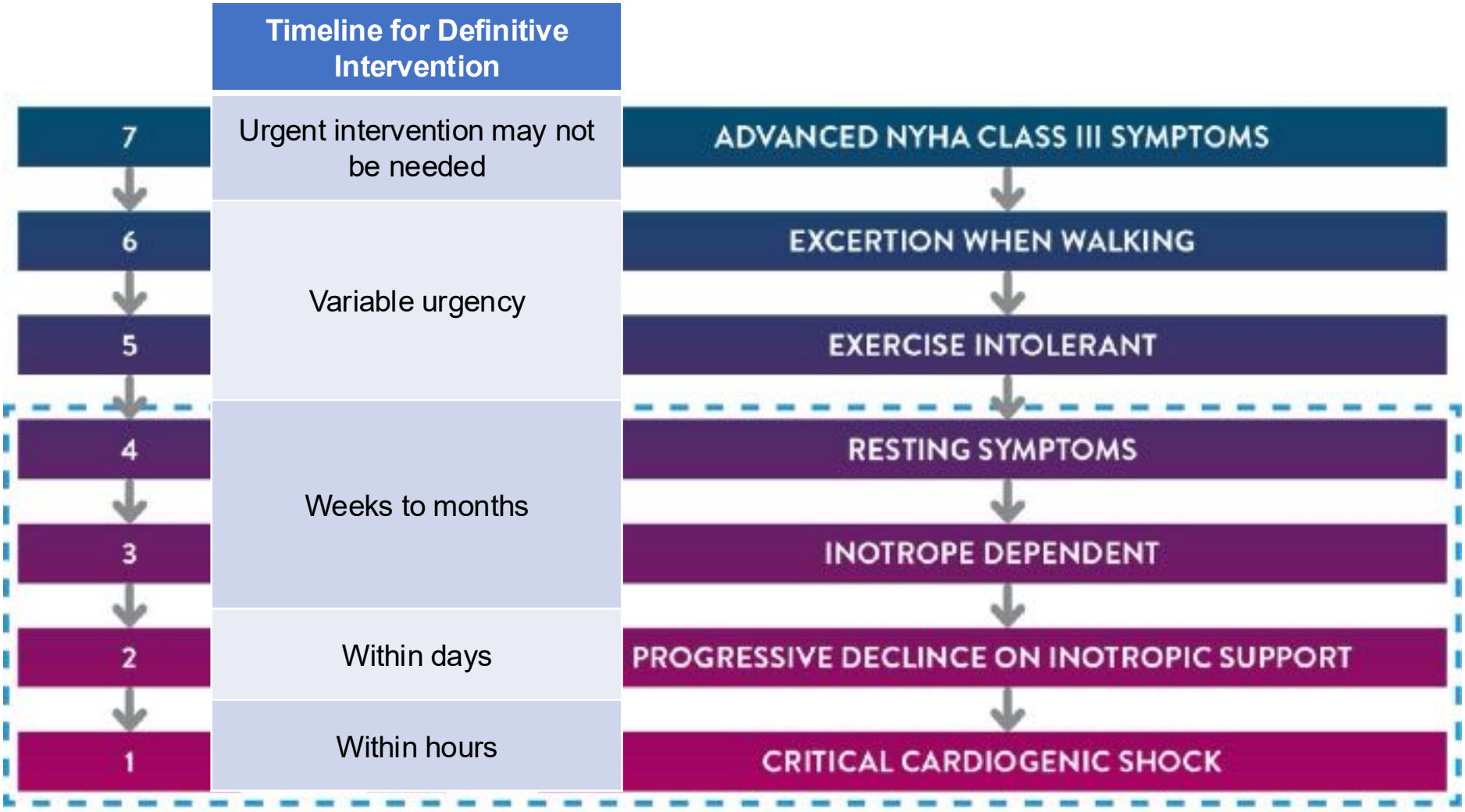


https://www.my-connext.com/heart-failure/heart-failure-disease/heart-failure/classification

Case Presentation

Vitals

- Tachypneic, increased work of breathing → Intubated, good SpO_2 on FiO2 0.4, AC/PC: PIP/PEEP 20/5

Steps

- Post-intubation vitals: BP 90/50, HR 141
- Norepi 0.5 mcg/kg/min, Dobutamine 5 mcg/kg/min

Labs

- Creatinine 138 mmol/L, BUN 14
- Lactate 7.2 mmol/L (from 6.9 mmol/L), pH 7.20, HCO_3 14

You are still on the phone with your CS Team (or ECMO Team)

Question 3

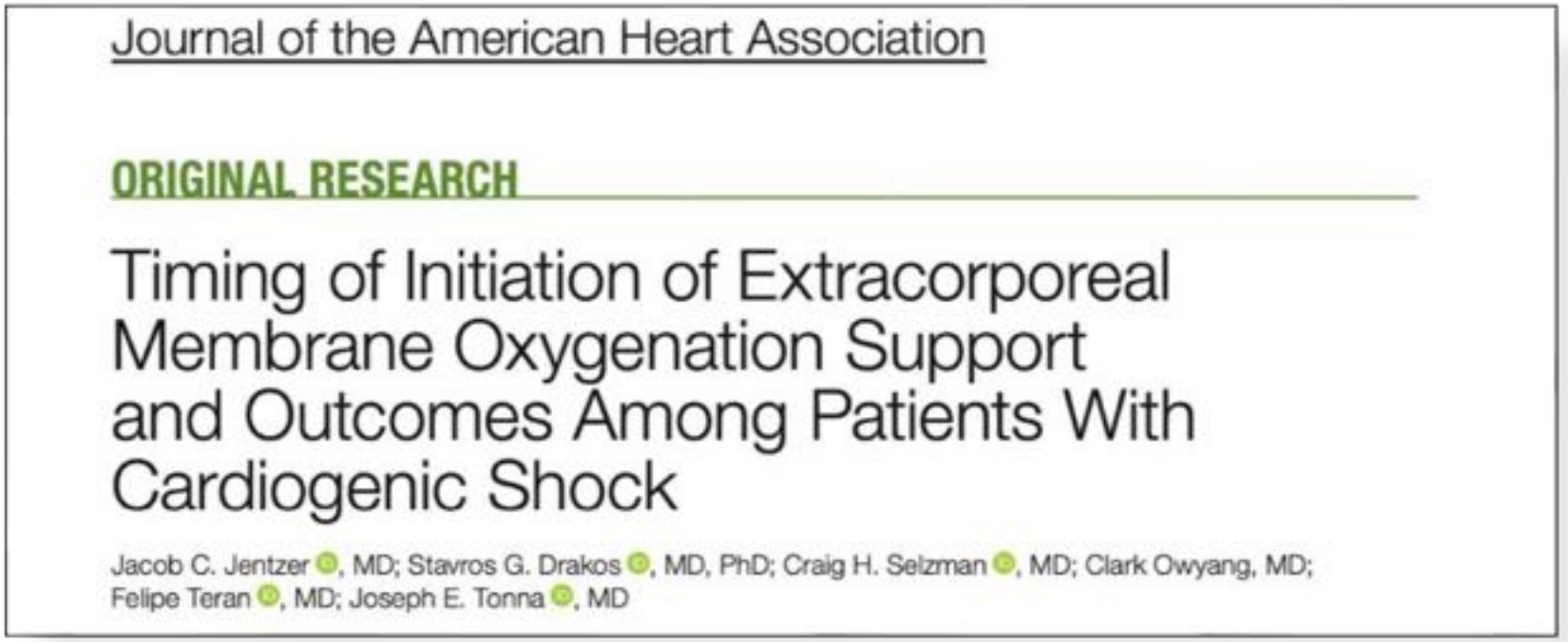
What is our “time window” for intervention?

A. 24 hours

B. 48 hours

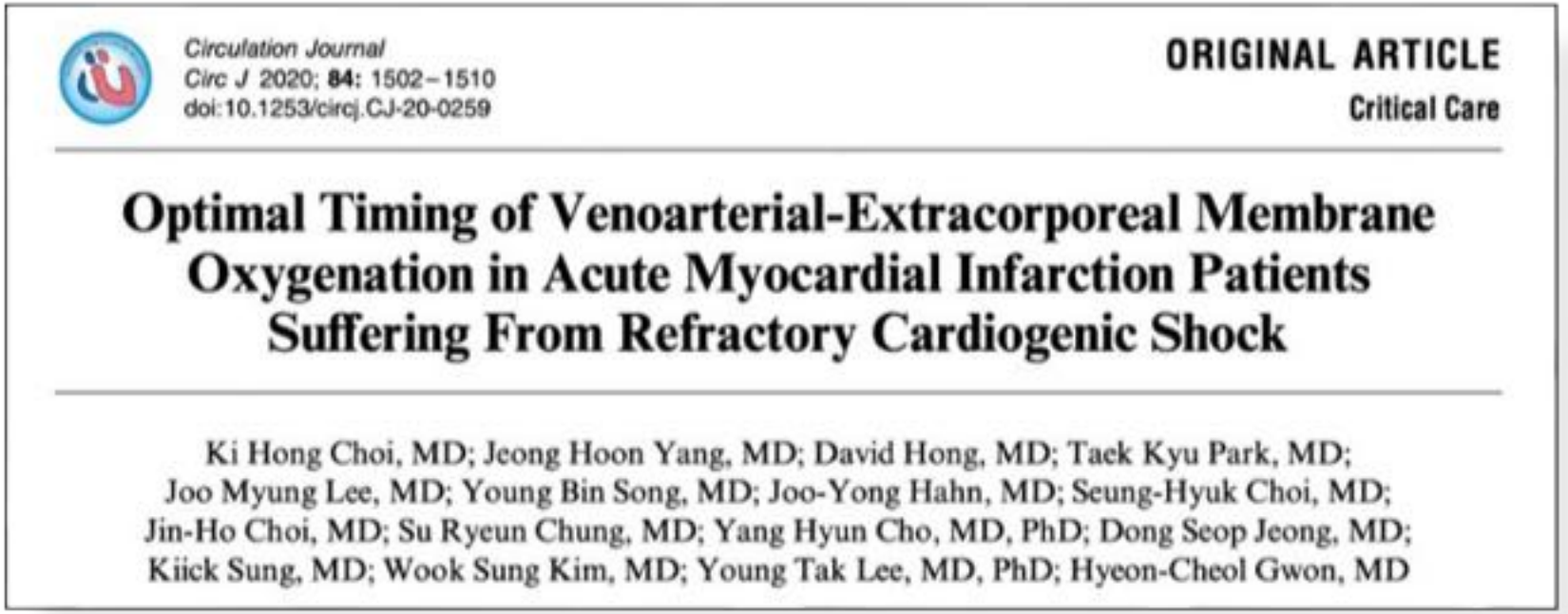
C. 72 hours

D. 1 week



- ELSO Registry (8,619) patients in cardiogenic shock.
- ECMO initiated **> 24 hours** after admission had a higher risk of in-hospital death after multivariable adjustment (adjusted OR, 1.20 [95% CI, 1.06–1.36]; P = 0.004).
- Each **12-hour increase** in the time from admission to ECMO initiation was incrementally associated with higher adjusted in-hospital mortality rate (adjusted OR, 1.06 [95% CI, 1.03–1.10]; P<0.001).

Jacob C Jentzer et al. Timing of Initiation of ECMO Support and Outcomes Among Patients With Cardiogenic Shock. J Am Heart Assoc. 2024 Feb 6;13(3):e032288.



Circulation Journal
Circ J 2020; 84: 1502–1510
doi:10.1253/circj.CJ-20-0259

ORIGINAL ARTICLE
Critical Care

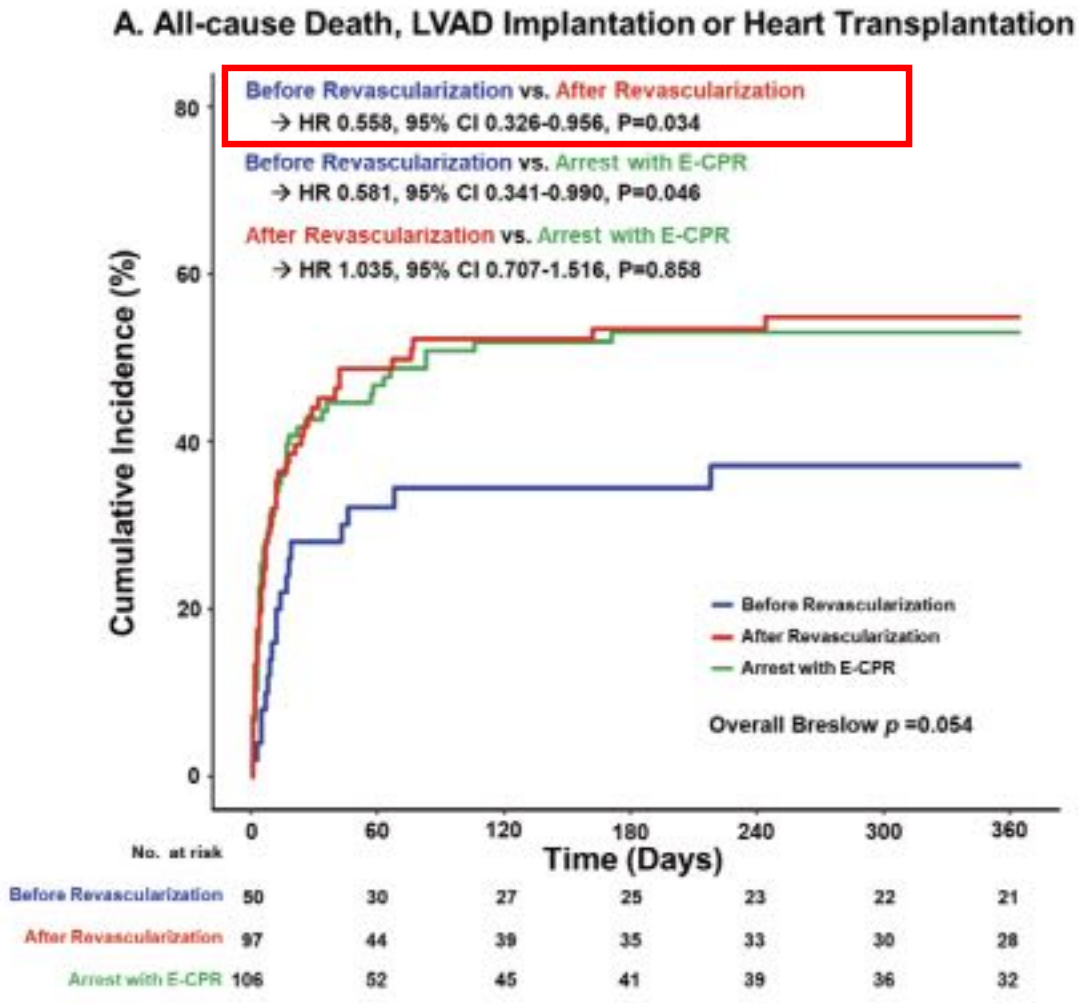
Optimal Timing of Venoarterial-Extracorporeal Membrane Oxygenation in Acute Myocardial Infarction Patients Suffering From Refractory Cardiogenic Shock

Ki Hong Choi, MD; Jeong Hoon Yang, MD; David Hong, MD; Taek Kyu Park, MD; Joo Myung Lee, MD; Young Bin Song, MD; Joo-Yong Hahn, MD; Seung-Hyuk Choi, MD; Jin-Ho Choi, MD; Su Ryeun Chung, MD; Yang Hyun Cho, MD, PhD; Dong Seop Jeong, MD; Kiick Sung, MD; Wook Sung Kim, MD; Young Tak Lee, MD, PhD; Hyeon-Cheol Gwon, MD

- AMI patients in cardiogenic shock.
- VA ECMO before revascularization (n=50) versus VA ECMO after revascularization (n=97).
- Primary outcome (composite of in-hospital mortality, LVAD implantation, heart transplantation) **significantly lower in VA-ECMO before revascularization** than in VA-ECMO after revascularization (32.0% vs. 49.5%, OR 0.480, 95% CI 0.235-0.982, P=0.045).

Ki Hong Choi et al. Optimal Timing of VA ECMO in AMI Patients Suffering From Refractory Cardiogenic Shock. Circ J. 2020 Aug 25;84(9):1502-1510.

Optimal Timing of VA ECMO in AMI Patients with Refractory CS



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ECMO Triage

VV ECMO

VA ECMO

https://www.istockphoto.com/photos/doctor-walking

Question 4

Which comorbidity is an **absolute contraindication** to VA ECMO?

A. Hypothyroidism
B. Obesity
C. Moderate aortic incompetence
D. Mild NASH cirrhosis (non-alcoholic steatohepatitis)

Patient Selection

Bridge-to-Decision

→ Recovery

→ Heart Transplant

→ Long-term MCS

→ Withdrawal of Life Support

Contraindications

- **Cardiac recovery unlikely** and not a candidate for heart transplant or durable LVAD.
- Non-recoverable **advanced comorbidity** with poor life expectancy (end-stage peripheral-organ diseases, malignant tumor, massive pulmonary embolisms in cancer patients, chemotherapy-induced chronic cardiomyopathy, etc.)
- **Severe neurologic impairment** (i.e., prolonged anoxic brain damage, extensive trauma and bleeding)
- Liver cirrhosis (Child-Pugh class B and C)

VA ECMO will not be of benefit

Lorusso R, et al. ELSO Interim Guidelines. ASAIO J. 2021

Contraindications

- **Moderate to severe aortic valve regurgitation**
- **Acute Type A or B aortic dissection** with extensive aortic branches (ascending, supra-aortic and femoral) involvement
- Severe immunologic disease with marked blood and coagulation disorders
- Severe vascular disease with extensive aortic and peripheral vessel involvement (calcification, stenosis, and closure), including axillary arteries

VA ECMO may make the patient worse
Or will be too challenging to insert

Lorusso R, et al. ELSO Interim Guidelines. ASAIO J. 2021

Question 4

Which comorbidity is an **absolute contraindication** to VA ECMO?

Luckily, our patient has no contraindications

A. Hypothyroidism

B. Obesity

C. Moderate aortic incompetence

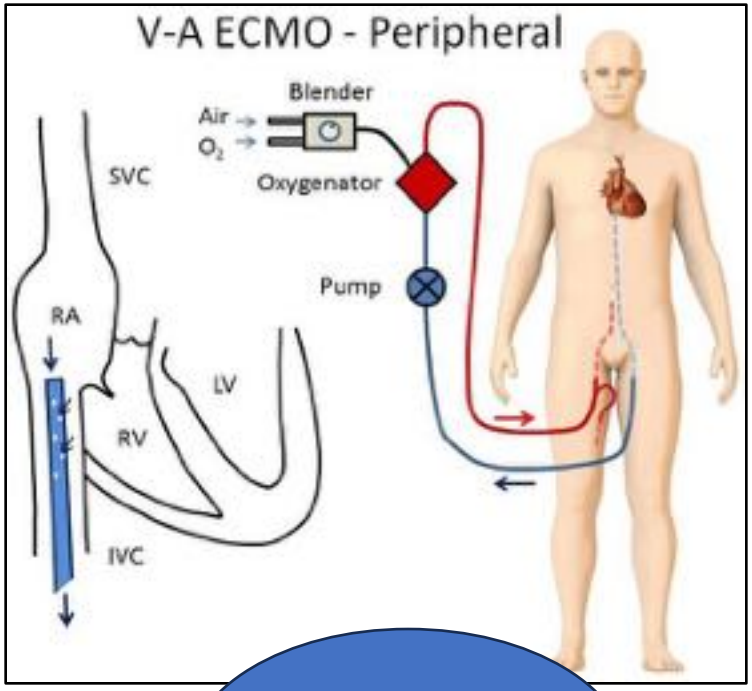
D. Mild NASH cirrhosis (non-alcoholic steatohepatitis)

Question 5

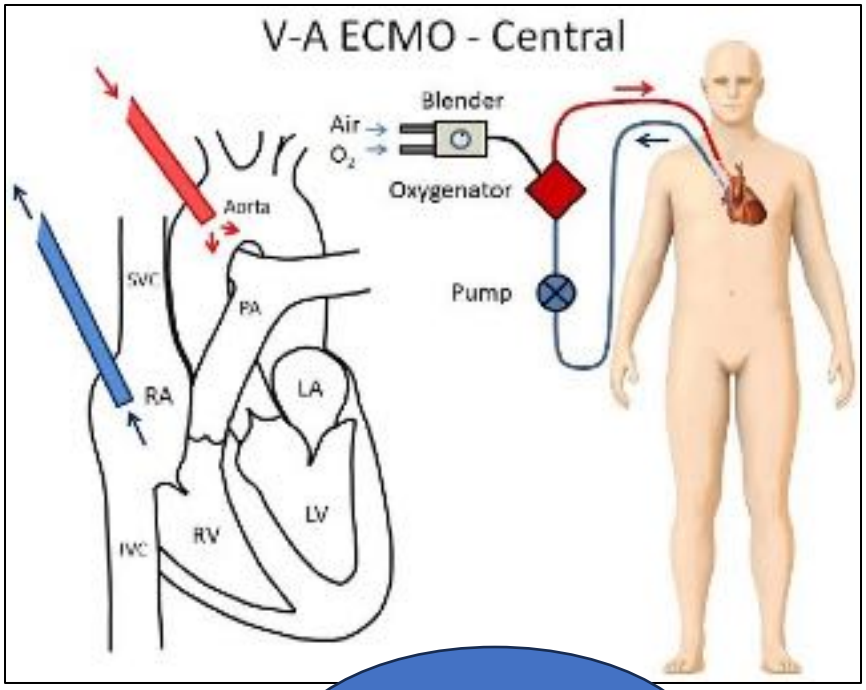
What is the best ECMO approach for this patient?

A. Central VA ECMO
B. Peripheral VA ECMO with a femoral-femoral approach
C. Peripheral VA ECMO with an internal jugular-subclavian approach
D. Peripheral V-AV ECMO with femoral-femoral/internal jugular approach

VA ECMO Configurations



Fem-fem cannulation



Atrio-aortic cannulation

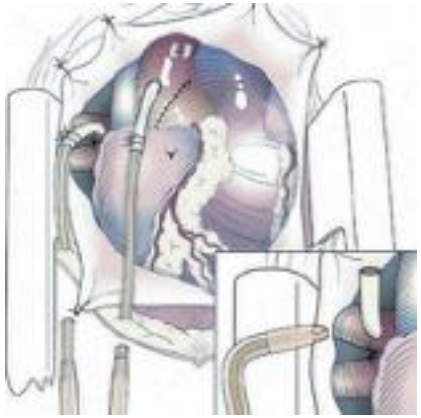
http://icuecmo.ca/icuECMO_content/icuECMO_ECMO_configuration_VA.html

Central VA ECMO

- Drain RA directly and return to ascending aorta

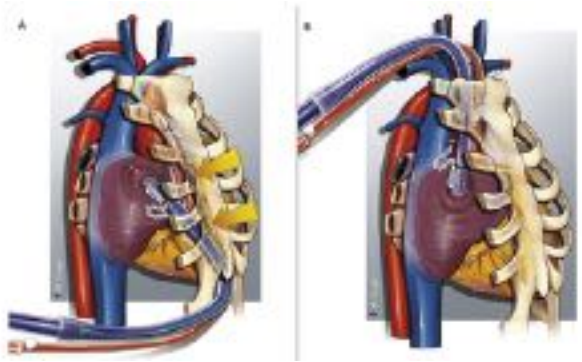
Advantages:

- Same CPB cannulas used for ECMO (may bring out below sternum to close the chest).
- Avoids femoral artery puncture (often in a fully heparinized patient), avoids lower limb ischemia, differential hypoxia.
- Higher flows
- More options for venting.



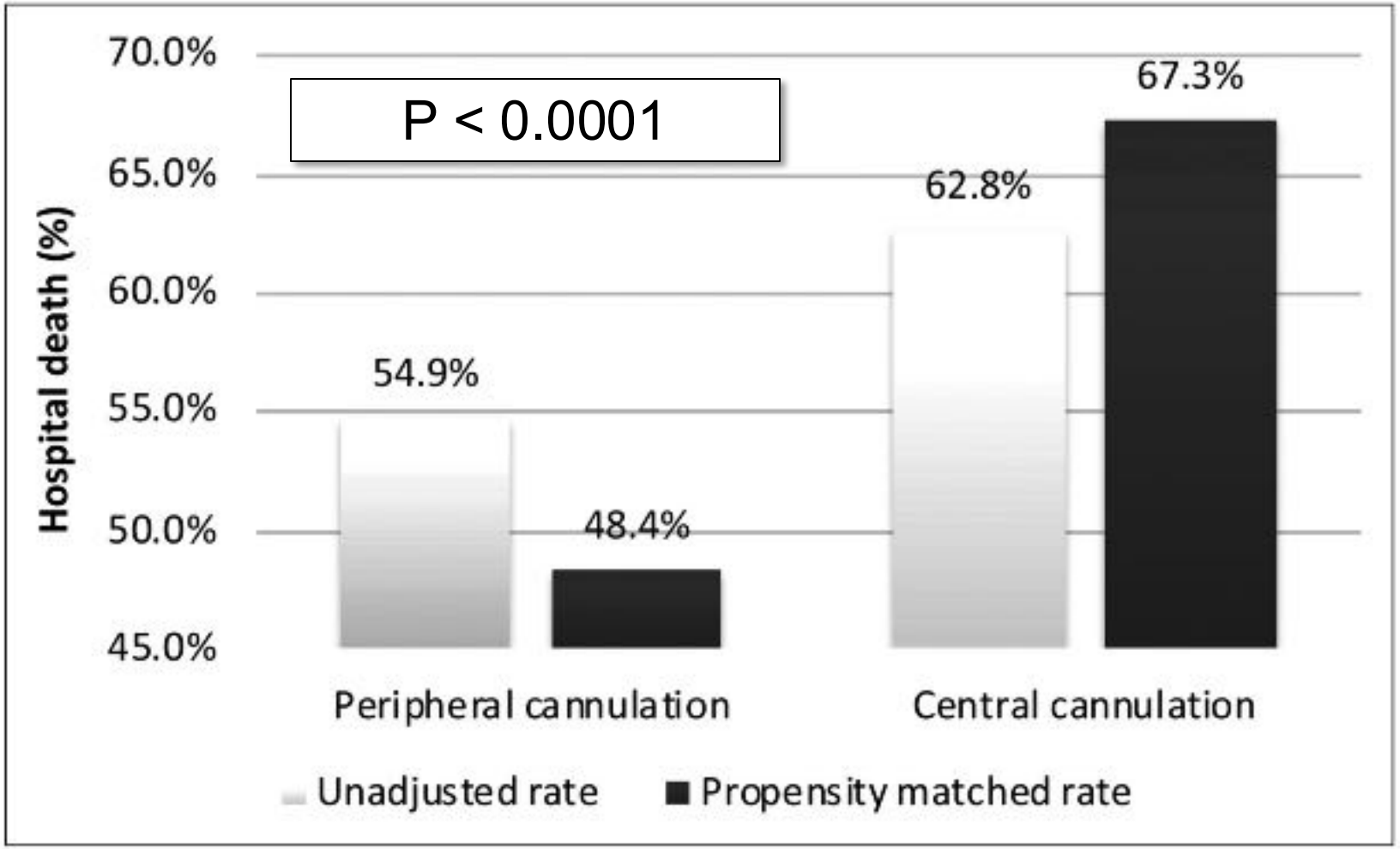
Disadvantages

- Needs reopening for decannulation.
- Higher risk of mediastinitis, bleeding.
- Higher risk of strokes.
- Generally, carries a higher mortality



Ravi J De Silva et al. Cannulation techniques for temporary right and left ventricular support: Simple solutions for a difficult problem.
European Journal of Cardio-Thoracic Surgery, Volume 42, Issue 4, October 2012, Pages 728–730

Postcardiotomy ECLS



Mariusz Kowalewski et al. Venoarterial Extracorporeal Membrane Oxygenation for Postcardiotomy Shock-Analysis of the Extracorporeal Life Support Organization Registry. Crit Care Med. 2021 Jul 1;49(7):1107-1117.

Peripheral VA ECMO

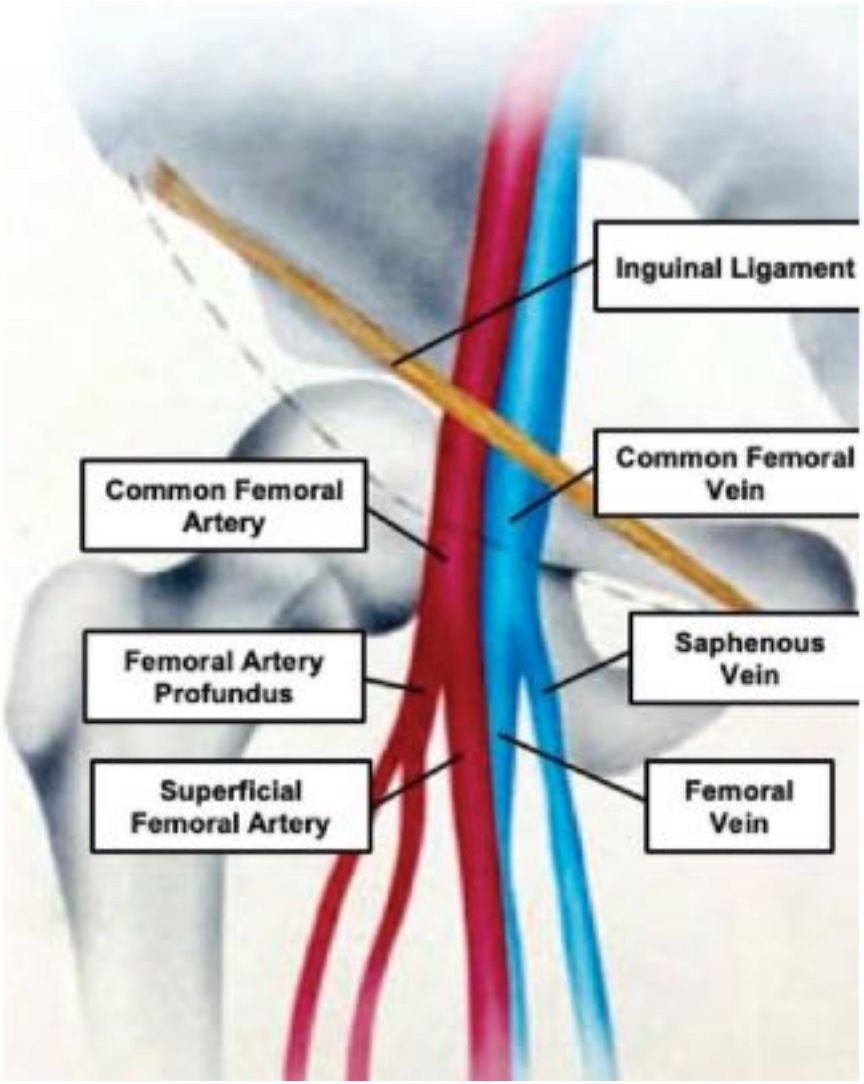
Puncture points:

- Common femoral vein
- Common femoral artery
  (just below the inguinal ligament and above their respective bifurcations)

Sequence:

- Start with venous (drainage cannula)
- Heparinize after guidewire in vein
  (target ACT 180-220)

Drainage
21 – 25 Fr

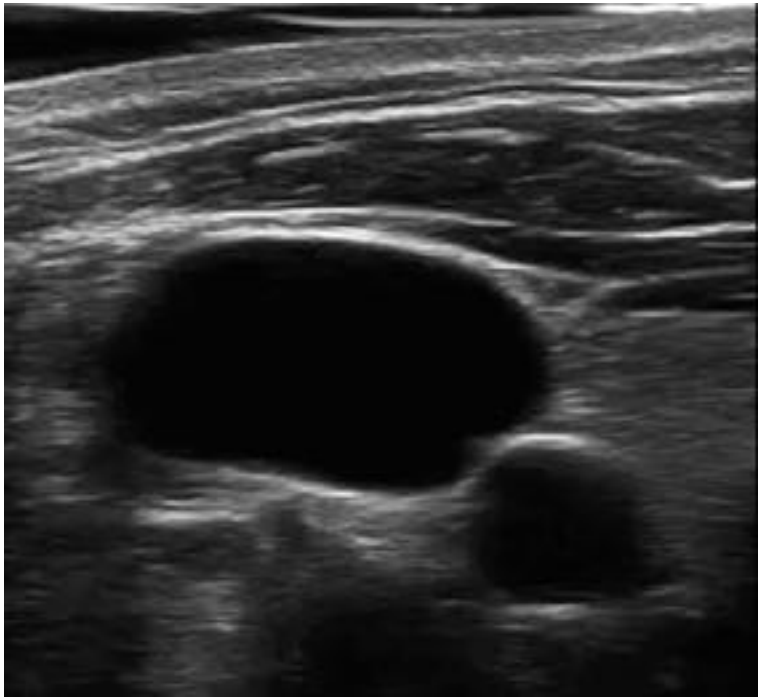


Roberto Lorusso et al. ELSO Interim Guidelines for VA-ECMO in Adult Cardiac Patients. ASAIO J. 2021 Aug 1;67(8):827-844.

Peripheral VA ECMO

Percutaneous

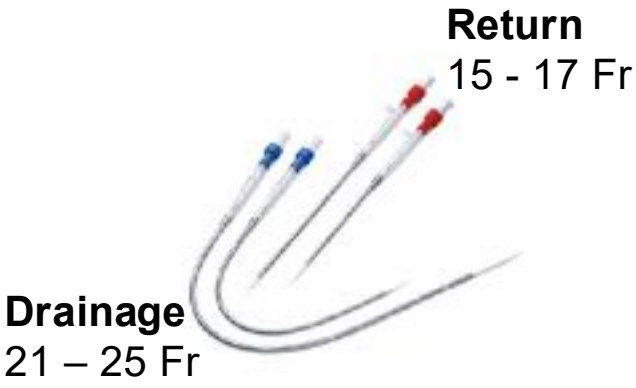
Open

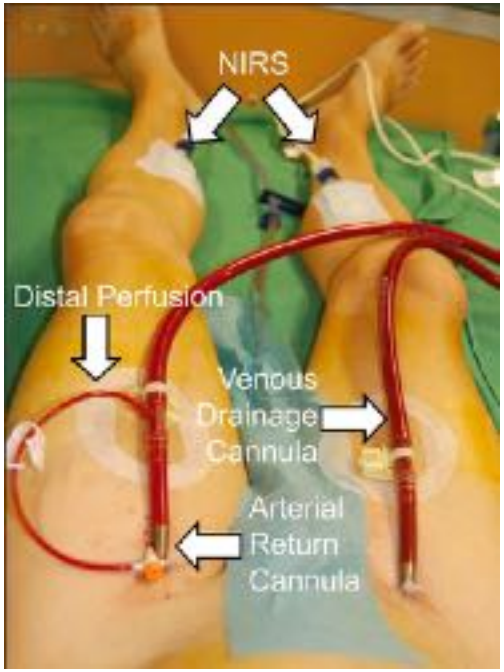


Curtesy of ELSO Foundations Course

Peripheral VA ECMO

- Arterial cannula: 15 – 17 Fr adequate. When higher flow needed (e.g. septic patient), 19 -21 Fr may be used
- Larger cannulas associated with more vascular complications e.g. limb ischemia
- Opinion:
  - arterial and venous cannulas in separate limbs to reduce vascular complications and to facilitate decannulation.
  - If feasible, the venous cannula should be placed in right femoral vein (more direct path to IVC and right atrium)





Roberto Lorusso et al. ELSO Interim Guidelines for VA-ECMO in Adult Cardiac Patients. ASAIO J. 2021 Aug 1;67(8):827-844.

Limb Ischemia – Prevention

Distal Perfusion Cannula (DPC)

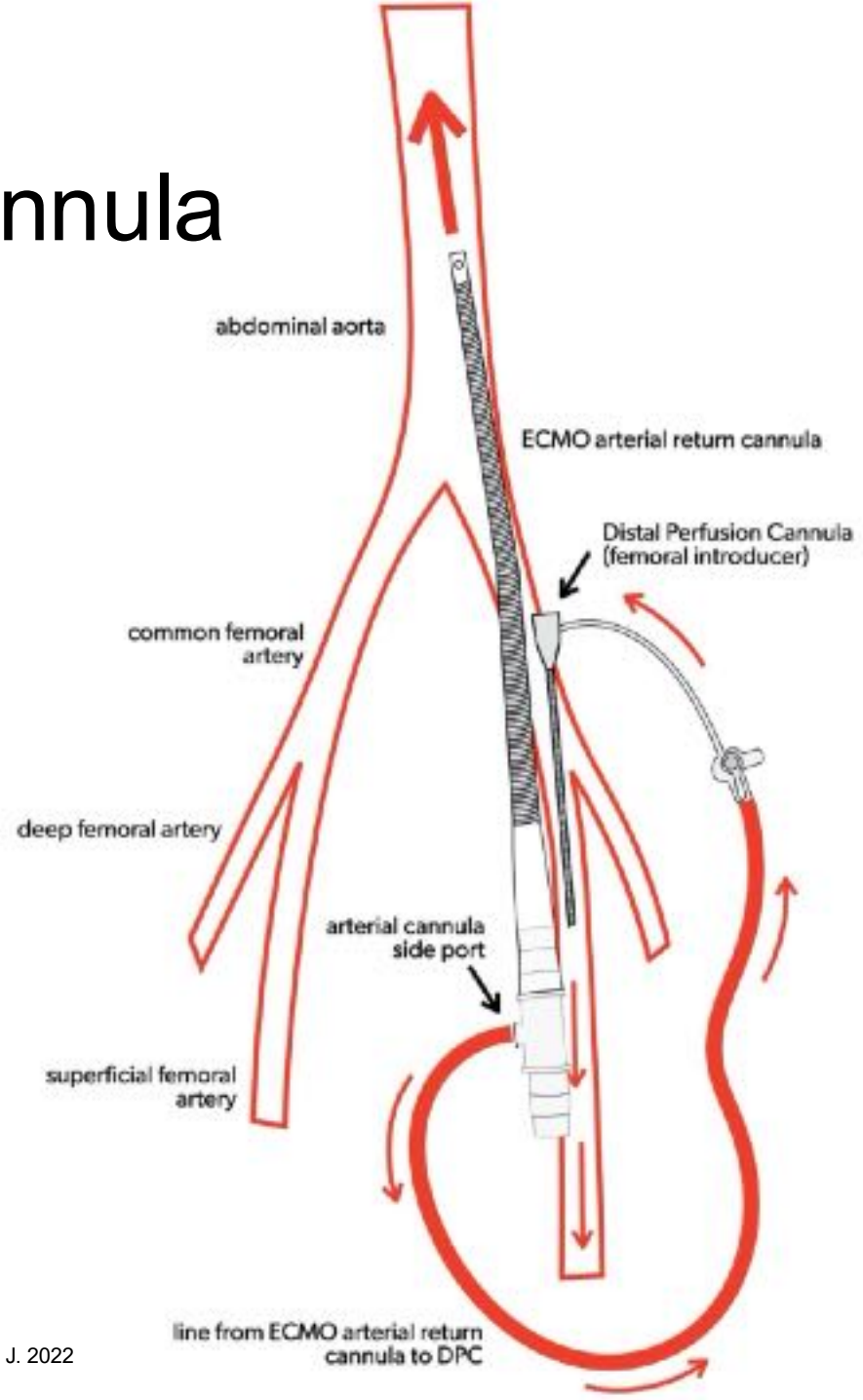
Set-up	Incidence of Lower Extremity Ischemia
Without DPC	7%
With DPC	0-3%

M.A. Mazzeffi et al. / Journal of Cardiothoracic and Vascular Anesthesia 35 (2021) 35133527

Curtesy of ELSO Foundations Course

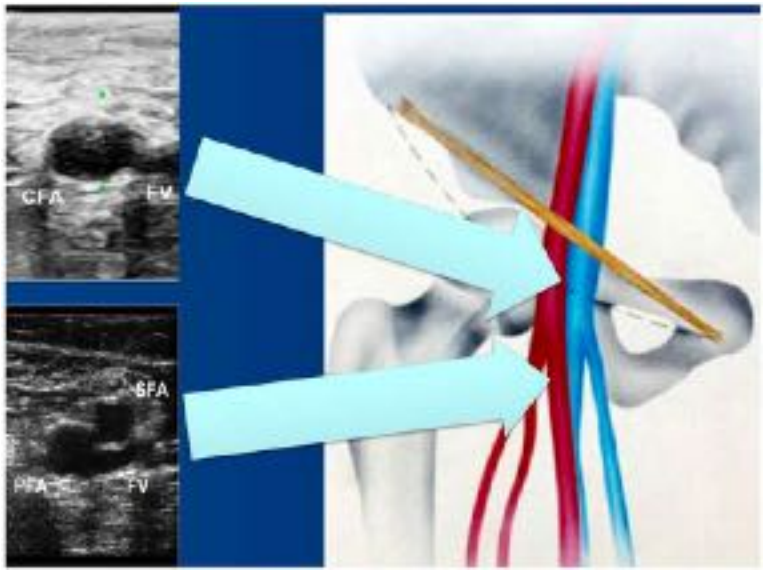
Distal Perfusion Cannula

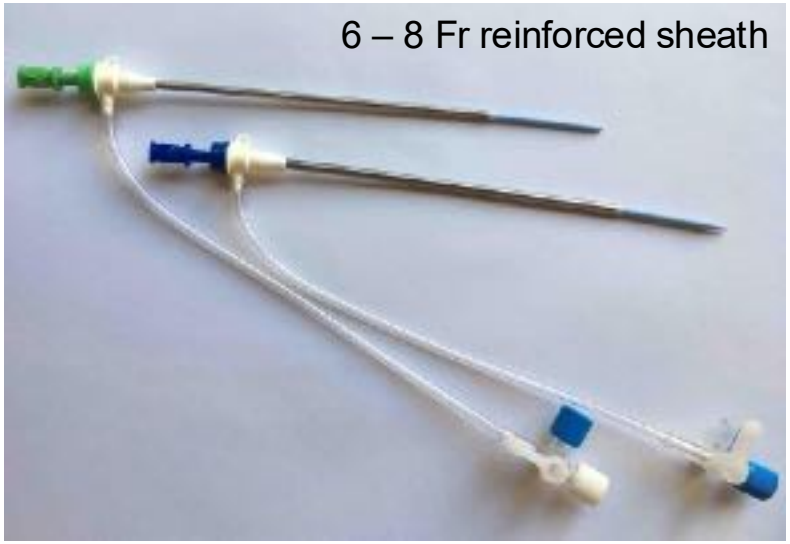
- Placed under US guidance or direct vision into the **superficial femoral artery**.
- Puncture point maybe common femoral artery (above bifurcation), then directed to superficial femoral.
- May confirm guide wire in superficial femoral artery by US or fluoroscopy
- Confirm flow in popliteal artery by ultrasound and continuous flow Doppler.

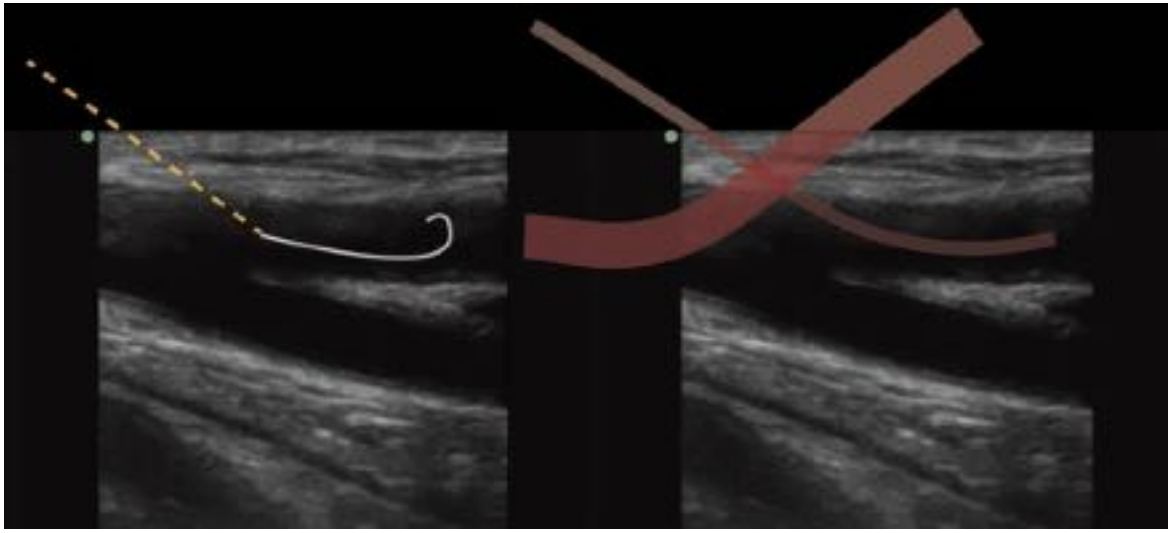


Evan F Gajkowski et al. ELSO Guidelines for Adult and Pediatric ECMO Circuits. ASAIO J. 2022 Feb 1;68(2):133-152.

Distal Perfusion Cannula







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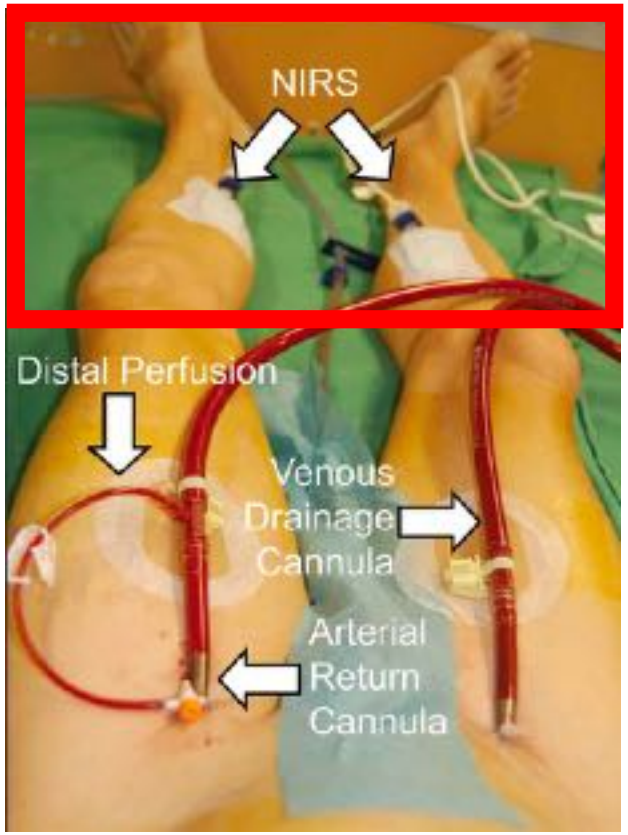
Distal Perfusion Cannula

- With small return cannulas (15 Fr & 17 Fr), distal perfusion not always needed.
- Decision making may be informed by Near-Infrared Spectroscopy (NIRS).
- DPC needed with NIRS values:
  - < 50% (preferably < 60%)
  - > 20% difference between extremities
- Insertion timing:
  - On ECMO institution
  - Salvage intervention



https://ecmo.icu/procedures-distal-perfusion-cannula/#

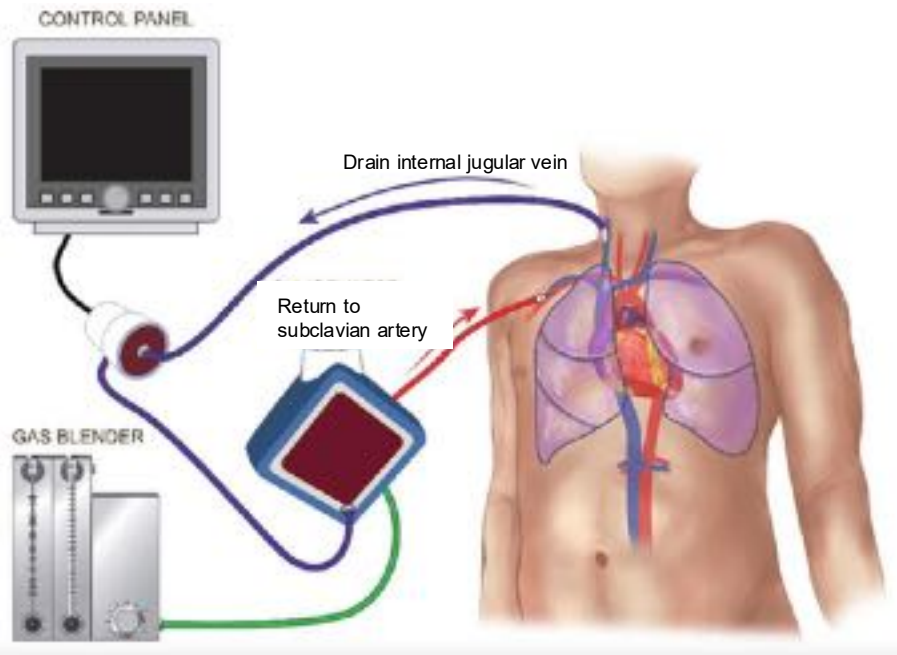
Roberto Lorusso et al. ELSO Interim Guidelines for VA-ECMO in Adult Cardiac Patients. ASAIO J. 2021 Aug 1;67(8):827-844.

Alternative Peripheral Cannulation Approach

- Drain RA via internal jugular
- Return to subclavian or axillary artery via surgical cut-down

- **Advantages:**
  1. May be of use in patients with severe peripheral vascular disease
  2. Avoid complications of femoral artery site
  3. Minimize differential oxygenation
  4. Facilitate patient mobilization in case of predicted long run

- **Disadvantages:**
  1. Smaller size cannulas, less flow
  2. Return cannula by cut-down



Roberto Lorusso et al. ELSO Interim Guidelines for VA-ECMO in Adult Cardiac Patients. ASAIO J. 2021 Aug 1;67(8):827-844.

Question 5

What is the best ECMO approach for this patient?

A. Central VA ECMO

B. Peripheral VA ECMO with a femoral-femoral approach

C. Peripheral VA ECMO with an internal jugular-subclavian approach

D. Peripheral V-AV ECMO with femoral – femoral / internal jugular approach

Question 6

6. She is now cannulated, and VA ECMO has been established.

The patient's younger brother is a medical student. He is asking what the likelihood is that she'll survive?

Her approximate average survival is:

A. 80%

B. 60%

C. 40%

D. 20%

26-year-old female
Viral myocarditis
64 kg
On norepi & dobutamine BP: 92/51 mmHg
Intubated 4 hours ago on AC PC PIP/PEEP: 20 / 5 cmH_2O
Creatinine: 138 mmol/L
Lactate 6.9, pH 7.20, HCO3: 14 mmol/L
No liver failure (yet)

Risk Scores for VA-ECMO

Risk Score Name[Reference]	VA ECMO Setting	Predictors
ENCOURAGE Score[7]	Cardiogenic shock (post AMI)	Age, sex, BMI, Glasgow Coma Scale, creatininemia, serum lactate value, prothrombin activity
REMEMBER Score[8]	Post cardiotomy cardiogenic shock (post CABG)	Older age, left main coronary artery disease, Inotropic score, CK-MB, serum creatinine, platelet count
CARDShock Score[9]	Cardiogenic shock	Older age, neurologic status, previous myocardial infarction or CABG, blood lactate value, acute coronary syndrome etiology, LV systolic dysfunction, estimated glomerular filtration

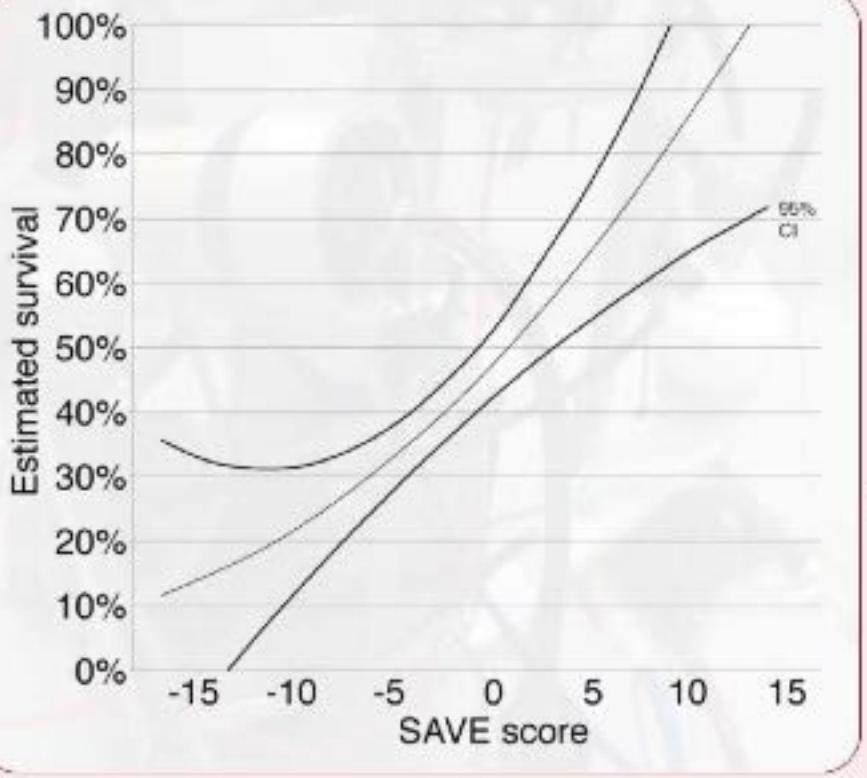
Lorusso R, et al. ELSO Interim Guidelines. ASAIO J. 2021

SAVE

Survival **A**fter **V**eno-arterial **E**CMO

The SAVE Score has been developed by ELSO and The Department of Intensive Care at The Alfred Hospital, Melbourne. It is designed to assist prediction of survival for adult patients undergoing Extra-Corporeal Membrane Oxygenation for refractory cardiogenic shock. It should not be considered a substitute for clinical assessment.

For more information see: *Predicting survival after ECMO for refractory cardiogenic shock: the survival after veno-arterial-ECMO (SAVE)-score*



The patient's SAVE Score is

Diagnosis:
- Myocarditis
- Refractory VT/VF
- Post heart or lung transplantation
- Congenital heart disease
- Other diagnoses

Age (years):
- 18-38
- 39-52
- 53-62
- ≥63

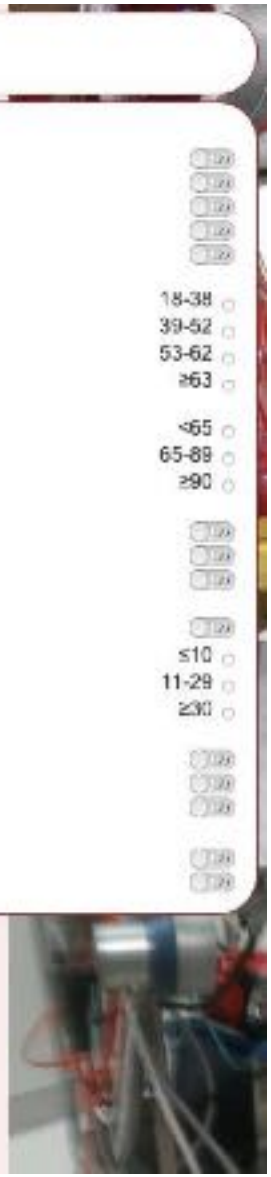
Weight (kg):
- <65
- 65-89
- ≥90

Cardiac:
- Pulse pressure pre ECMO ≤20 mmHg
- Diastolic BP pre ECMO ≥40 mmHg
- Pre-ECMO cardiac arrest

Respiratory:
- Peak inspiratory pressure ≤20 cmH_2O
- Intubation duration pre ECMO (hrs)
  - ≤10
  - 11-29
  - ≥30

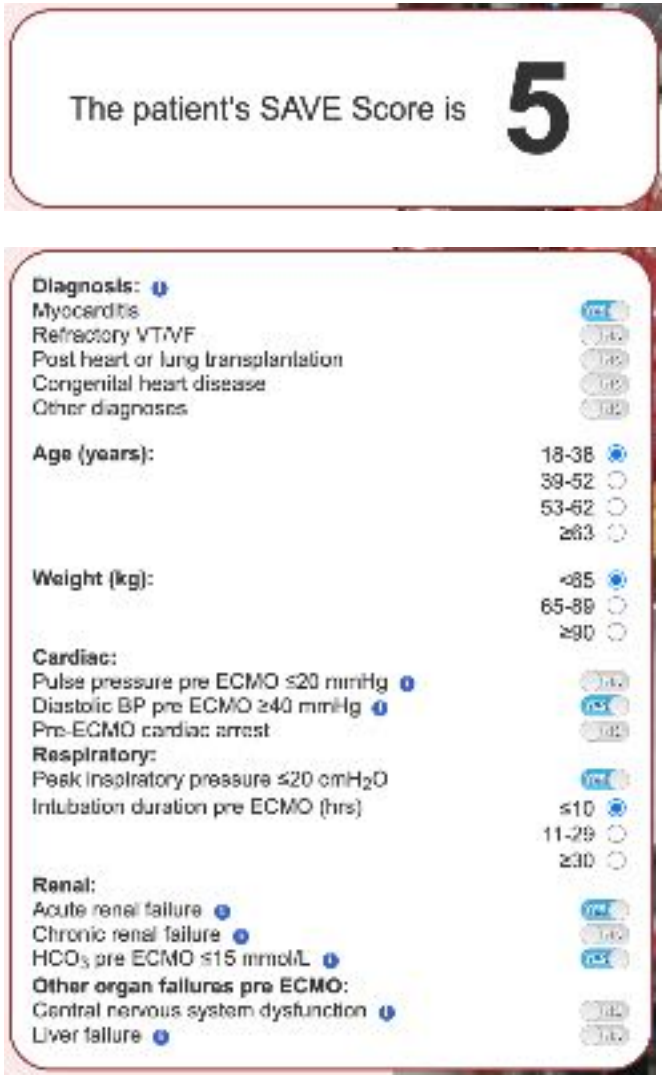
Renal:
- Acute renal failure
- Chronic renal failure
- HCO_3 pre ECMO ≤15 mmol/L

Other organ failures pre ECMO:
- Central nervous system dysfunction
- Liver failure



http://www.save-score.com

Question 5



26-year-old female
Viral myocarditis
64 kg
On norepi & dobutamine BP: 92/51 mmHg
Intubated 4 hours ago on AC PC PIP/PEEP: 20 / 5 cmH_2O
Creatinine: 138 mmol/L
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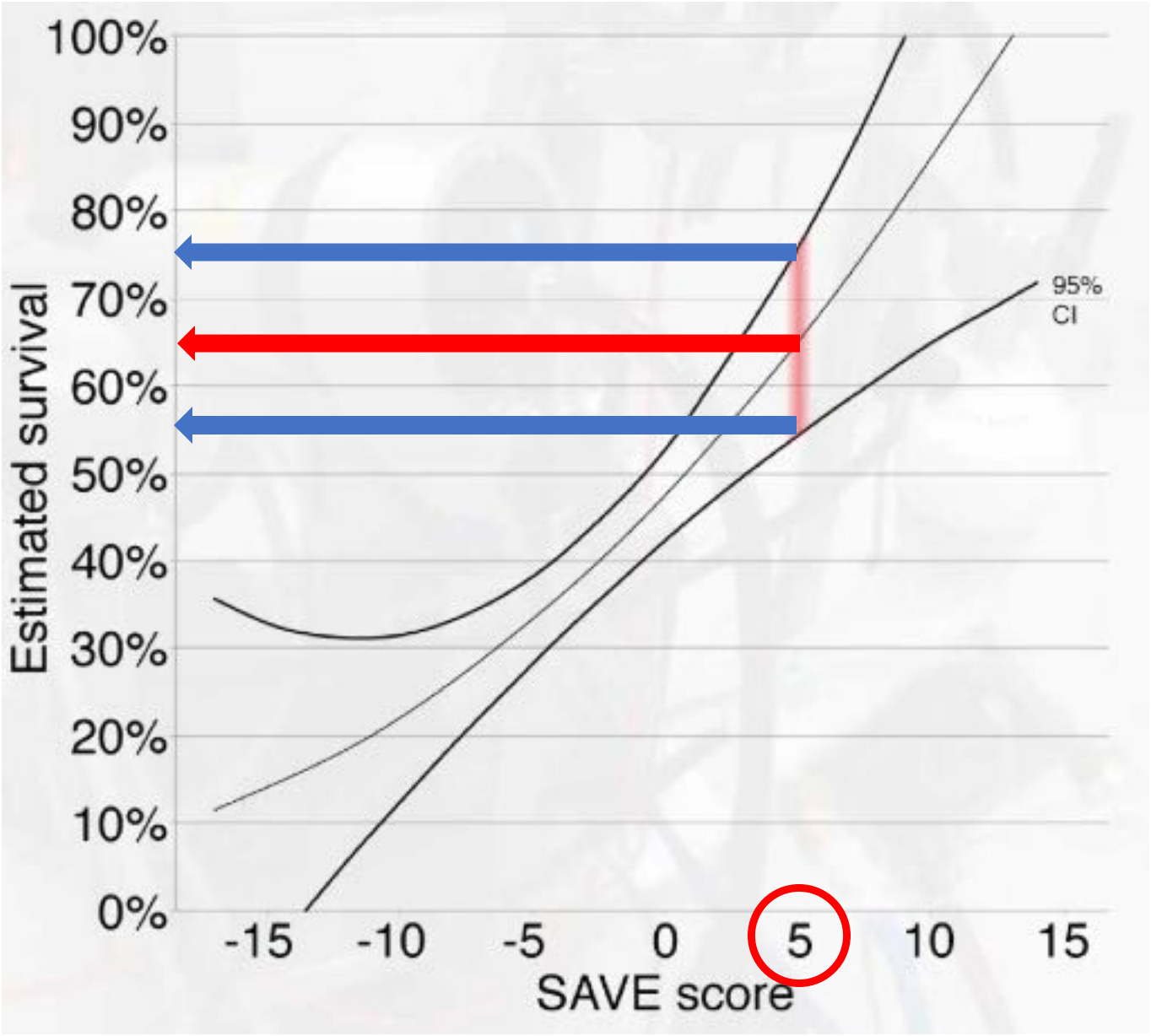
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Estimated survival
95%
CI
-15
-10
-5
0
5
10
15
SAVE score

Question 6

She is now cannulated, and VA ECMO is established. The patient's younger brother is a medical student.
He is asking what is the likelihood she'll survive?

A. Average survival 80%

B. Average survival 60%

C. Average survival 40%

D. Average survival 20%

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Saving Lives Academy

Outline

- Patient Selection
- VA ECMO Initiation
- **VA ECMO Goals**

VA ECMO Goals

- Provides hemodynamic support
- Restores end-organ perfusion
- Buys time to heal

Rationale for VA ECMO:

- Bedside cannulation
- Biventricular support
- Resipratory support

VA ECMO Goals

Restore Organ Perfusion

- Reduce inotropes
- Reduce vasopressors

- Assess for lactate normalization
- Improvement in urine output
- Resolution of shock liver

Case Resolution

- Decannulated on ECMO day 19

- Discharged from ICU day 31
- Discharged from hospital day 47

- Came back to visit us in ICU!

Saving Lives Academy

Outline

- Patient Selection
- VA ECMO Initiation
- VA ECMO Goals

Saving Lives Academy

Thank you!