LV Unloading in Acute MI Complicated by Shock
Is there Equipoise in STEMI-Shock Management?

Navin K. Kapur MD
FAHA FACC FSCAI FHFSA

Professor of Medicine
Interventional Cardiology and Advanced Heart Failure
Executive Director, The CardioVascular Center for Research and Innovation
Executive Director, The Cardiogenic Shock Working Group
Tufts Medical Center & Tufts University School of Medicine

Tufts Medical Center
The CardioVascular Center

The Cardiogenic Shock Working Group

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Disclosures:

NHLBI: RO1HL139785, RO1H133215; RO1HL159089

Institutional Research Support: Abbott, Abiomed, Boston Scientific, Getinge, LivaNova, Teleflex

Speaker/Consulting Honoraria: Abbott, Abiomed, Boston Scientific, Getinge, LivaNova, Edwards, Zoll

Co-Founder: PreCardia, Tulyp, X-Tension

The Operator's Mindset in AMI Shock: A ***Majority*** of Cath Labs in 2023

65 yo M with acute anterior STEMI. SBP 70. HR 90. Lactate 5.

Levophed started at 3 mcg/min SBP 90. HR 90. Intubated post-PCI.

PA Catheter: RA 14. PCWP 20. CI 2.1 MVO2 67% Fio2 100%




No MCS prior to Cath Lab discharge. Escalating vasopressors within 12 hours. VA-ECMO initiated with Impella CP. 5 days in the CCU. Unable to wean ECPella. **Died on hospital Day 7.**

The New Mindset in AMI Shock: A ***Minority*** of Cath Labs in 2023

65 yo M with acute anterior STEMI. SBP 80. HR 70. Lactate 3.

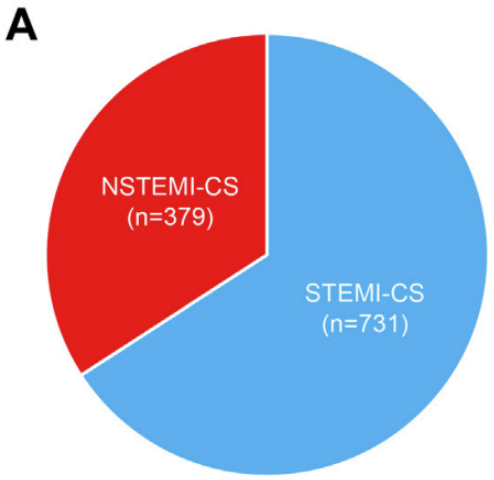
Impella CP Inserted Pre-PCI
SBP 94 – No Pressors
Single-Access PCI with PreClose

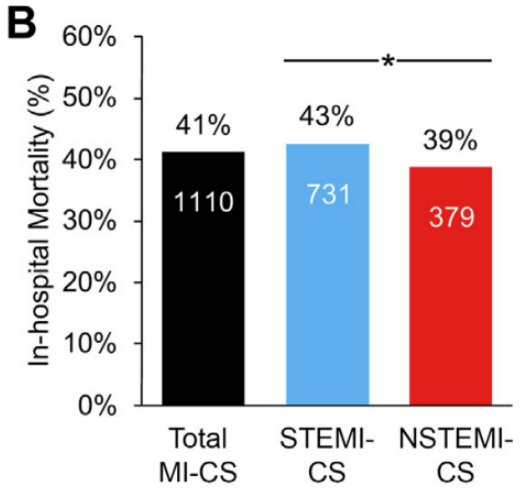
LAD Revasc with IVUS
SBP 100 – No Pressors
PAC Placed : CI > 2.6 on P8

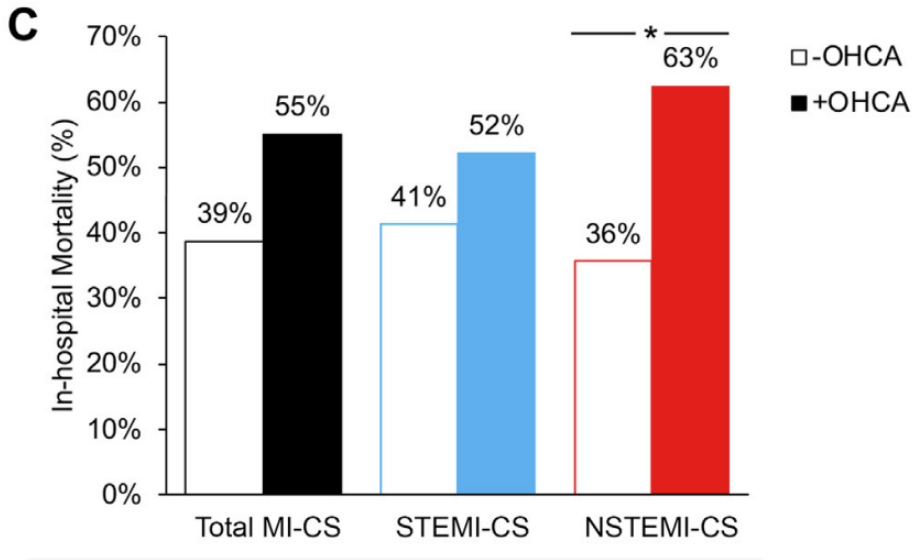


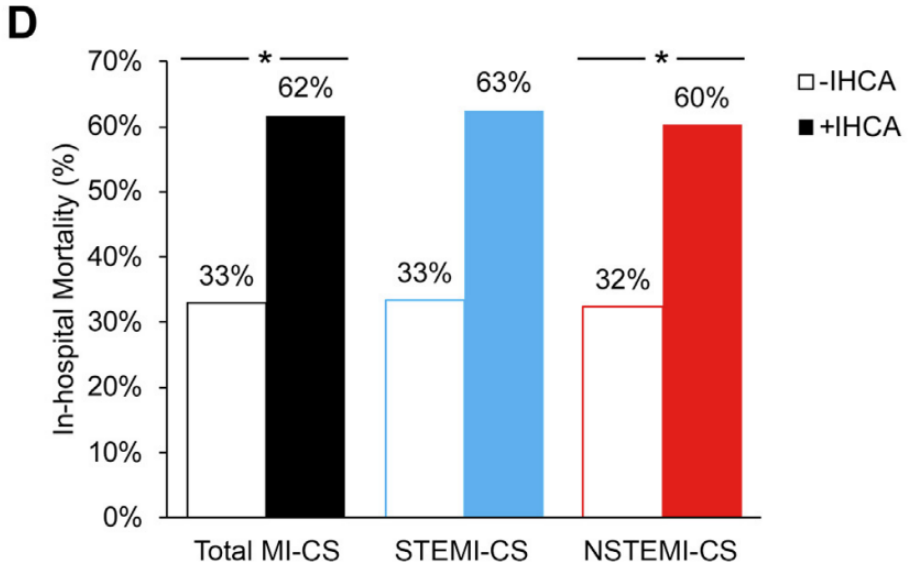
MCS and PAC prior to Cath Lab discharge. **No vasopressors.** Impella weaned within 24 hours. Removed at bedside with Perclose. Discharged on Day 4. LVEF 30 to 50% at 30-days

High Mortality in AMI-CS and Higher Mortality with OHCA or IHCA









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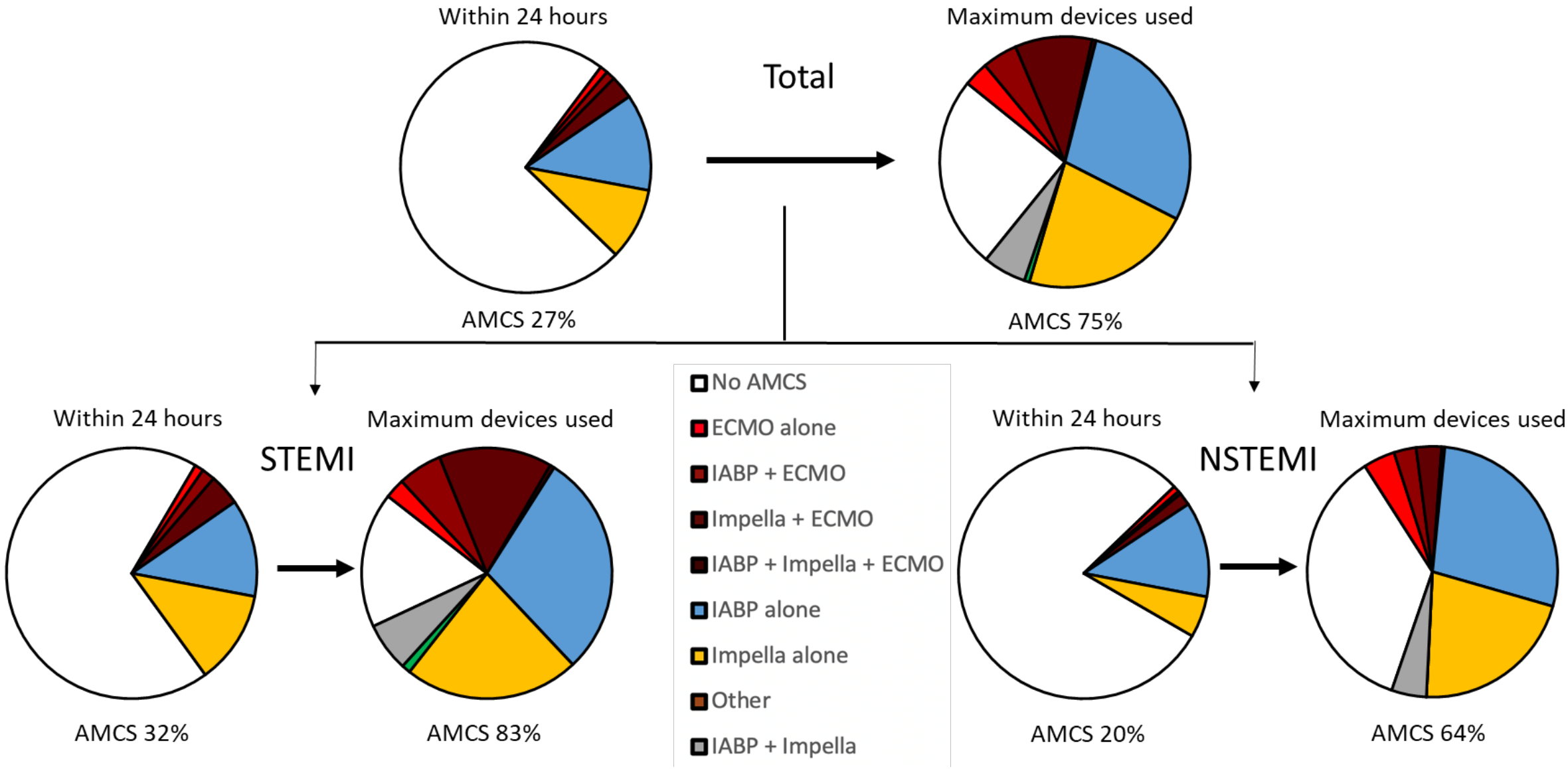
Sinha and Kapur et al JACC Advances 2023

We Don’t Provide Mechanical Support Early or Often Enough in AMI-CS



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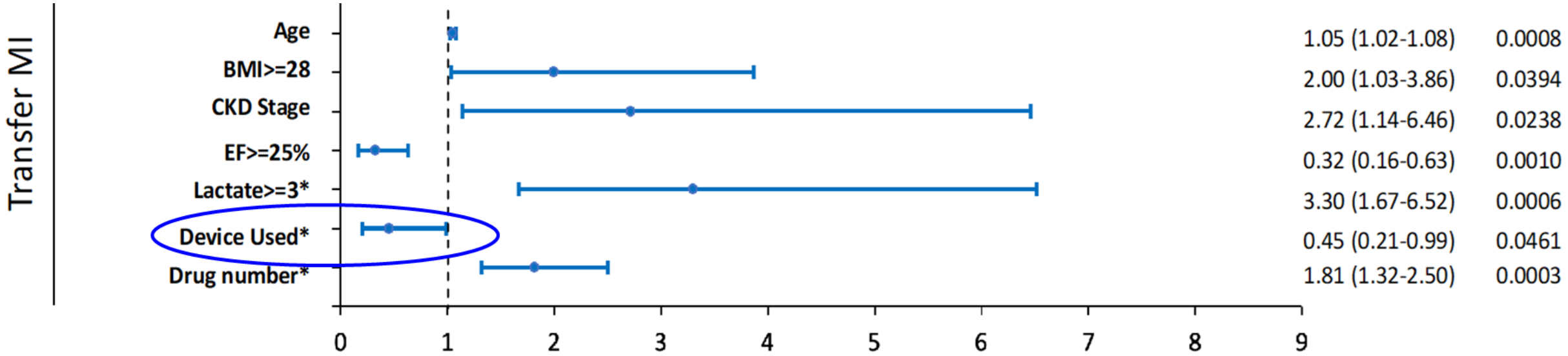
LV Support Prior to Transfer May Lead to Better Outcomes in AMI-CS



* Prior to transfer or within 24 hours of CSWG site arrival.

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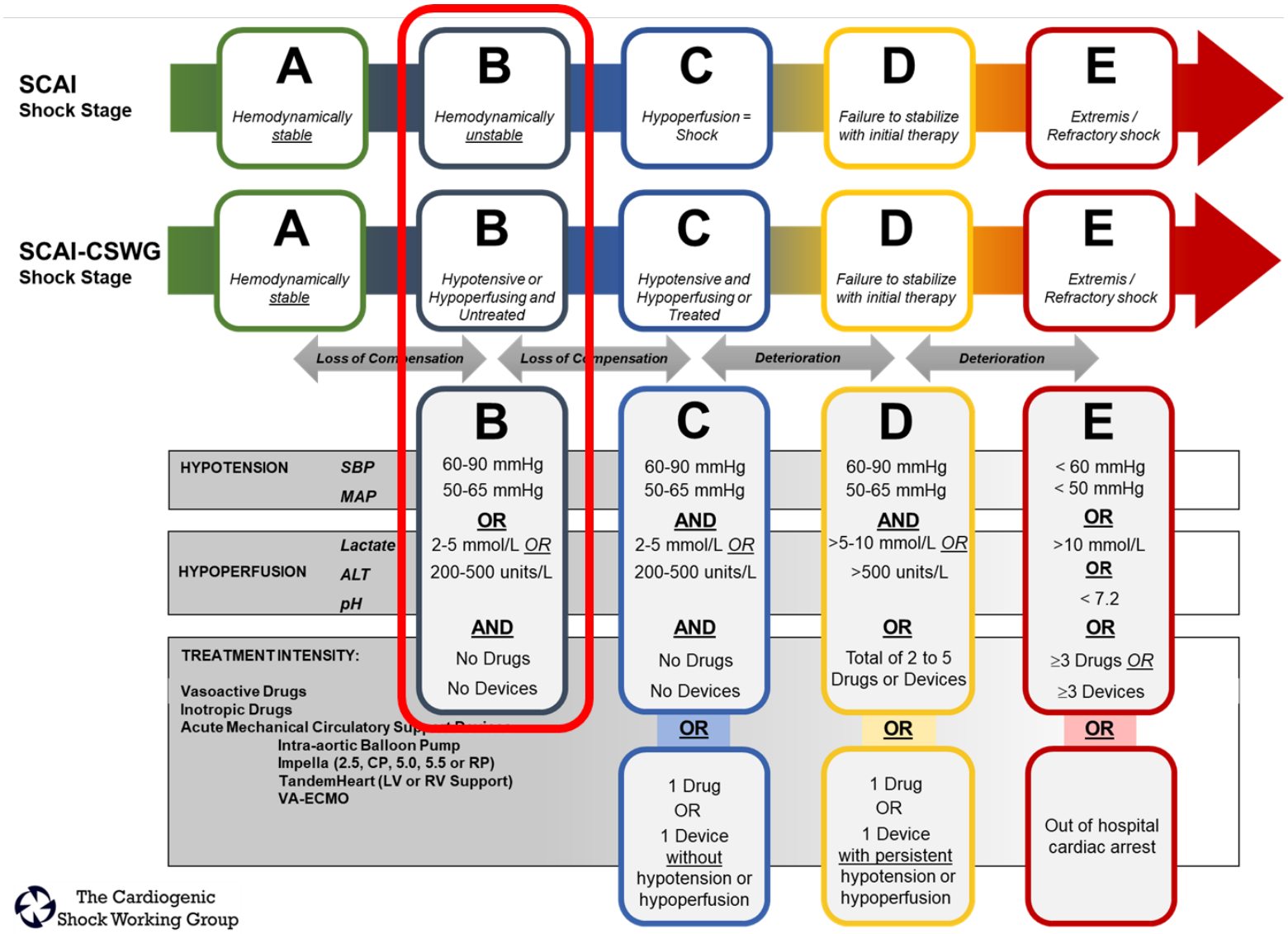
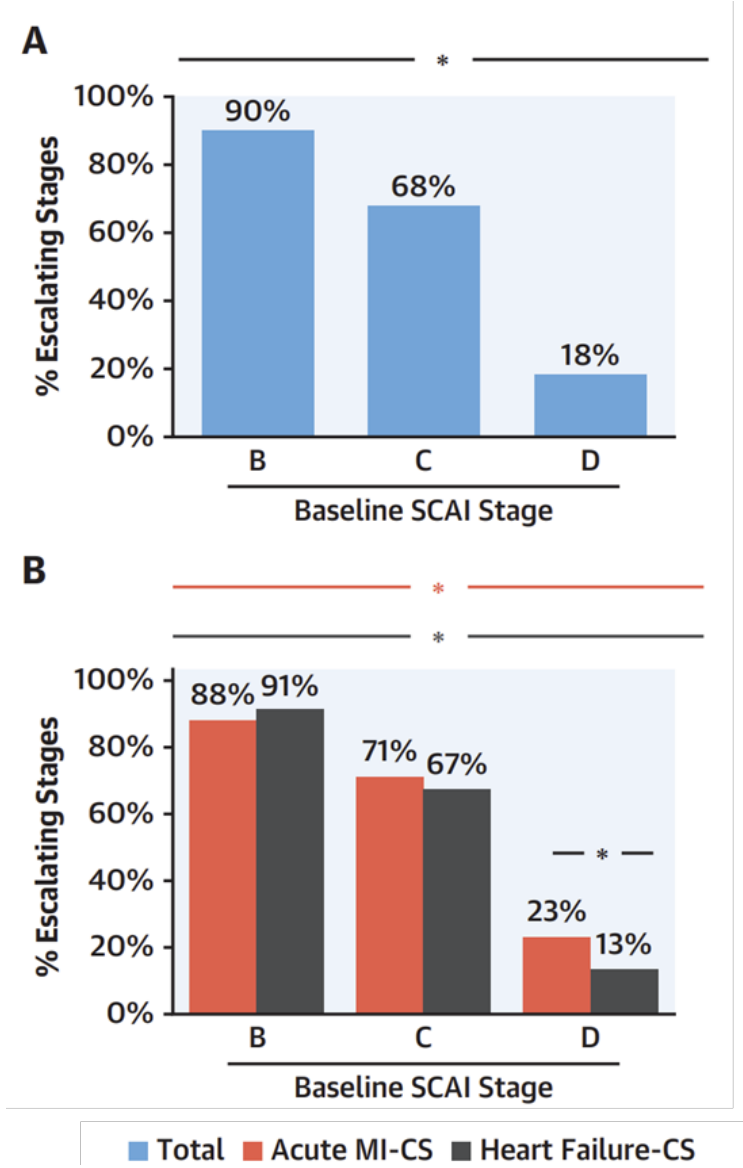
Garan and Kapur et al J Card Fail 2023 (Under Review)

SCAI B – *'B' is for Bad – Identify Early and Initiate Therapy*



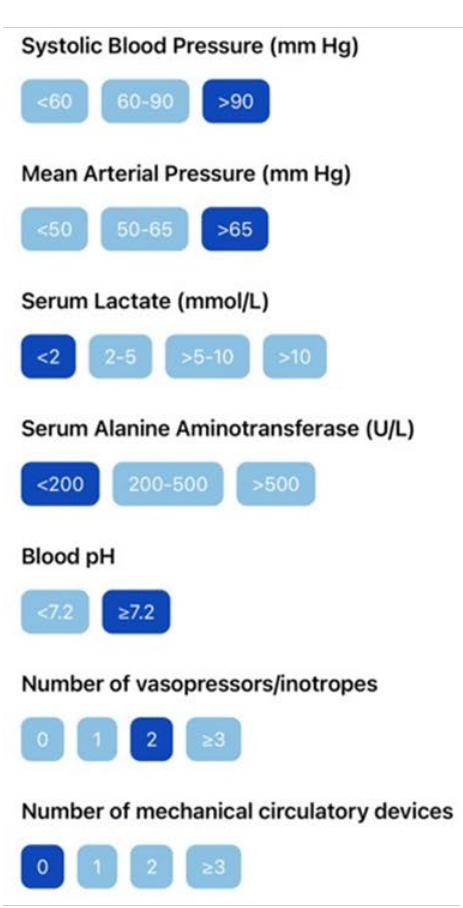


Kapur and Burkhoff et al JACC 2022

First Step Towards a Clinical Decision Support Platform: The CSWG App

The Cardiogenic Shock Working Group

- Shock Stage Calculator
- Hemodynamics Calculator
- Shock Phenotype Calculator
- Terms & Conditions



Cardiac Output by Fick: **4.38** L/min

Cardiac Index (CI): **2.22** L/min/m²

Cardiac Power Output (CPO): **0.91** W

Cardiac Power Index (CPI): **0.46** W/m²

Mean Arterial Pressure (MAP): **93.33** mm Hg

Pulse Pressure (PP): **40.00** mm Hg

Aortic Pulsatility Index (API): **5.00** mm Hg

Systemic Vascular Resistance (SVR): **1613.24**

Pulmonary Vascular Resistance (PVR): **97.40**

Mean Pulmonary Artery Pressure: **13.33** mm Hg

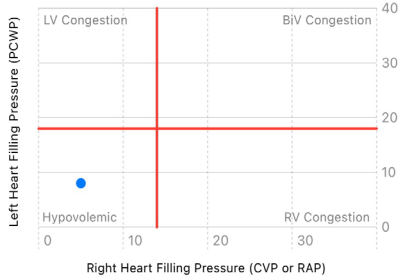
Right Atrial Pressure (RAP) / Pulmonary Capillary Wedge Pressure (PCWP): **0.62**

Pulmonary Arterial Pulsatility Index (PAPi): **2.00**

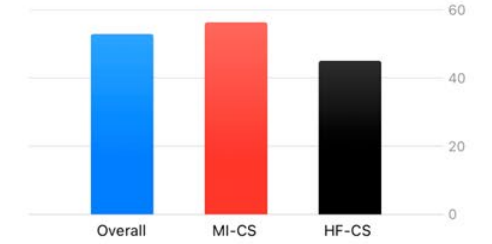
Right Ventricular Stroke Work Index (RVSWI): **3.50** g/m/beat/m²

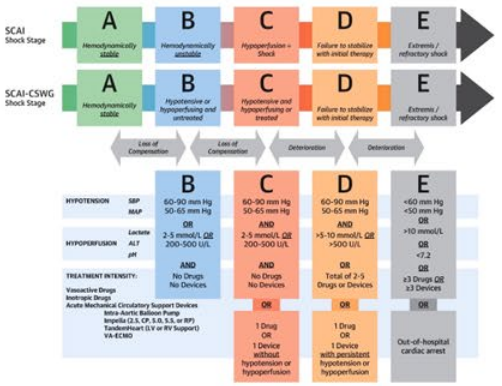
Transpulmonary Gradient (TPG): **5.33** mm Hg

Diastolic Pulmonary Gradient (DPG): **2.00** mm Hg



The CSWG-SCAI shock stage is **E**
Predicted in-hospital mortality: **52.9%**
Predicted in-hospital mortality for MI-CS: **56.35%**
Predicted in-hospital mortality for HF-CS: **45.06%**





References:
Kapur, Navin K et al. "Criteria for Defining Stages of Cardiogenic Shock Severity. Journal of the American College of Cardiology vol. 80, 3 (2022): 185-198. doi:10.1016/j.jacc.2022.04.049

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26

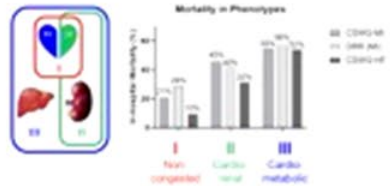
Platelet Count (K/µL)

142

White Cell Count (K/µL)

32

CSWG-SCAI Shock Phenotype III (Cardio-Metabolic)
In-hospital mortality: 52-55%



References:
Zweck, Elric et al. "Phenotyping Cardiogenic Shock." Journal of the American Heart Association vol. 10,14 (2021): e020085. doi:10.1161/JAHA.120.020085

Jentzer JC, Soussi S, Lawler PR, Kennedy JN, Kashani KB. Validation of cardiogenic shock phenotypes in a mixed cardiac intensive care unit population. Catheter Cardiovasc Interv. 2022 Mar;99(4):1006-1014. doi: 10.1002/ccd.30103.

* For educational, research or entertainment purposes only

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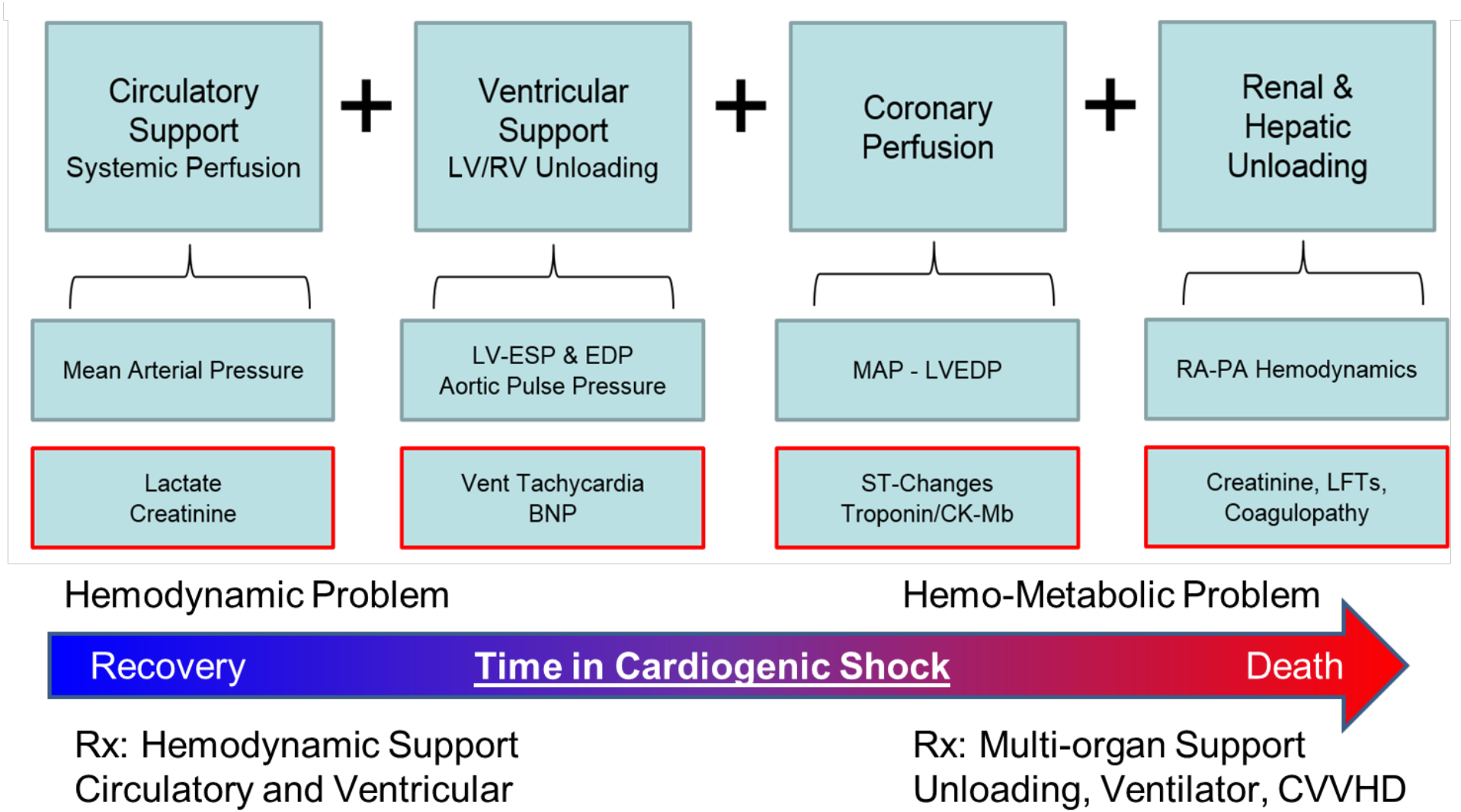
MCRI20 Molecular Cardiology Research Institute

Credit: Kevin John, Elric Zweck, Song Li

Available Free on Apple App Store

Clinical Treatment Objectives in Acute MI + Cardiogenic Shock



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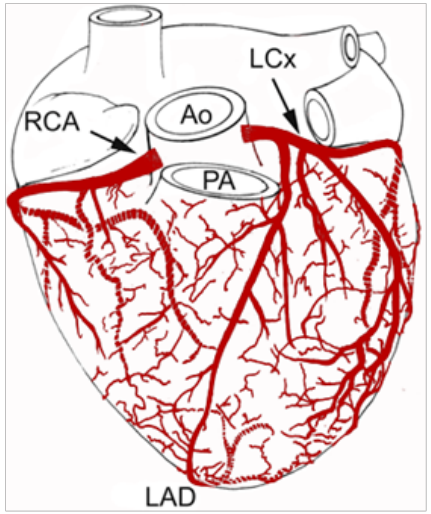
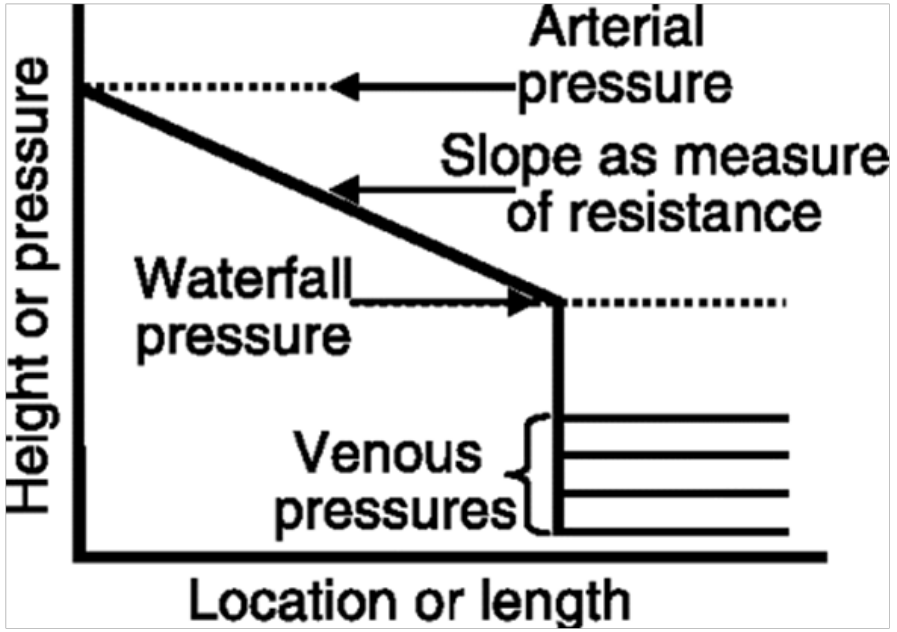
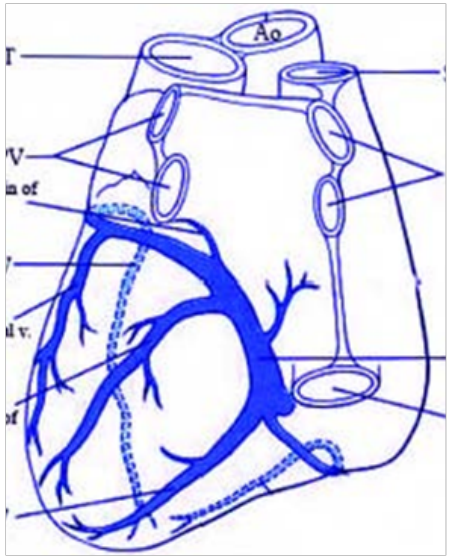
Kapur NK ACC SAP 2021

Myocardial Perfusion in Acute MI: The Waterfall Concept







1. **Increased Systemic Aortic Pressure**
2. **Increased Coronary Perfusion Pressure**
3. **Reduced Myocardial Microvascular Obstruction**

1. **Reduced LVEDP**
2. **Decreased LV Wall Stress**
3. **Enhanced Collateral Coronary Flow**

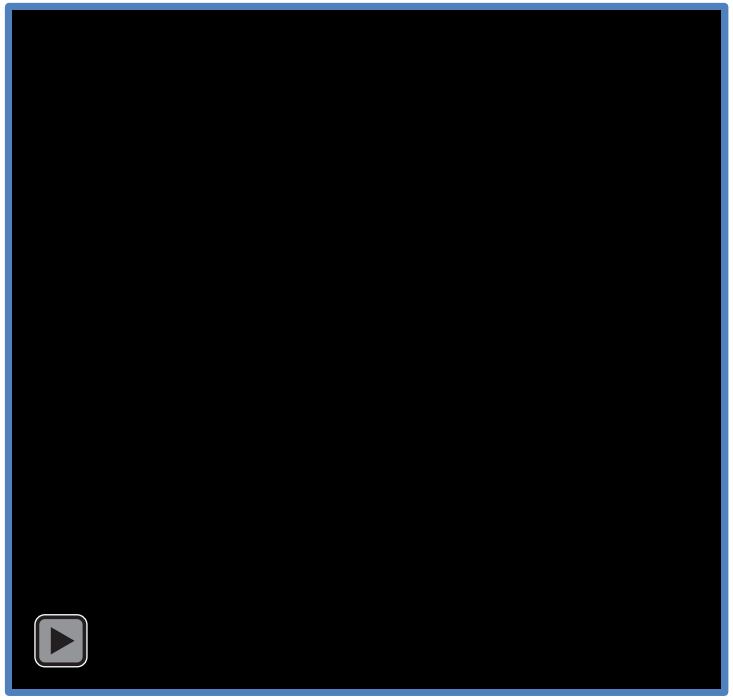
Optimal Ventricular Unloading Improves Systemic & Myocardial Perfusion

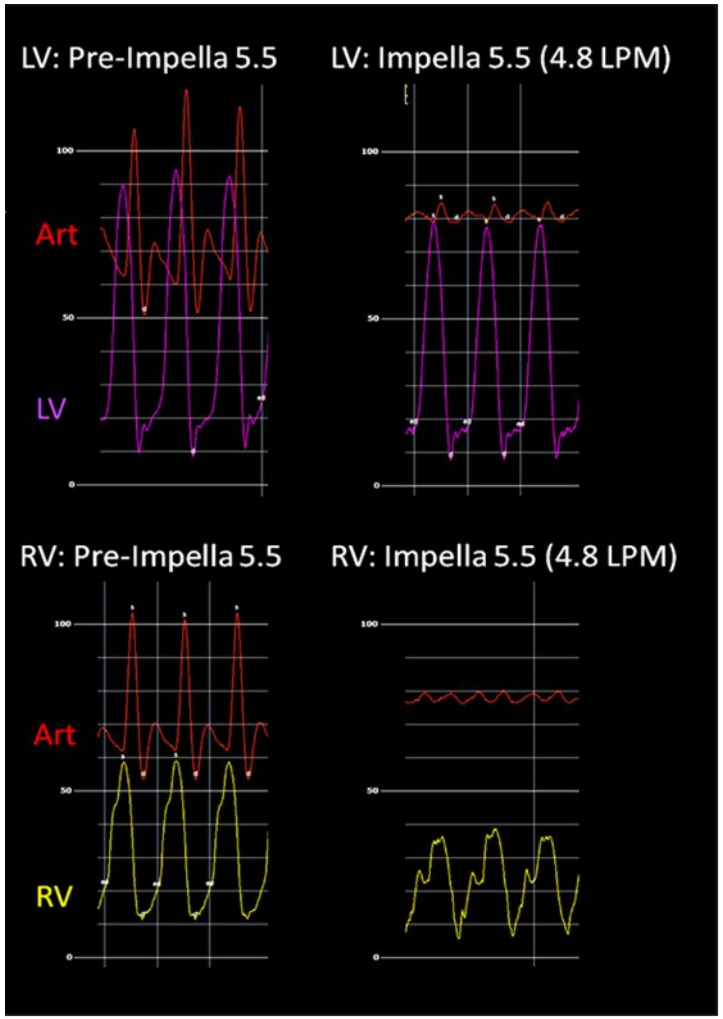
Physiol Rev 86: 1263–1308, 2006

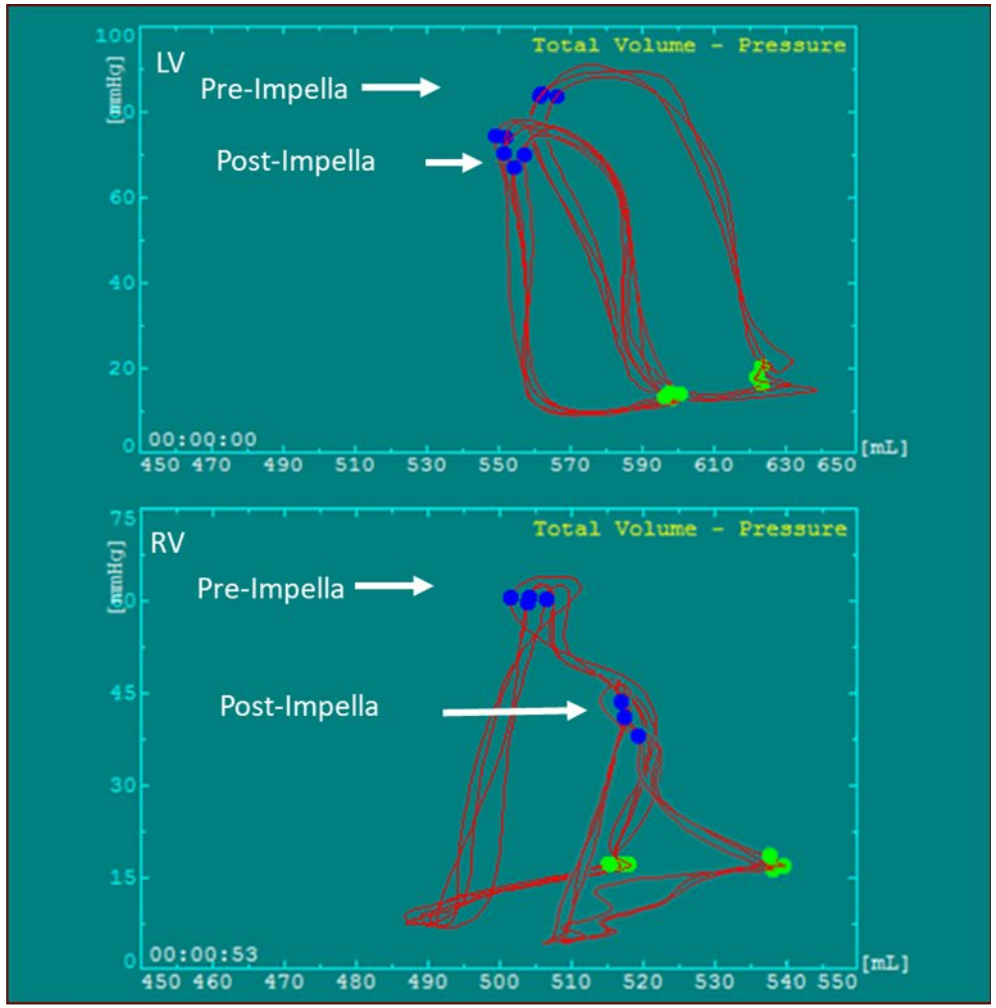
What does LV Unloading look like clinically?

Both Reducing LV PVA (LV ESP, SW, and EDP) AND Uncoupling Ventriculo-Arterial Pressures

Impella LV Unloading

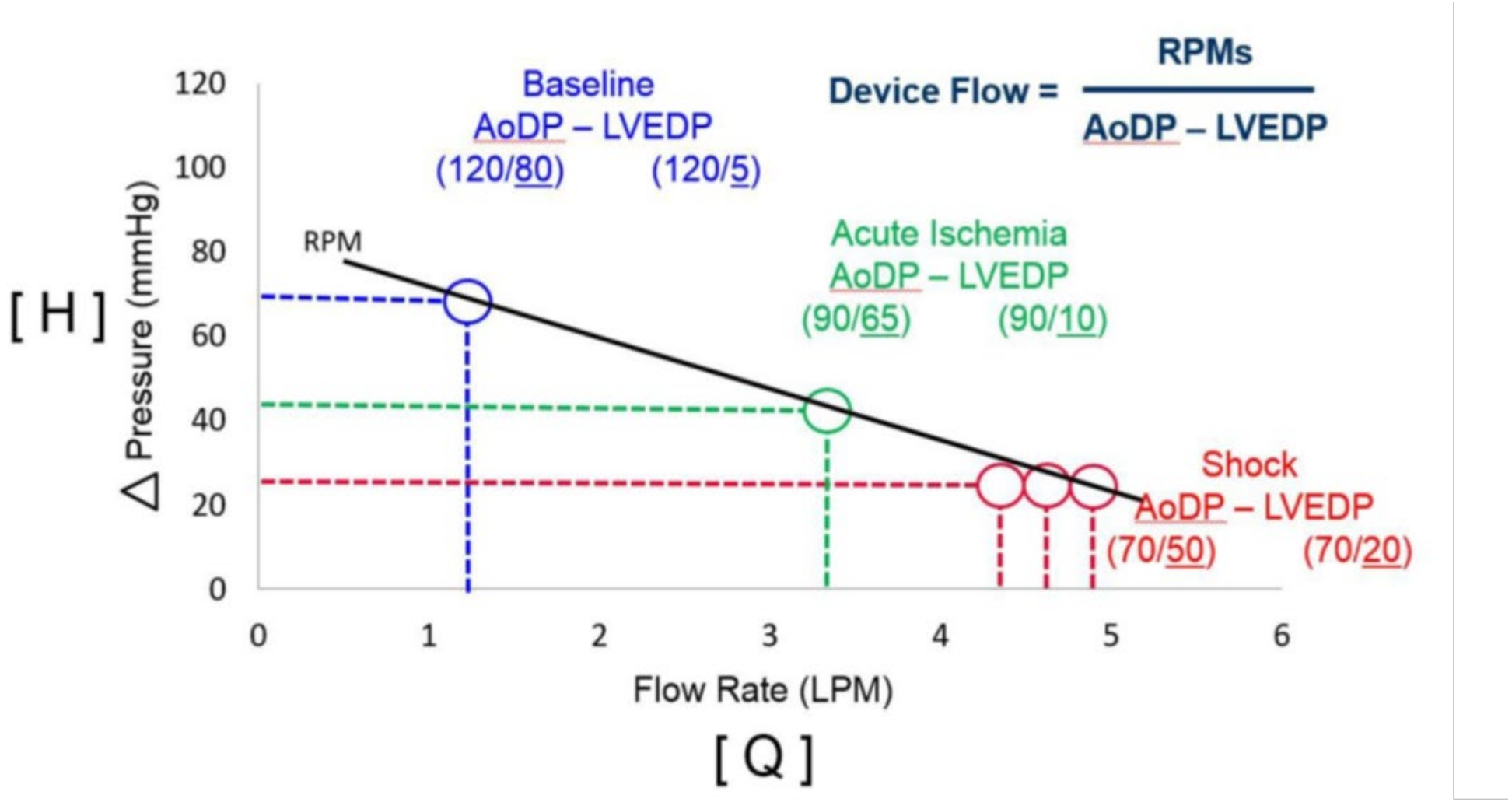






Everett and Kapur et al Circ HF 2021

What is the Rationale for Endovascular Trans-Valvular MCS?



The More Impaired the LV, The More Efficient a Trans-Valvular Pump Becomes

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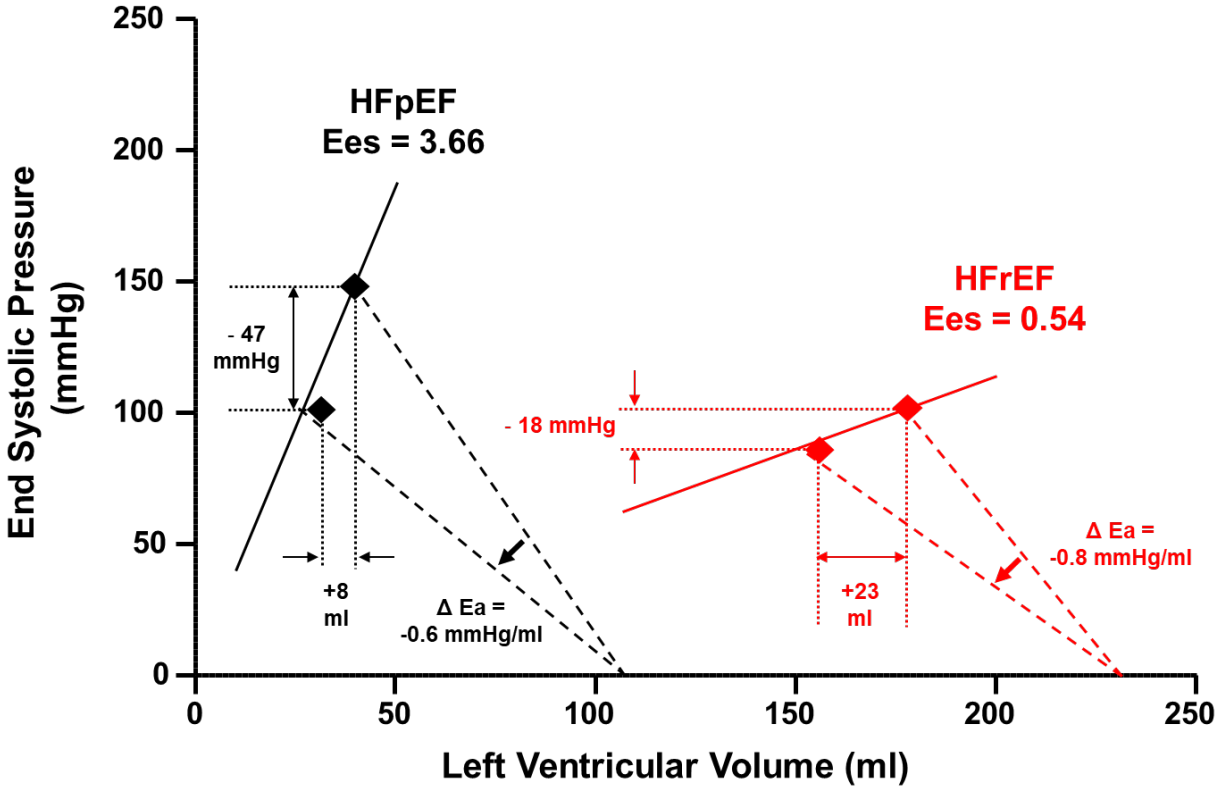
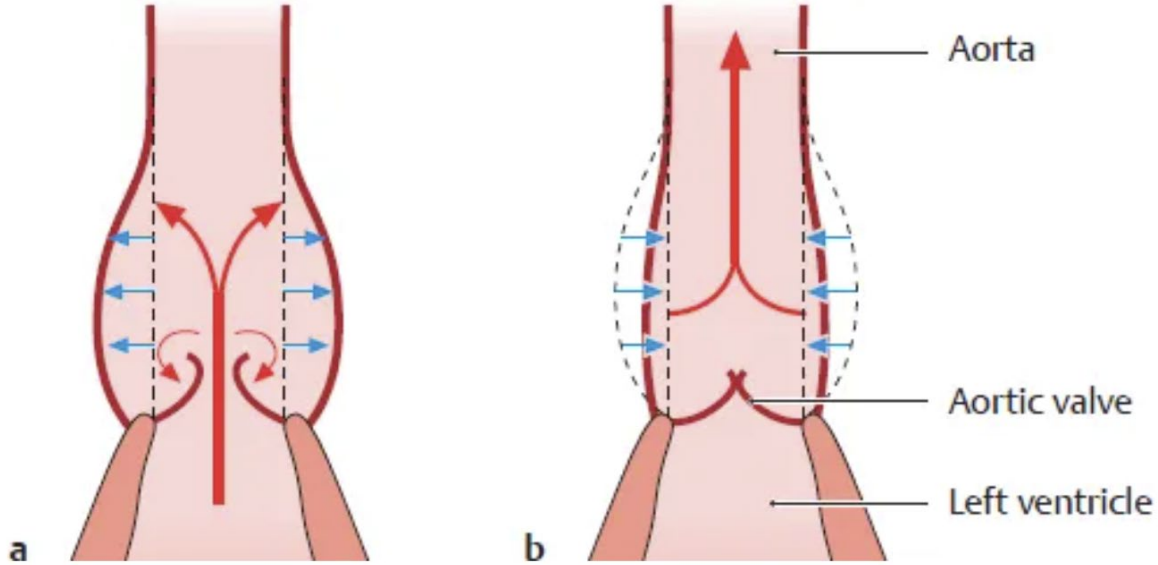
What is the Rationale for Endovascular Counterpulsation Pumps?

Reducing Afterload Increases Stroke Volume In Heart Failure Where SVR is Elevated



Wind-Kessel Effect of an IABP

Counterpulsation Requires Pulsation



Borlaug Circ HF 2015

Kapur NK ACC SAP 2021

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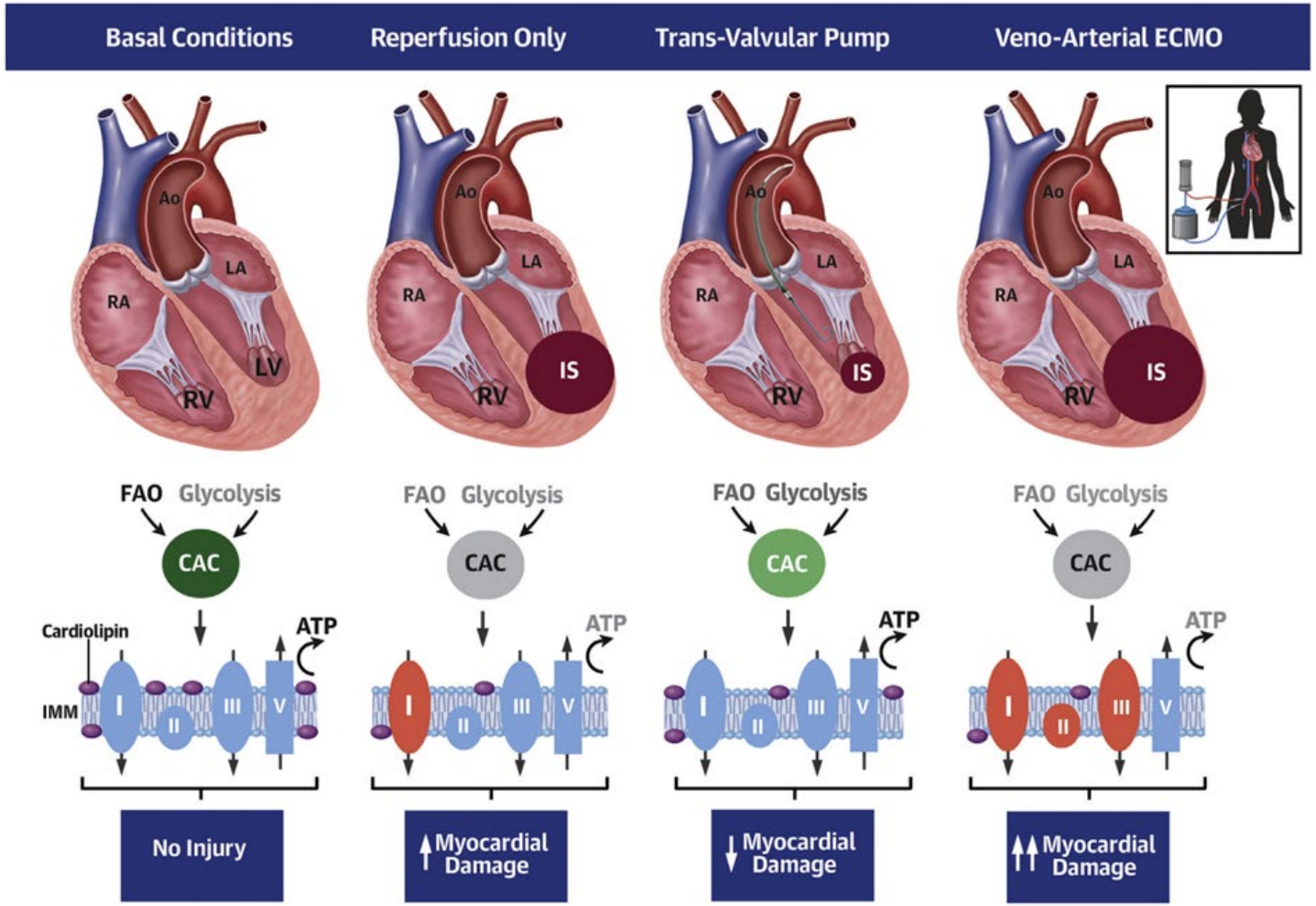
Transvalvular Ventricular Unloading Before Reperfusion in Acute Myocardial Infarction

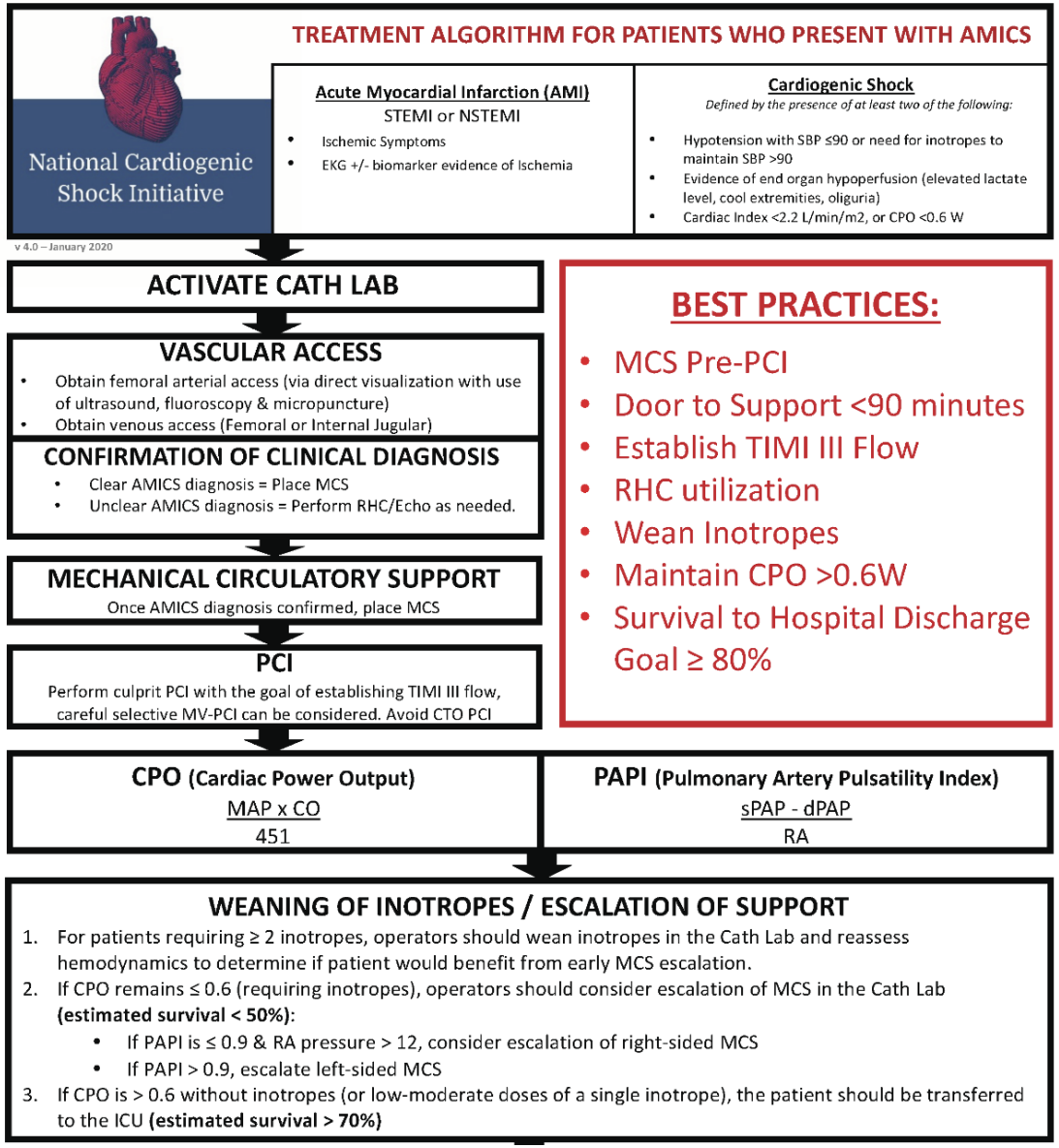


"These novel findings identify that transvalvular ***unloading and delayed reperfusion limits ischemic injury*** before reperfusion, ***improves myocardial energy substrate use***, and ***preserves mitochondrial structure and function*** after reperfusion."

NIH RO1HL139785 (Kapur)
NIH RO1H133215 (Kapur)
AHA CDA Award (Swain)

Kapur and Karas Circulation 2013
Kapur and Karas JACC HF 2015
Esposito and Kapur JACC 2018
Kapur and O'Neill Circulation 2019
Swain and Kapur et al JACC 2020
Qiao and Kapur et al JCTR 2022
Everett and Kapur et al JACC BTS 2023
Swain and Kapur et al Circulation 2023 (Under Review)

The National Cardiogenic Shock Initiative: Impella Pre-PCI for AMI-Shock



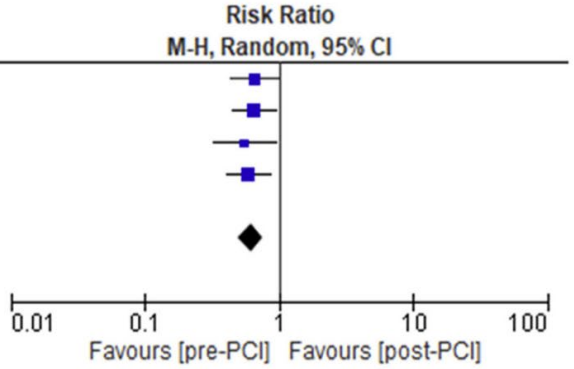
	All	SCAI C or D	SCAI E	p-value
Procedural Survival	99%	99%	98%	0.74
Survival to Discharge	71%	79%	54%	<0.01
Survival at 30-days	68%	77%	49%	<0.01
Survival at 1-Year	53%	62%	31%	<0.01

Lumping All Data Together Favors Impella Pre-PCI for AMI-Shock

(A) In-hospital mortality

Study or Subgroup	pre-PCI Events	pre-PCI Total	post-PCI Events	post-PCI Total	Weight	Risk Ratio M-H, Random, 95% CI
Chatzis 2021	16	35	32	46	25.5%	0.66 [0.44, 0.99]
Loehn 2020	17	34	30	39	29.9%	0.65 [0.45, 0.95]
Meraj 2017	9	20	13	16	14.7%	0.55 [0.32, 0.95]
Oneill 2014	22	63	54	91	29.9%	0.59 [0.40, 0.86]
Total (95% CI)		**152**		**192**	**100.0%**	**0.62 [0.50, 0.76]**
Total events	64		129			

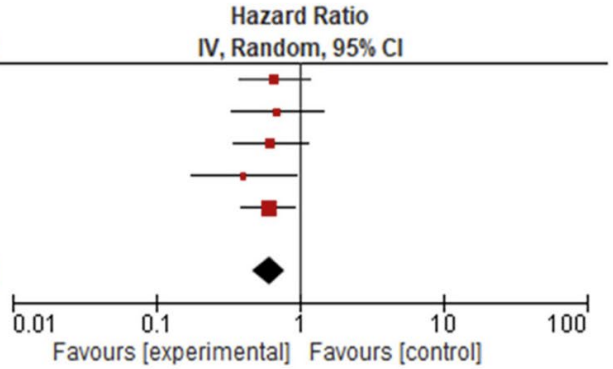
Heterogeneity: Tau² = 0.00; Chi² = 0.38, df = 3 (P = 0.94); I² = 0%
Test for overall effect: Z = 4.57 (P < 0.00001)



(B) 30-day mortality

Study or Subgroup	log[Hazard Ratio]	SE	Weight	Hazard Ratio IV, Random, 95% CI
Chatzis 2021	-0.4005	0.29	21.2%	0.67 [0.38, 1.18]
Hemradj 2020	-0.3567	0.37407	12.7%	0.70 [0.34, 1.46]
Loehn 2020	-0.462	0.3	19.8%	0.63 [0.35, 1.13]
Meraj 2017	-0.8916	0.43	9.6%	0.41 [0.18, 0.95]
Oneill 2014	-0.4943	0.22	36.8%	0.61 [0.40, 0.94]
Total (95% CI)			**100.0%**	**0.61 [0.47, 0.80]**

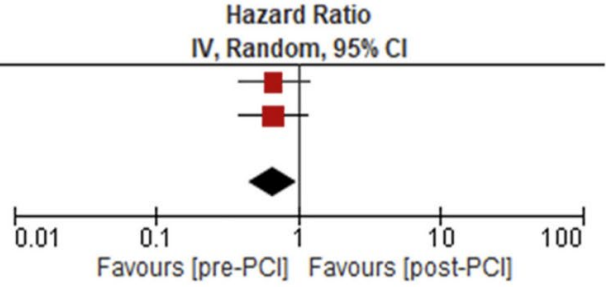
Heterogeneity: Tau² = 0.00; Chi² = 1.10, df = 4 (P = 0.89); I² = 0%
Test for overall effect: Z = 3.66 (P = 0.0002)



(C) 6-month mortality

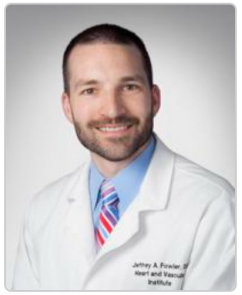
Study or Subgroup	log[Hazard Ratio]	SE	Weight	Hazard Ratio IV, Random, 95% CI
Chatzis 2021	-0.40048	0.29	48.2%	0.67 [0.38, 1.18]
Loehn 2020	-0.40048	0.28	51.8%	0.67 [0.39, 1.16]
Total (95% CI)			**100.0%**	**0.67 [0.45, 0.99]**

Heterogeneity: Tau² = 0.00; Chi² = 0.00, df = 1 (P = 1.00); I² = 0%
Test for overall effect: Z = 1.99 (P = 0.05)



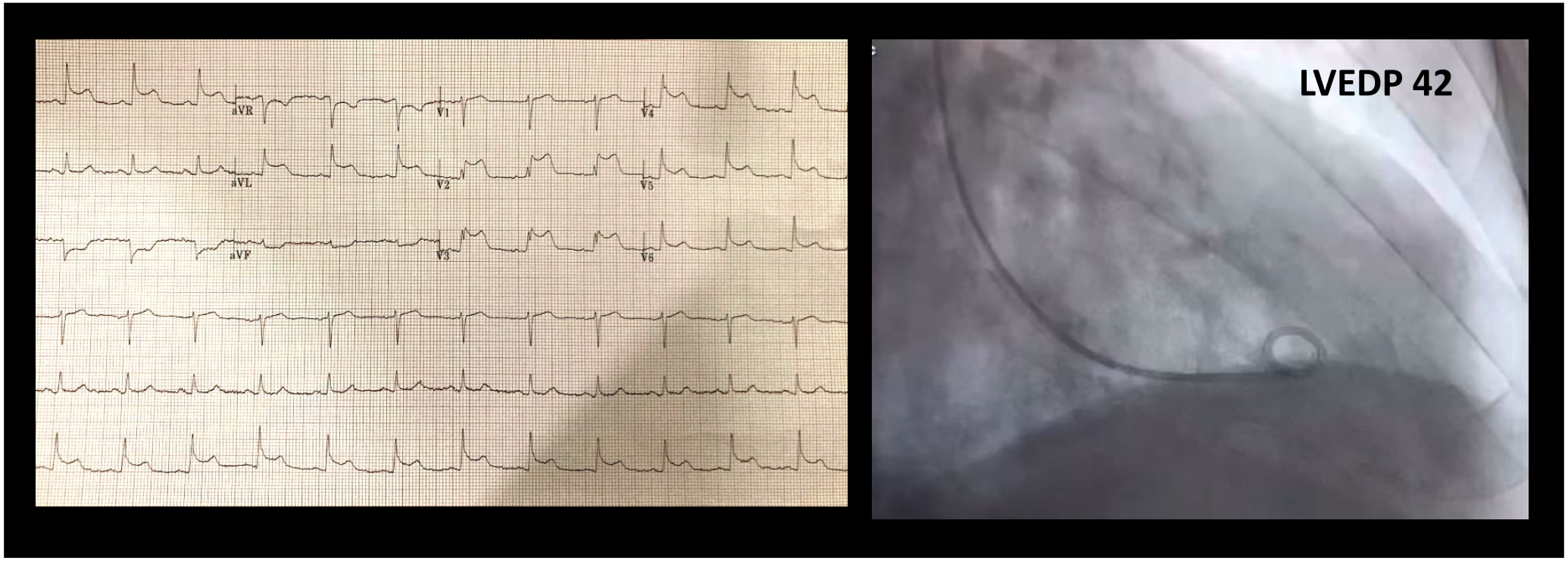
Miyashita and Kapur et al
Card Rev Med 2021

The Door to Unload Concept:
LV Unloading Before PCI in Anterior STEMI



Jeffrey A Fowler, DO

Anterior STEMI – Normotensive – No Vasopressors – Chest pain – No Dyspnea – Warm



STEMI DTU

SCAI-CSWG Shock Stage

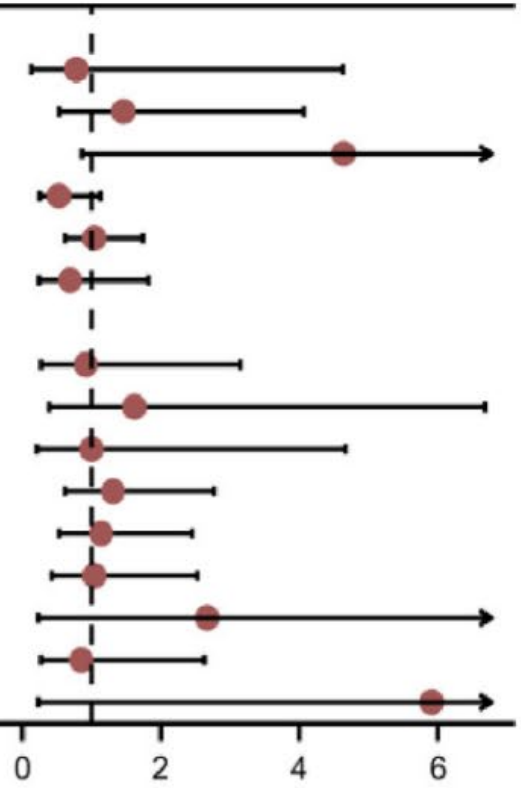
A	B	C	D	E
Hemodynamically stable	Hypotensive or Hypoperfusing and Untreated	Hypotensive and Hypoperfusing or Treated	Failure to stabilize with initial therapy	Extremis / Refractory shock

RECOVER IV

If you don't have Equipoise in AMI-CS, Get Some….

No Existing RCT Data Supports the use of pVAD over IABP for AMI-Shock

Studies	pVAD, n	IABP, n	Weight	HR (95% CI)
OBS				
Shah R et al (2012)	2/22	4/35	2.5%	0.78 (0.13, 4.63)
Manzo et al (2013)	27/35	30/43	5.6%	1.46 (0.53, 4.07)
Pieri M et al (2018)	6/28	2/36	1.2%	4.64 (0.86, 25.07)
Alushi et al (2019)	32/62	36/54	16.9%	0.53 (0.25, 1.13)
Schrage B et al (2019)	53/115	52/115	25.4%	1.04 (0.62, 1.74)
Nakajima T et al (2021)	19/49	35/90	4.2%	0.69 (0.24, 1.82)
RCT				
Thiele H et al (2005)	9/21	9/20	4.8%	0.92 (0.27, 3.15)
Burkhoff D et al (2006)	9/19	5/14	2.8%	1.62 (0.39, 6.68)
Seyfarth M et al (2008)	6/13	6/13	2.9%	1.00 (0.21, 4.67)
O'Neill et al (2012)	17/225	13/222	11.0%	1.31 (0.62, 2.77)
Dangas GD et al (2014)	15/216	13/211	11.1%	1.14 (0.53, 2.45)
Kovacic JC et al (2015)	11/167	10/158	8.7%	1.04 (0.43, 2.53)
Ouweneel DM et al (2016)	3/12	1/9	0.8%	2.67 (0.23, 31.07)
Ouweneel DM et al (2017)	11/24	12/24	5.9%	0.85 (0.27, 2.63)
Bochaton T et al (2020)	2/7	0/6	0.3%	5.91 (0.23, 151.15)



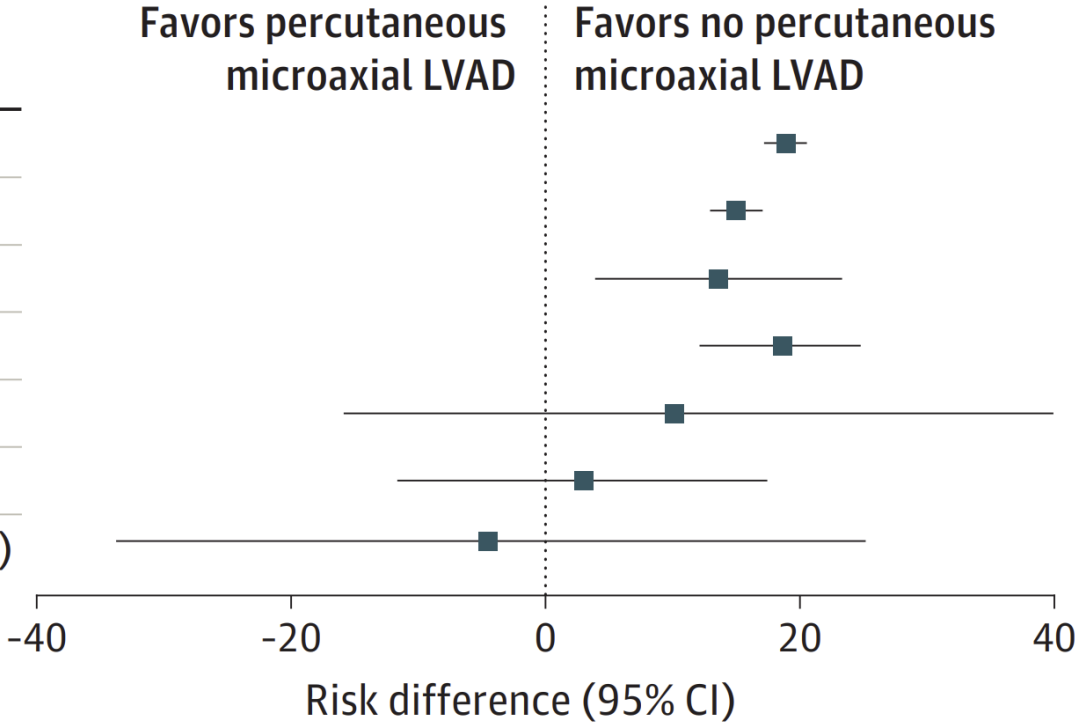
RECOVER IV

Wang et al Asian J Surg 2023

Despite Rigorous Statistical Acrobatics, Medicare Claims Generate Equipoise

No Clear Answer Here Either

Study method	Risk difference (95% CI)
Unweighted	18.9 (17.2 to 20.5)
IPTW	14.9 (12.9 to 17.0)
Instrumental variable	13.5 (3.9 to 23.2)
Grace period	18.4 (12.1 to 24.7)
DiD rapidly increasing vs moderately increasing[a]	9.7 (-15.9 to 39.9)
DiD rapidly increasing vs declining[a]	2.6 (-11.6 to 17.4)
DiD moderately increasing vs declining[a]	-4.7 (-33.7 to 25.1)



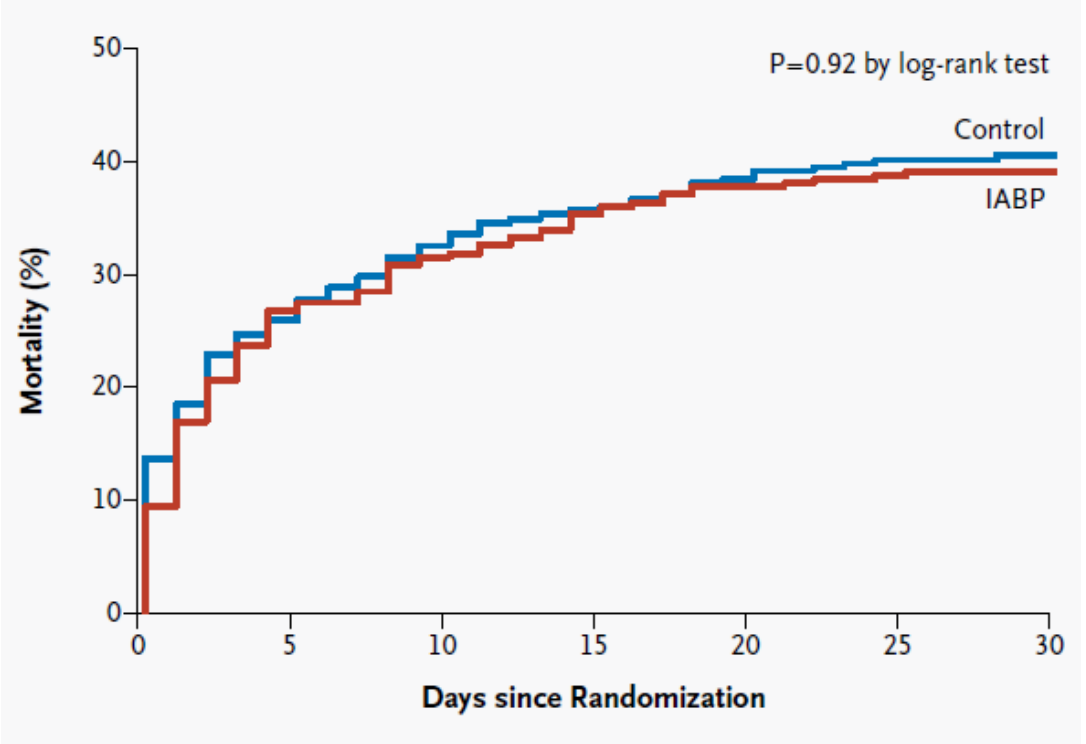
RECOVER IV

Almarzooq and Yeh et al JAMA Cardio 2023

Misplaced Bias Against IABP? IABP Shock II Was Not Definitive 'Routine Use of IABP in AMI-CS is not Beneficial'

Randomized to IABP or Not….

- One-third of patients were NSTEMI
- ~45% of STEMI were Anterior MI
- 25% had RCA Culprit (RV-MI)
- IABP use pre- or post-PCI
- No PA catheter indices
- ~45% with Out of Hospital Cardiac Arrest
- ~25% Cross-Over to MCS in Control Arm

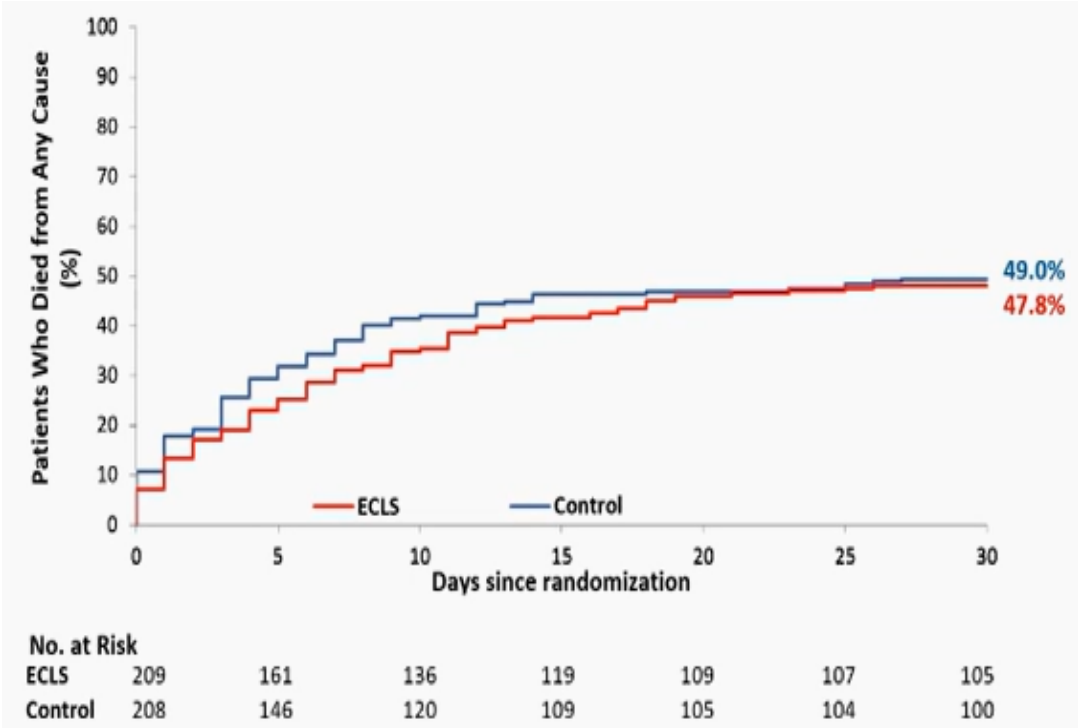


Thiele H et al. NEJM 2012

Same Trial, Different Pump… ECLS Shock Was Not Definitive
'Routine Use of VA-ECMO in AMI-CS is not Beneficial'

Randomized to VA-ECMO or Not….

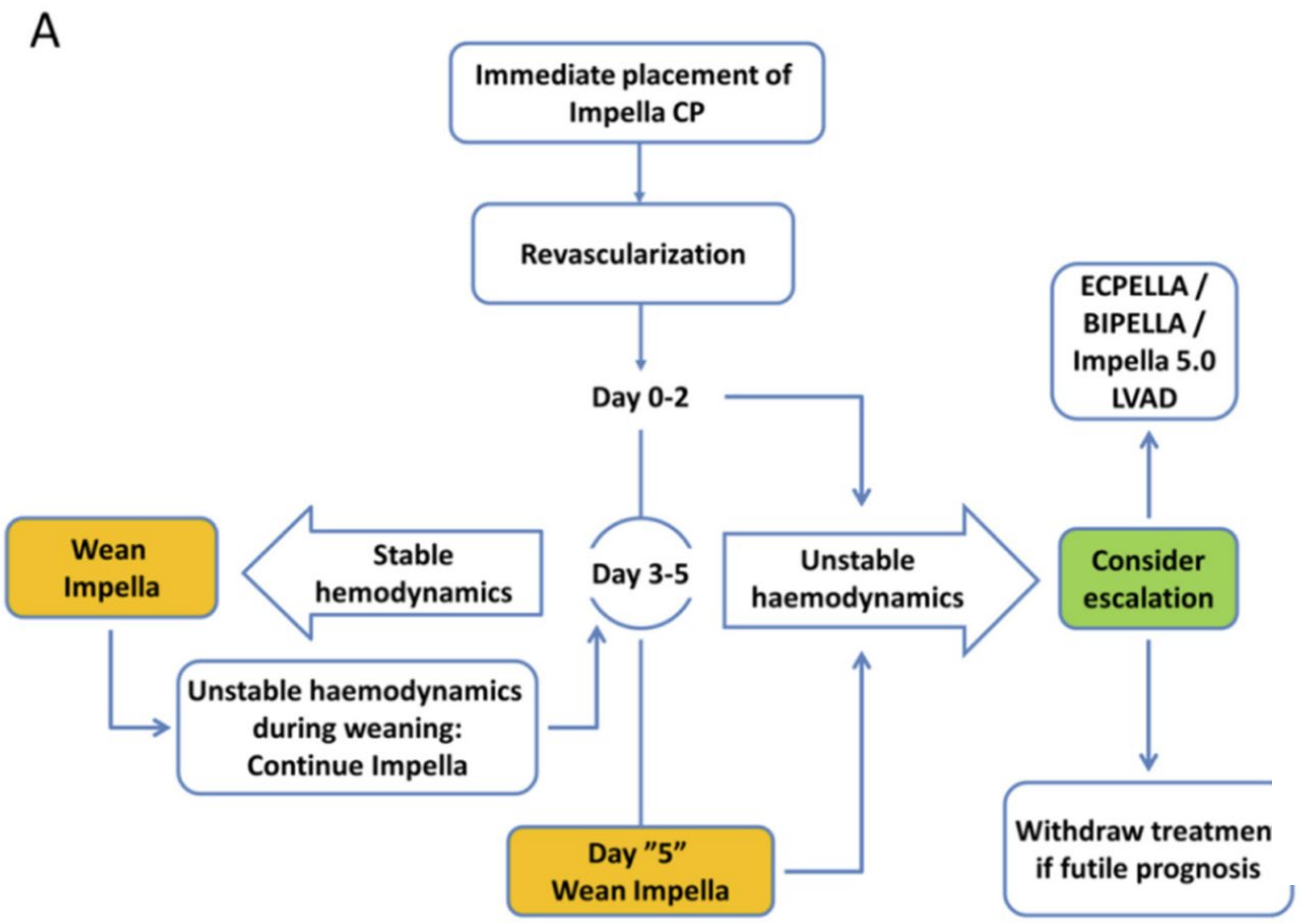
- One-third of patients were NSTEMI
- ~45% of STEMI were Anterior MI
- 25% had RCA Culprit (RV-MI)
- VA-ECMO use pre- or post-PCI
- No PA catheter indices
- ~77% with Out of Hospital Cardiac Arrest
- ~25% Cross-Over to MCS in Control Arm

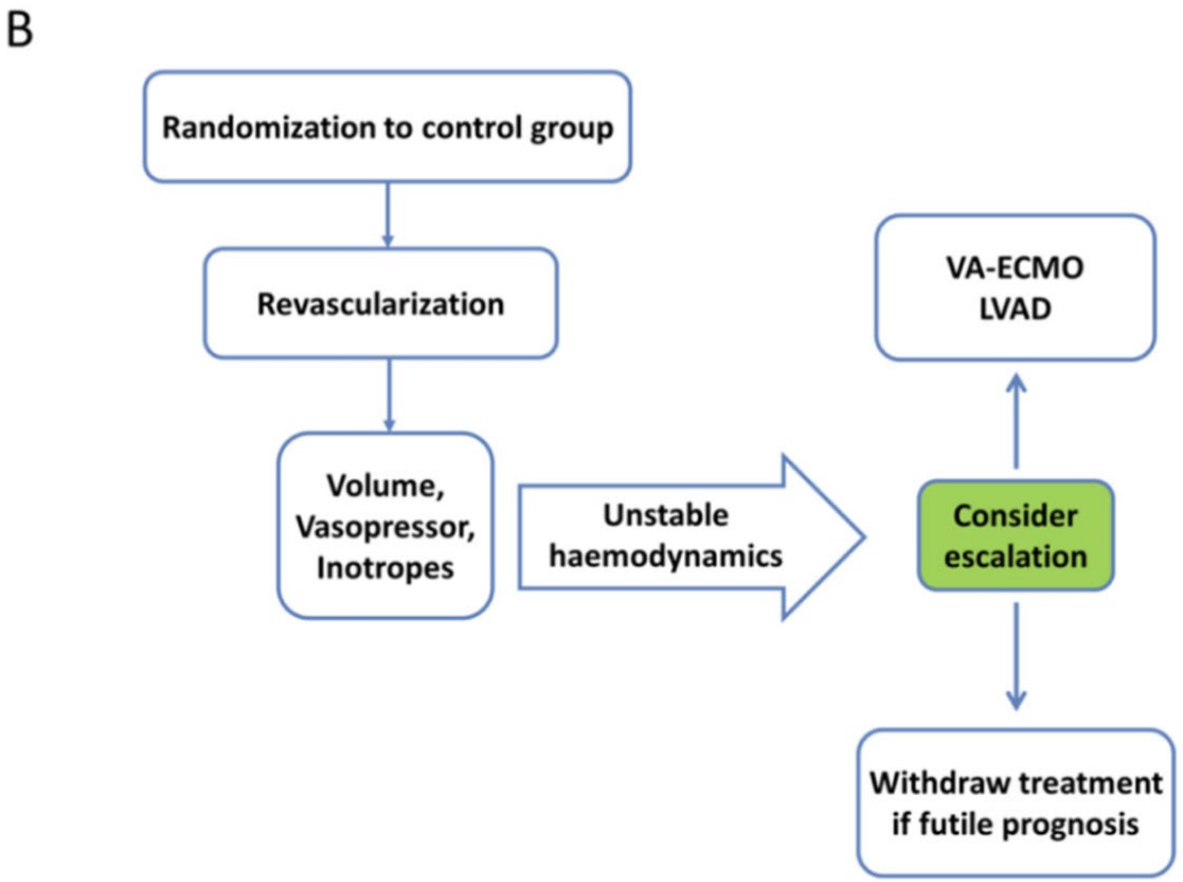


Thiele H et al. NEJM 2023

DanGer Shock Trial in STEMI-Shock: First to Test Algorithms of Care

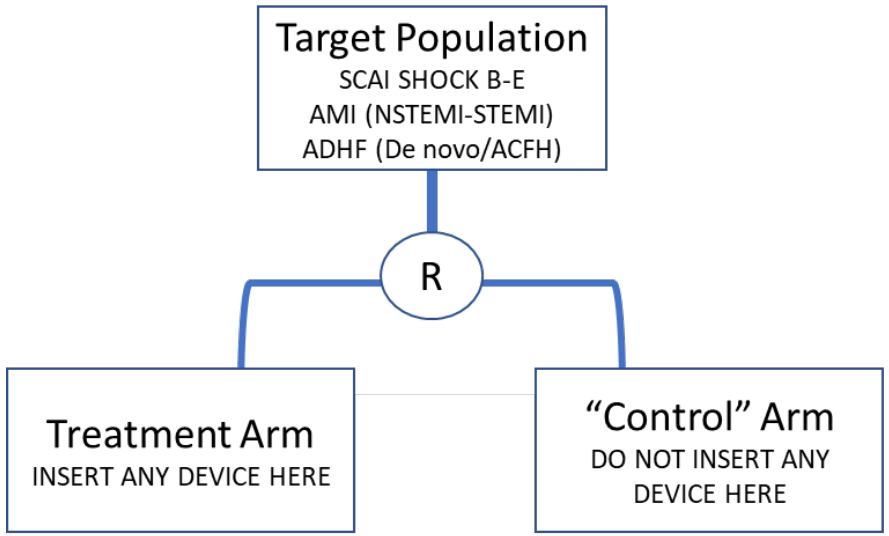
Enrollment Complete! Results in Early 2024 (6-month Endpoint)

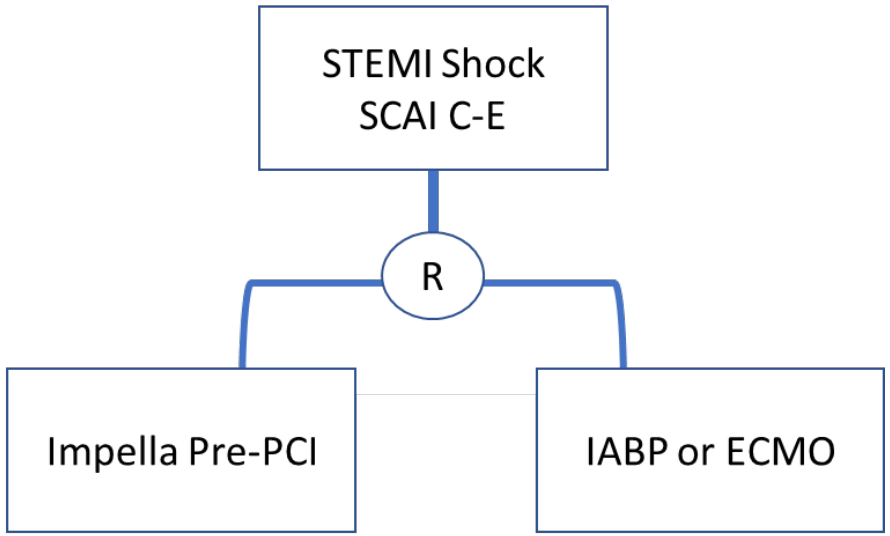




Udesen et al Am H J 2019

Objective: To Generate Class IA Recommendations for AMI-CS

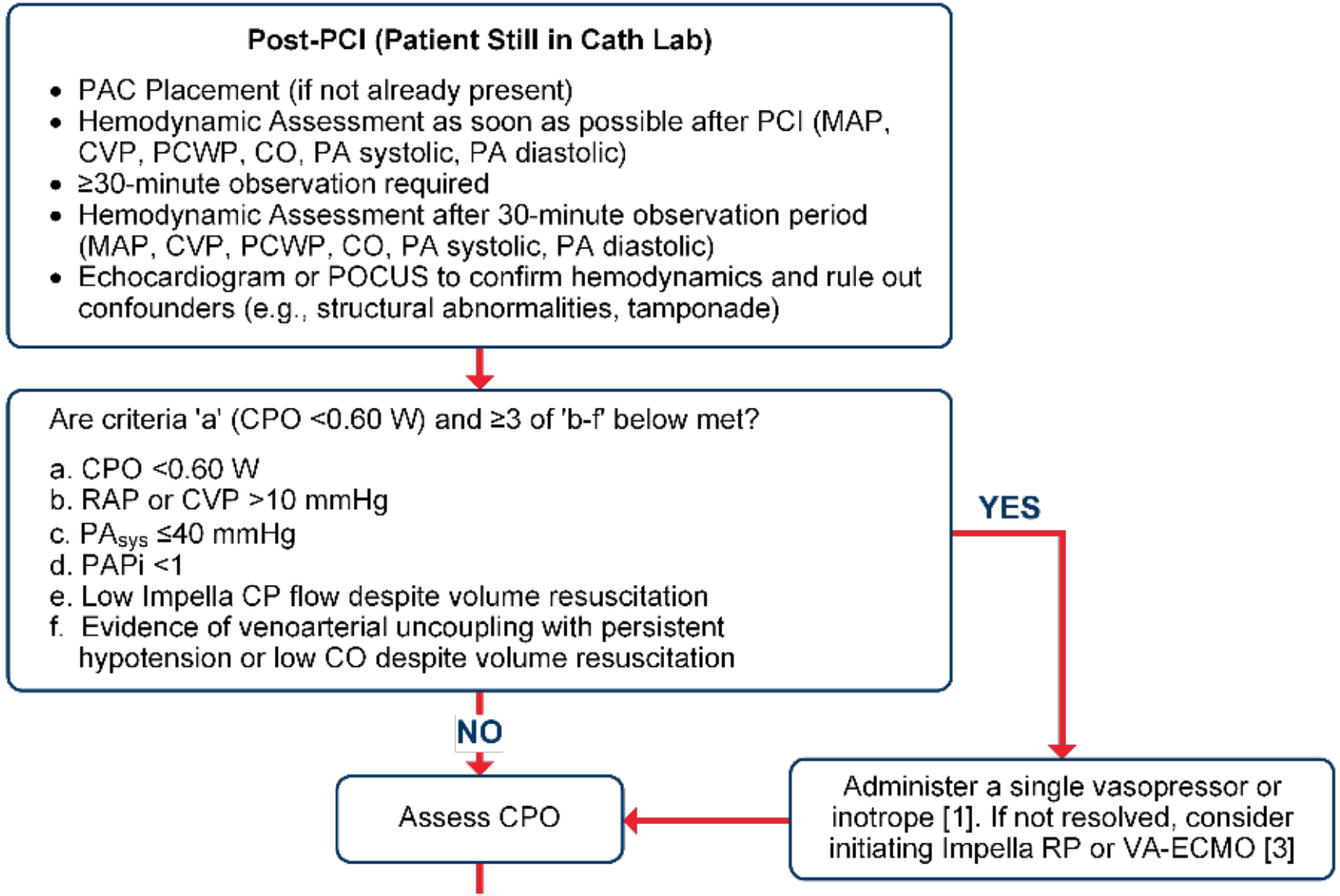




Hemodynamic Assessment? Limb Protection Plan?	Protocolized
Device Escalation: No Data-Supported Algorithm	Protocolized
Management Targets vs Optimizing the Current SOC?	Protocolized
Device De-Escalation: No Data-Supported Algorithm	Protocolized
Device Explant: No Data-Supported Approach	Protocolized
What's your Anticipated Treatment Effect?	30 Day Mortality : 13.5% Treatment Effect

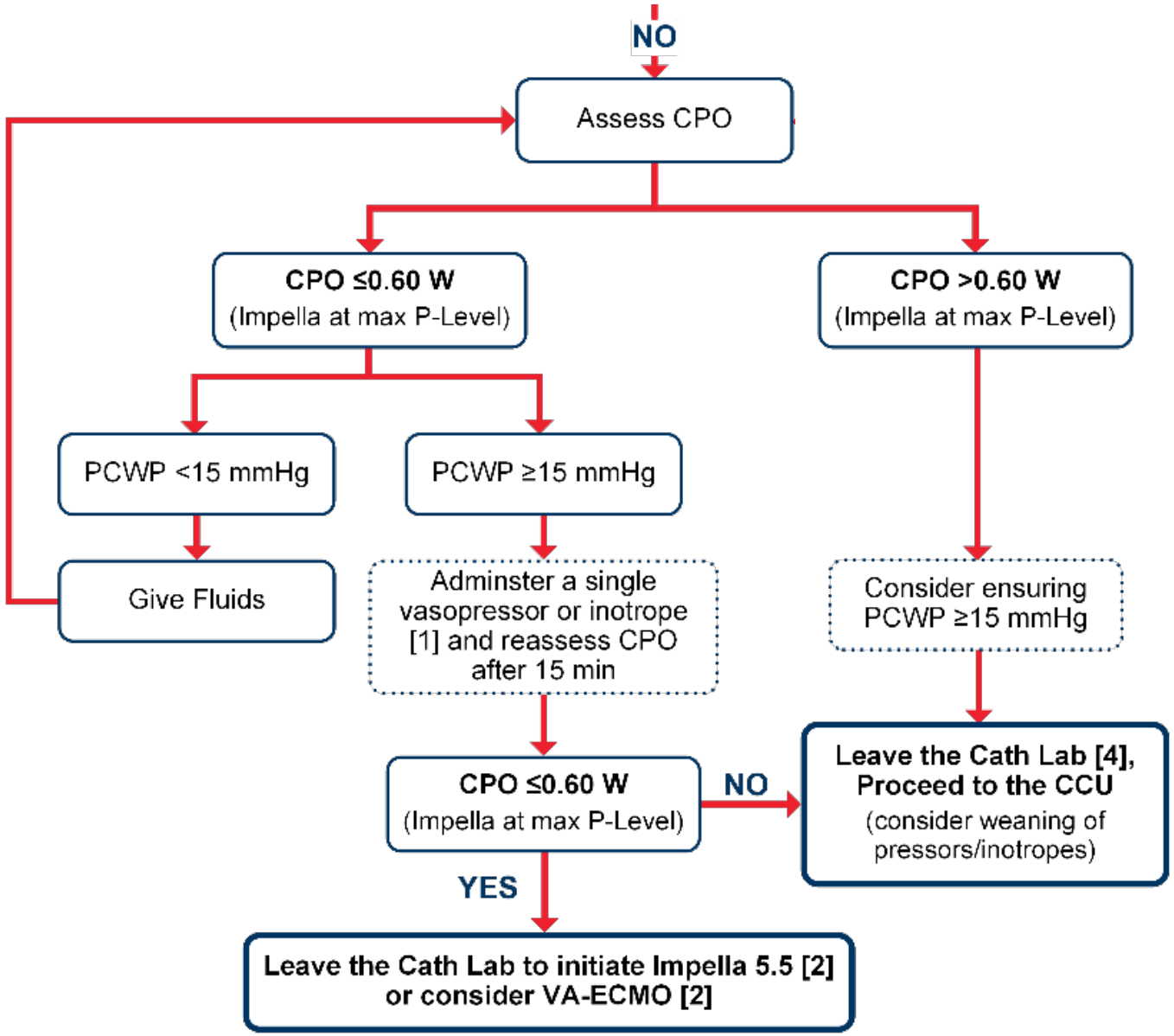
Kapur Lab

A Unique In-Cath Lab Escalation Assessment Algorithm (Impella Arm)



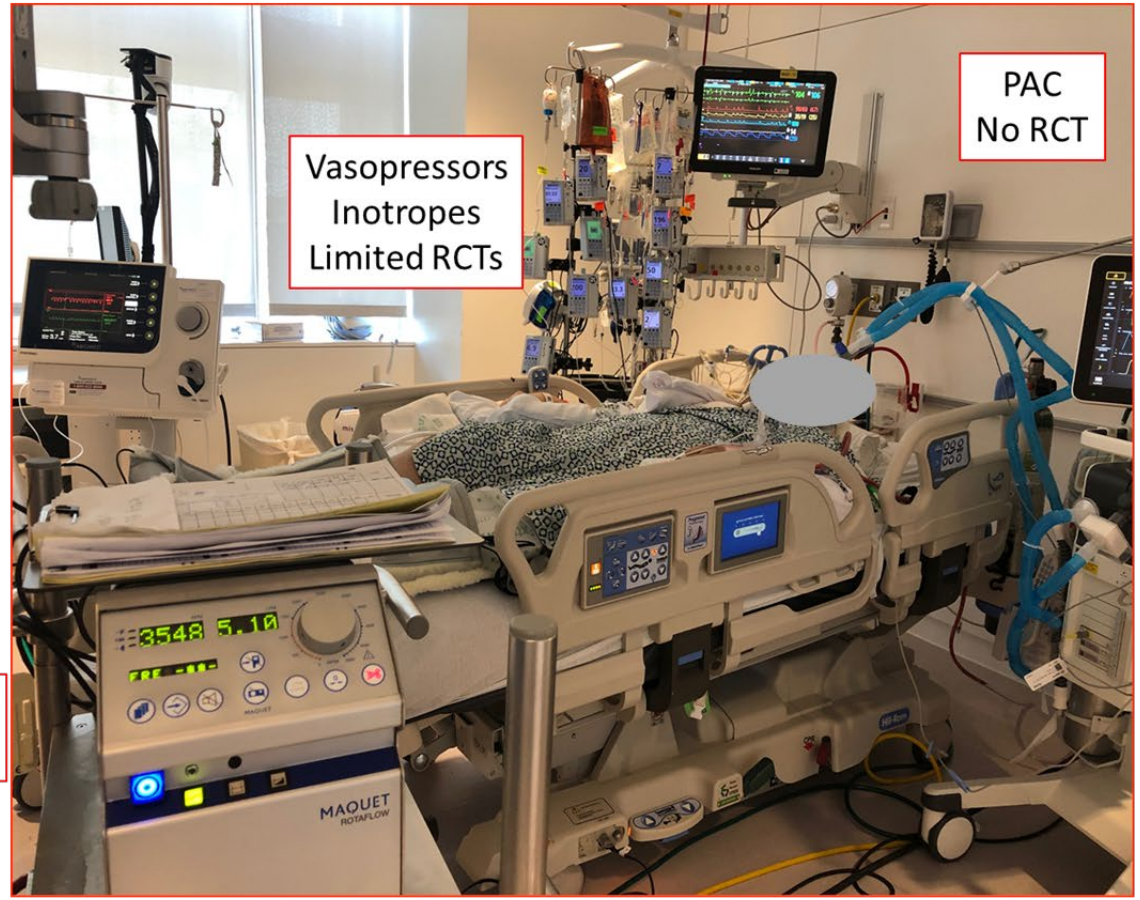
RECOVER IV

A Unique In-Cath Lab Escalation Assessment Algorithm (Impella Arm)



RECOVER IV

Cardiogenic Shock Remains one of the Highest Mortality Conditions



To Change This Fact We Must Rigorously Pursue Data and

Be Willing to Randomize in PACCS, STEMI-DTU, RECOVER IV

LV Unloading in Acute MI Complicated by Shock
Is there Equipoise in STEMI-Shock Management?

Thank you

nkapur@tuftsmedicalcenter.org
@navinkapur4

Tufts Medical Center
The CardioVascular Center

The Cardiogenic Shock Working Group

MCRI20
Molecular Cardiology Research Institute

Tufts CTSI
Tufts Clinical and Translational Science Institute