SHOCK 2.0: WHERE ARE WE TODAY?

Northwell Health 9th Annual Reimagining Heart Failure Care Symposium

April 17, 2026

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Interventional Heart Failure
Staten Island University Hospital – Northwell Health

Northwell Health®

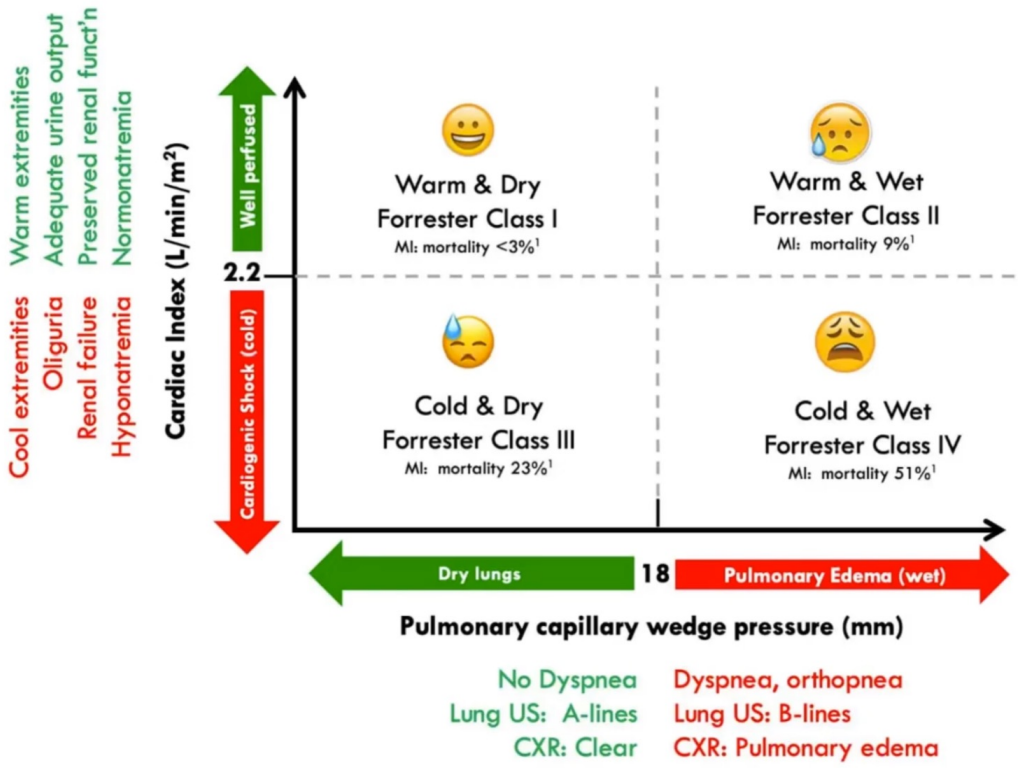
DISCLOSURES

I have no relevant financial interests or relationships to disclose

1. Explore cardiogenic shock of the past
2. Examine the practice of cardiogenic shock in the 21st century
3. Explore opportunities for innovation cardiogenic shock going forward

CARDIOGENIC SHOCK OF THE PAST

Congestion



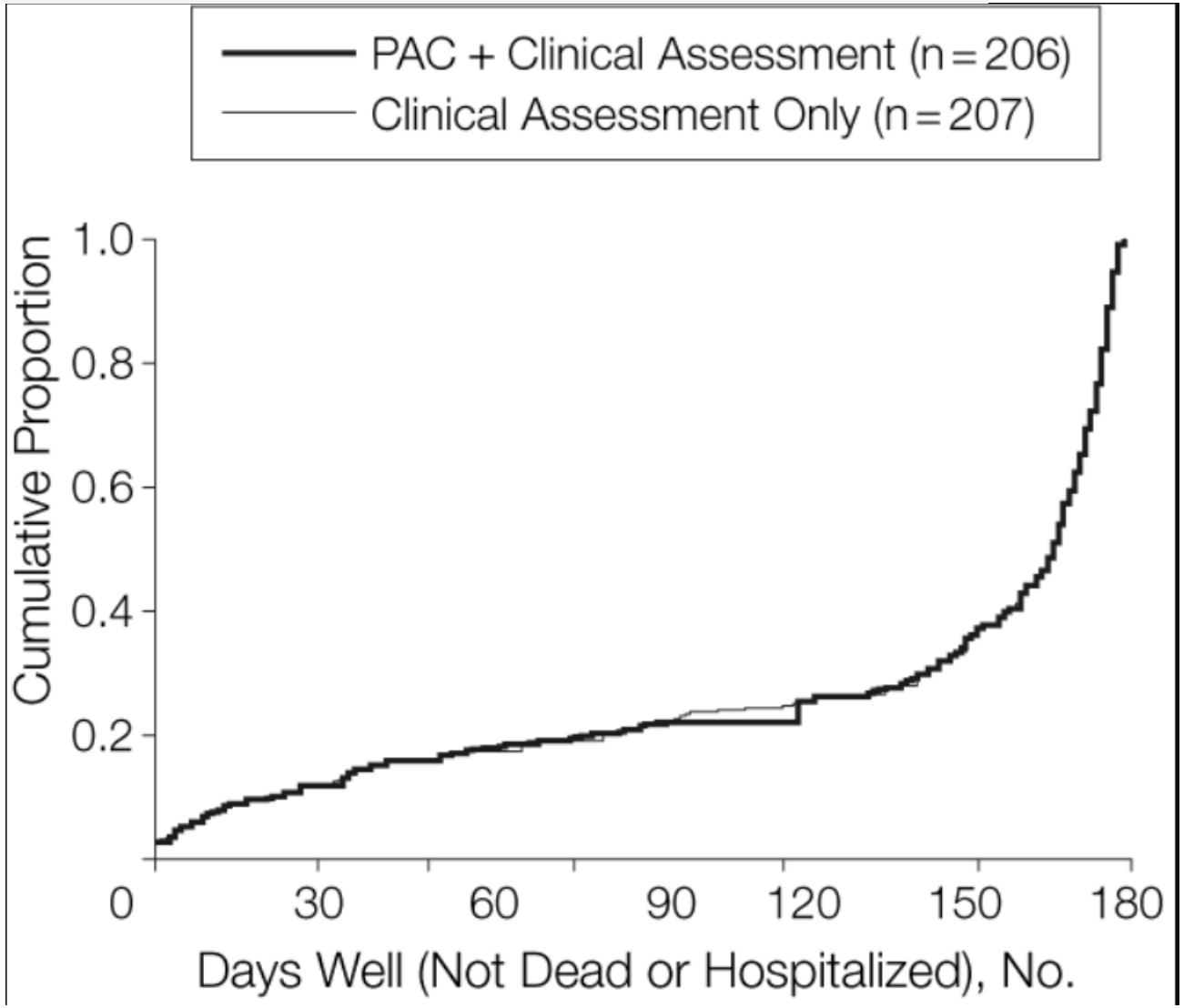
Hypotension

Clinical Definition	SHOCK Trial[9]*	IABP-SHOCK II[1]†	ESC HF Guidelines[15]
Cardiac disorder that results in both clinical and biochemical evidence of tissue hypoperfusion	Clinical criteria: SBP <90 mm Hg for ≥30 min OR Support to maintain SBP ≥90 mm Hg AND End-organ hypoperfusion (urine output <30 mL/h or cool extremities)Hemodynamic criteria: CI of ≤2.2 $L \cdot min^{-1} \cdot m^{-2}$ AND PCWP ≥15 mm Hg	Clinical criteria: SBP <90 mm Hg for ≥30 min OR Catecholamines to maintain SBP >90 mm Hg AND Clinical pulmonary congestion AND Impaired end-organ perfusion (altered mental status, cold/clammy skin and extremities, urine output <30 mL/h, or lactate >2.0 mmol/L)	SBP <90 mm Hg with adequate volume and clinical or laboratory signs of hypoperfusionClinical hypoperfusion: Cold extremities, oliguria, mental confusion, dizziness, narrow pulse pressureLaboratory hypoperfusion: Metabolic acidosis, elevated serum lactate, elevated serum creatinine

Evaluation Study of Congestive Heart Failure and Pulmonary Artery Catheterization Effectiveness

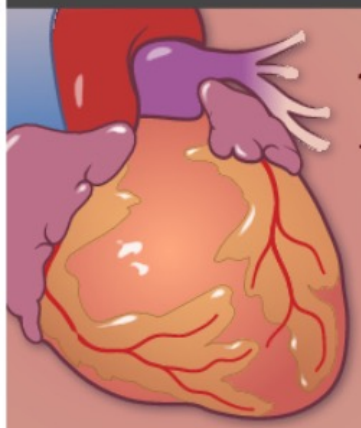
The ESCAPE Trial

The ESCAPE Investigators and ESCAPE Study Coordinators*



Milrinone vs. Dobutamine in Cardiogenic Shock

DOUBLE-BLIND, RANDOMIZED TRIAL



192

Patients admitted to the cardiac ICU with cardiogenic shock

	Milrinone N=96	Dobutamine N=96
In-hospital death from any cause, TIA, stroke, or cardiovascular or renal events	49% (47 patients)	54% (52 patients)

Relative risk, 0.90; 95% CI, 0.69–1.19; P=0.47

No between-group difference was observed in the primary composite outcome or in important secondary outcomes.

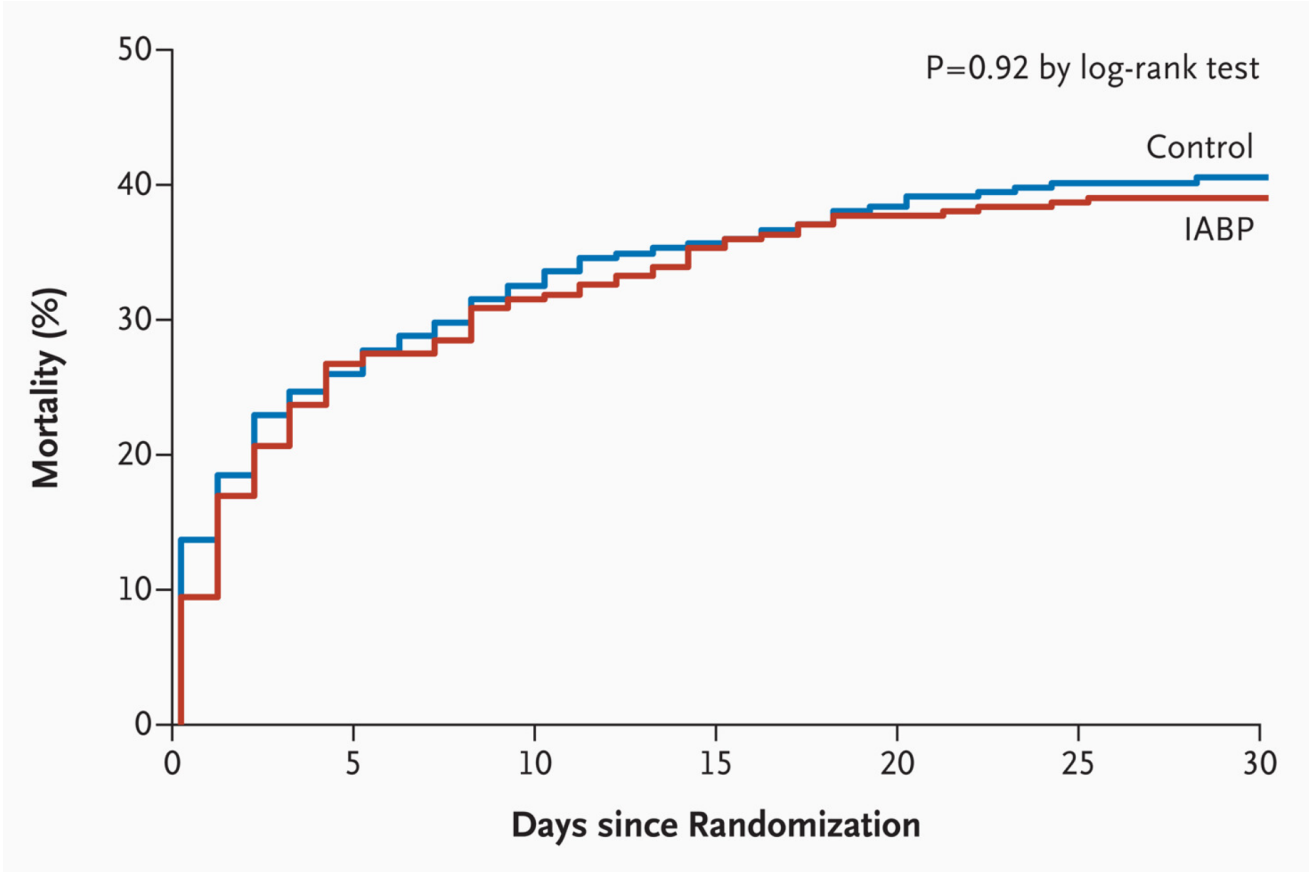
R. Mathew et al. 10.1056/NEJMoa2026845

Intraaortic Balloon Support for Myocardial Infarction with Cardiogenic Shock

The NEW ENGLAND JOURNAL of MEDICINE

Authors: Holger Thiele, M.D., Uwe Zeymer, M.D., Franz-Josef Neumann, M.D., Miroslaw Ferenc, M.D., Hans-Georg Olbrich, M.D., Jörg Hausleiter, M.D., Gert Richardt, M.D., +12 , for the IABP-SHOCK II Trial Investigators* Author Info & Affiliations

Published October 4, 2012 | N Engl J Med 2012;367:1287-1296 | DOI: 10.1056/NEJMoa1208410 | VOL. 367 NO. 14



Extracorporeal Life Support in Infarct-Related Cardiogenic Shock

Authors: Holger Thiele, M.D. , Uwe Zeymer, M.D., Ibrahim Akin, M.D., Michael Behnes, M.D., Tienush Rassaf, M.D., Amir Abbas Mahabadi, M.D., Ralf Lehmann, M.D., +28 , for the ECLS-SHOCK Investigators* Author Info & Affiliations

Published August 26, 2023 | N Engl J Med 2023;389:1286-1297 | DOI: 10.1056/NEJMoa2307227
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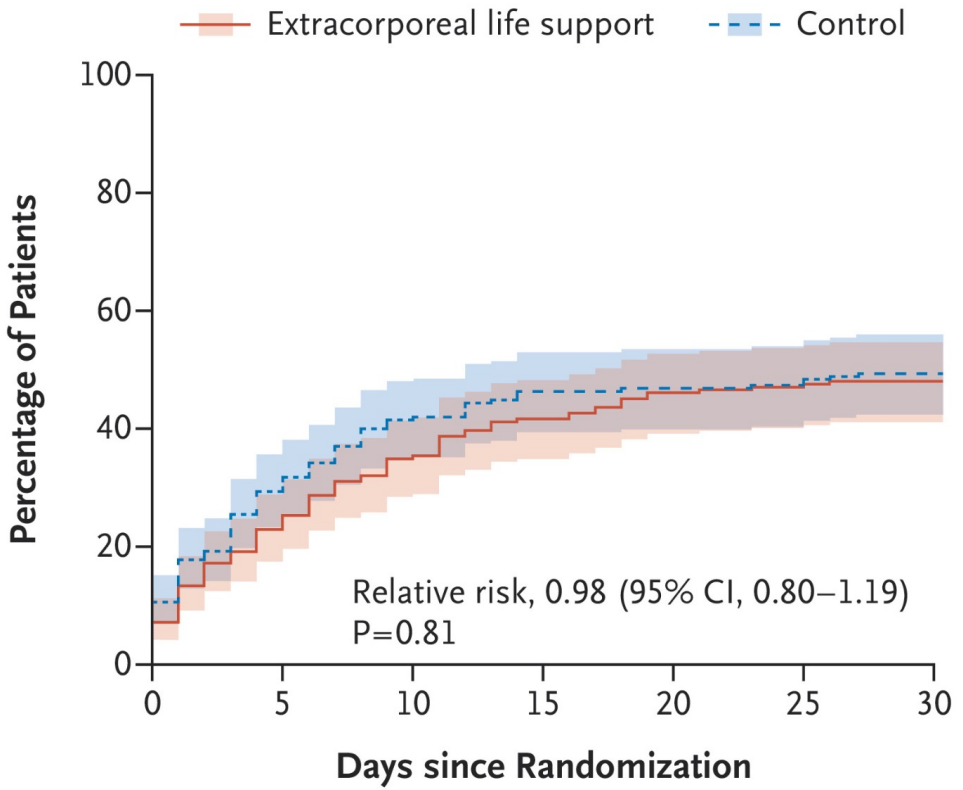


No. at Risk

Control	208	146	120	109	105	104	100
Extracorporeal life support	209	161	136	119	109	107	105

JACC VOL. 85, NO. 16, 2025

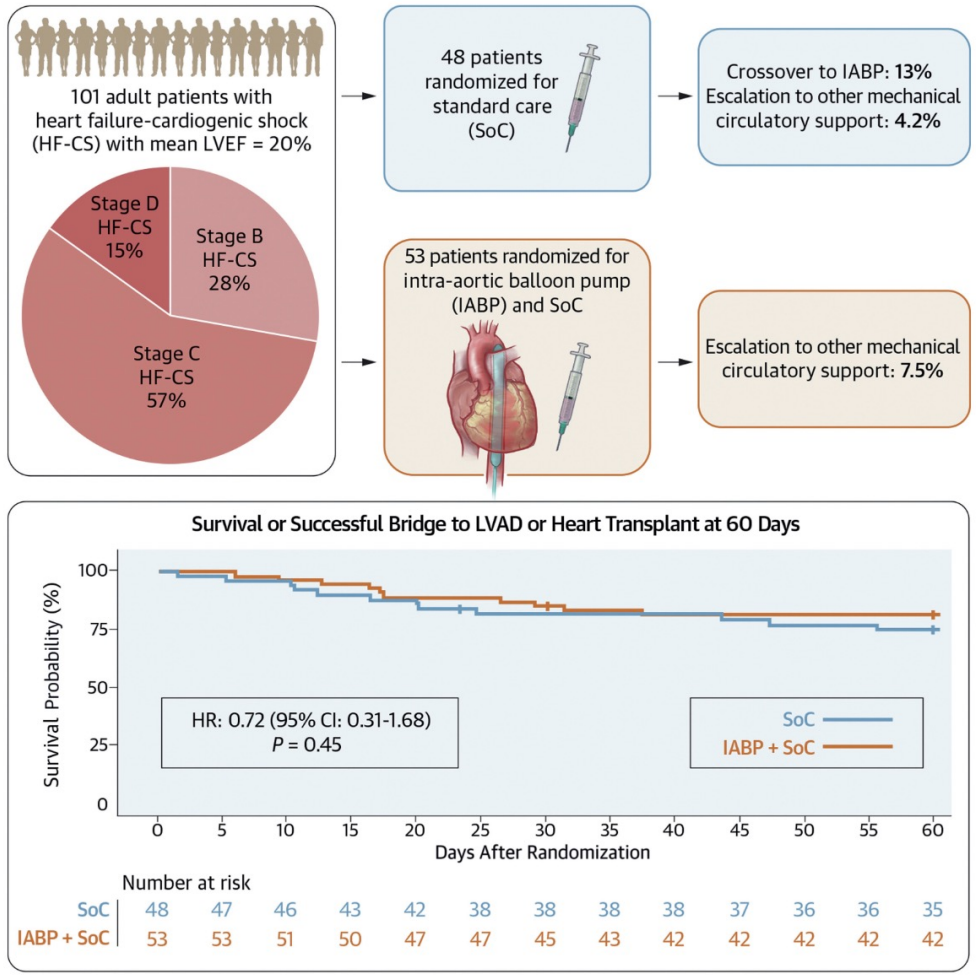
ORIGINAL RESEARCH

Early Intra-Aortic Balloon Support for Heart Failure-Related Cardiogenic Shock

A Randomized Clinical Trial

Nuccia Morici, MD, PhD,[a] Alice Sacco, MD,[b] Simone Frea, MD,[c] Matteo Rota, PhD,[d] Luca Villanova, MD,[b] Carol Gravinese, MD,[c] Carlotta Sorini Dini, MD,[e] Nicoletta D'Ettore, MD,[f] Giulia Maj, MD,[f] Giulia De Lio, MD,[c] Luciano Potena, MD,[g] Serafina Valente, MD,[e] Mario Sabatino, MD,[g] Giovanna Viola, MD,[b] Laura Garatti, MD,[b] Giovanni Amedeo Tavecchia, MD,[b] Letizia Bertoldi, MD,[h] Fabrizio Oliva, MD,[b] Navin K. Kapur, MD,[i] Guido Tavazzi, MD,[j,k] Gaetano Maria De Ferrari, MD,[c] Federico Pappalardo, MD,[l] the Altshock-2 Investigators

CENTRAL ILLUSTRATION: Early Intra-Aortic Balloon Pump in Heart Failure Complicated by Cardiogenic Shock



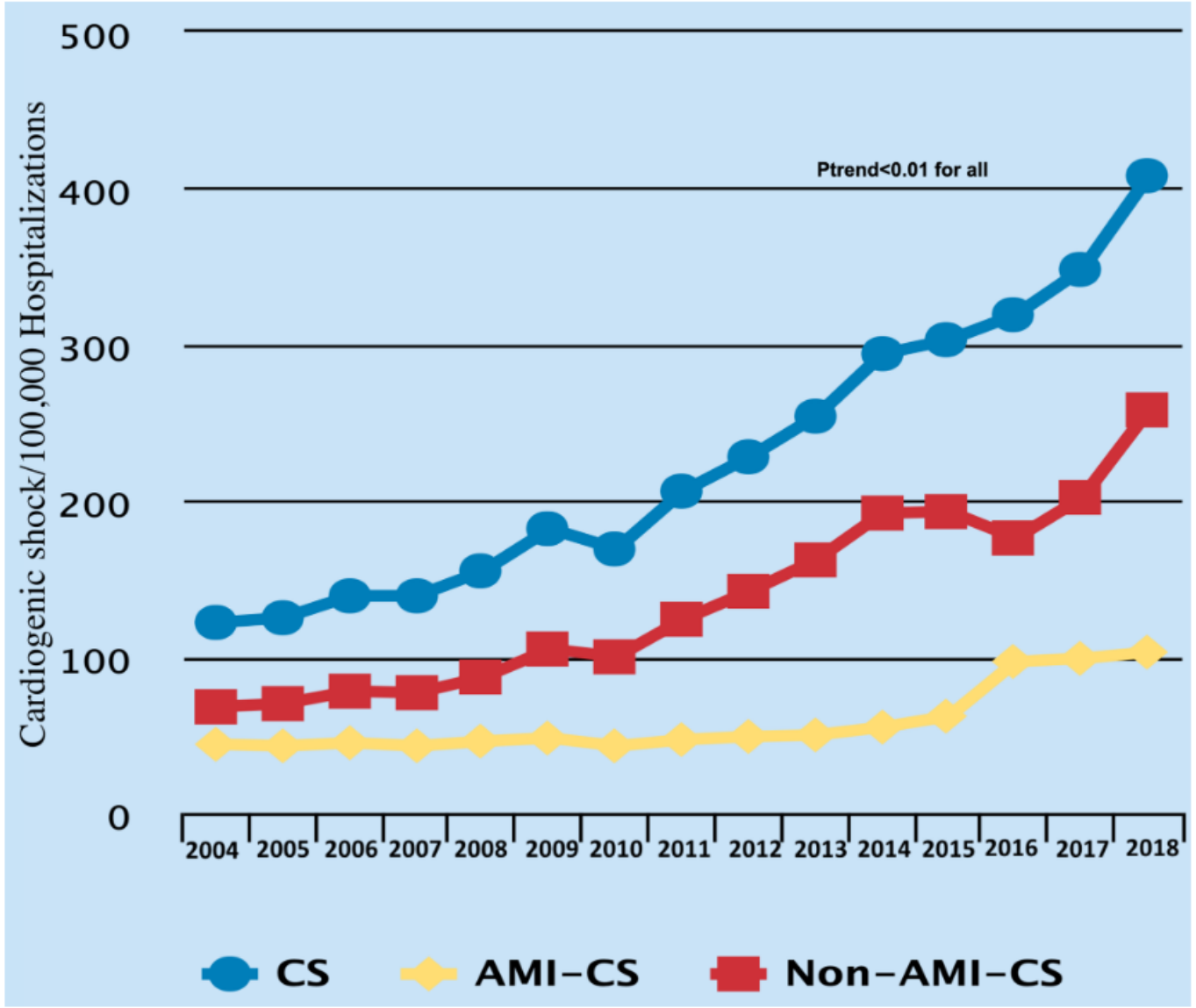
The routine early use of IABP plus standard care, compared to standard care alone, did not result in significantly better survival or successful bridge to LVAD or heart transplantation in patients with HF-CS.

Morici N, et al. JACC. 2025;85(16):1587-1597.

CHATGPT

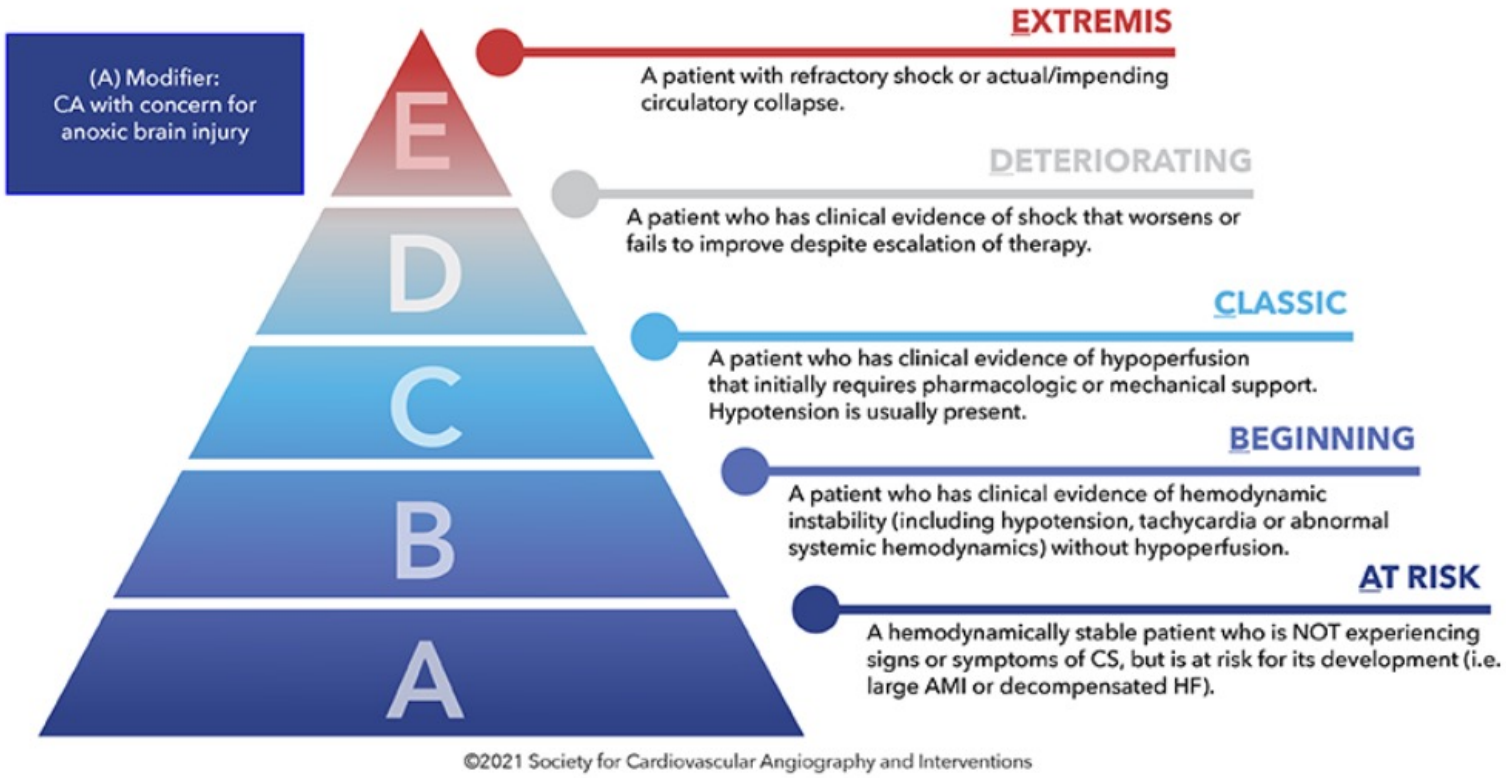
Trial	Year	Population	Intervention vs Control	Primary Outcome	Key Result
IABP-SHOCK II	2012	AMI-CS + early revascularization	IABP vs no IABP	30-day mortality	No benefit (40% vs 41%)
IMPRESS in Severe Shock	2017	Severe AMI-CS (high CPR rates)	Impella CP vs IABP	30-day mortality	No difference (50% vs 46%)
ECLS-SHOCK	2023	AMI-CS	Early VA-ECMO vs standard care	30-day mortality	No reduction; ↑ bleeding/limb ischemia
EURO SHOCK	2023	AMI-CS	VA-ECMO vs standard care	30-day mortality	Neutral (underpowered)
DANSHOCK	2024	AMI-CS	VA-ECMO vs standard care	30-day mortality	No mortality benefit
LV unloading + ECMO (pilot RCTs)	2020s	AMI-CS on ECMO	LV venting vs none	Feasibility/mortality	No clear mortality benefit (small trials)

CARDIOGENIC SHOCK IS HERE TO STAY

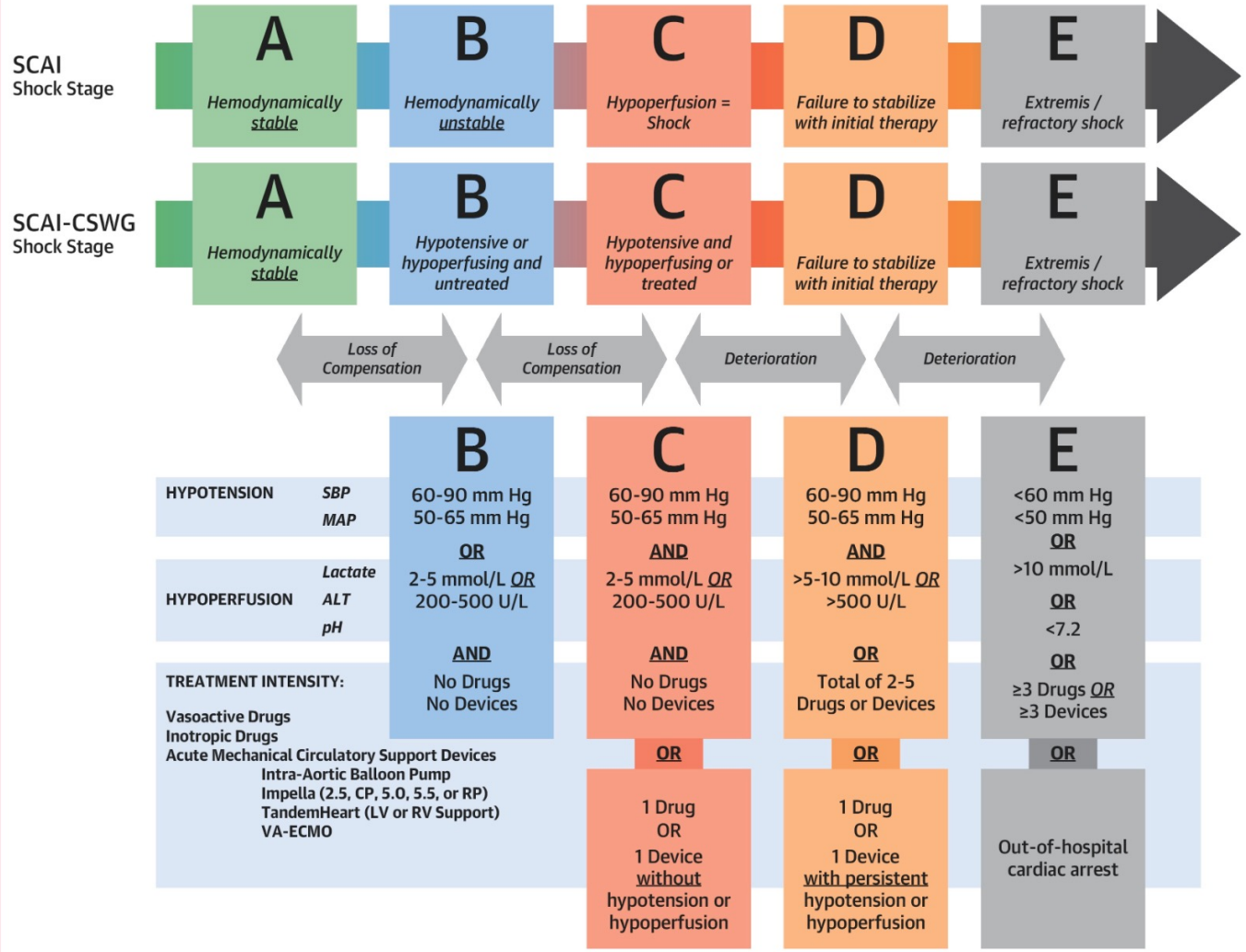


WHAT ARE WE TO DO?

IDENTIFY THE PROBLEM



CENTRAL ILLUSTRATION: Clinical Variables and Parameters to Define Society for Cardiovascular Angiography and Interventions Stages



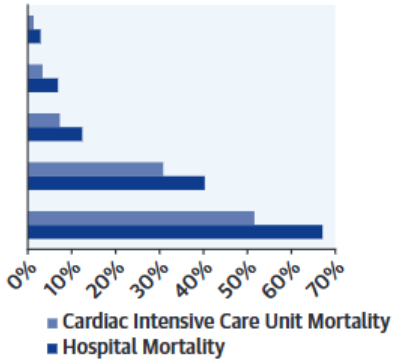
Kapur NK, et al. J Am Coll Cardiol. 2022;80(3):185-198.

SCAI STAGING APPLIES TO REAL WORLD

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

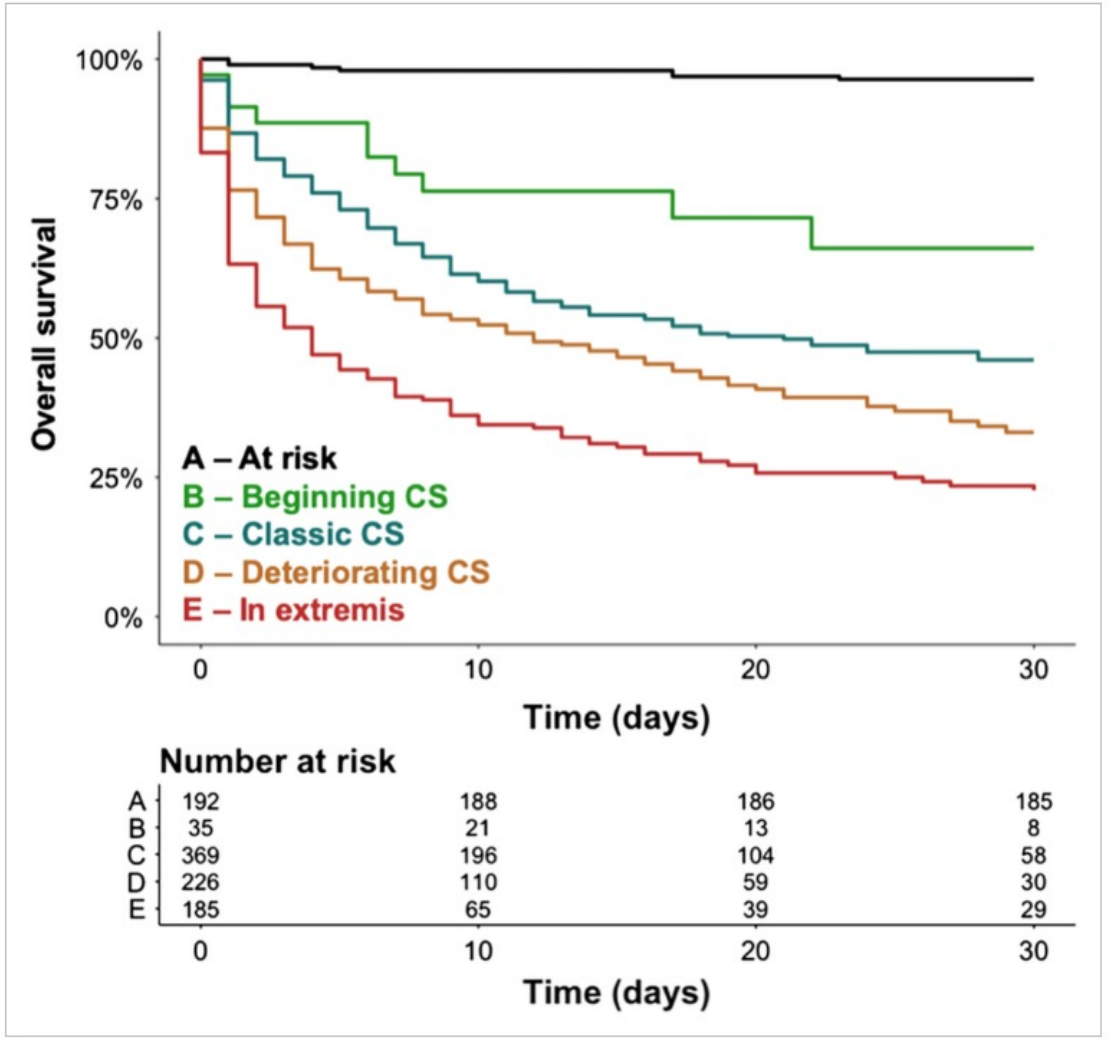
Cardiogenic Shock Stage	Study Definition
Stage A ("At risk")	Neither hypotension/tachycardia nor hypoperfusion
Stage B ("Beginning")	Hypotension/tachycardia WITHOUT hypoperfusion
Stage C ("Classic")	Hypoperfusion WITHOUT deterioration
Stage D ("Deteriorating)"	Hypoperfusion WITH deterioration NOT refractory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

Observed Mortality in Overall Cohort

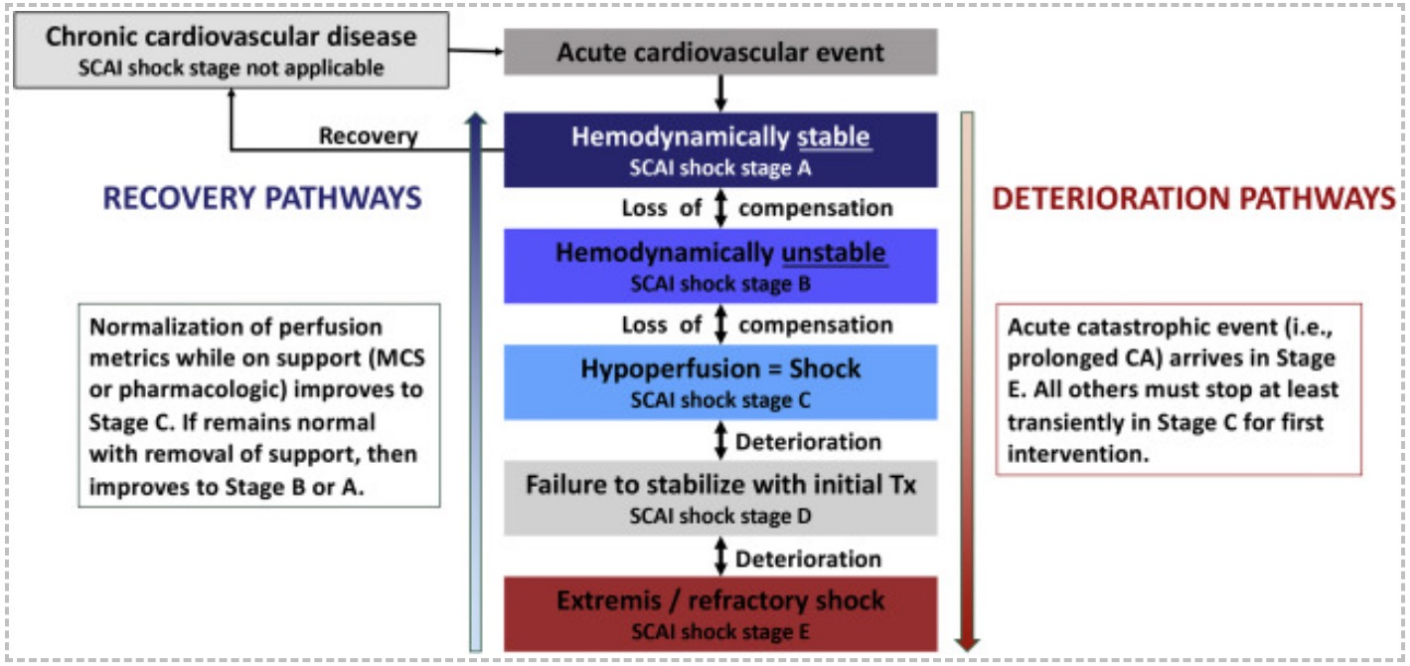


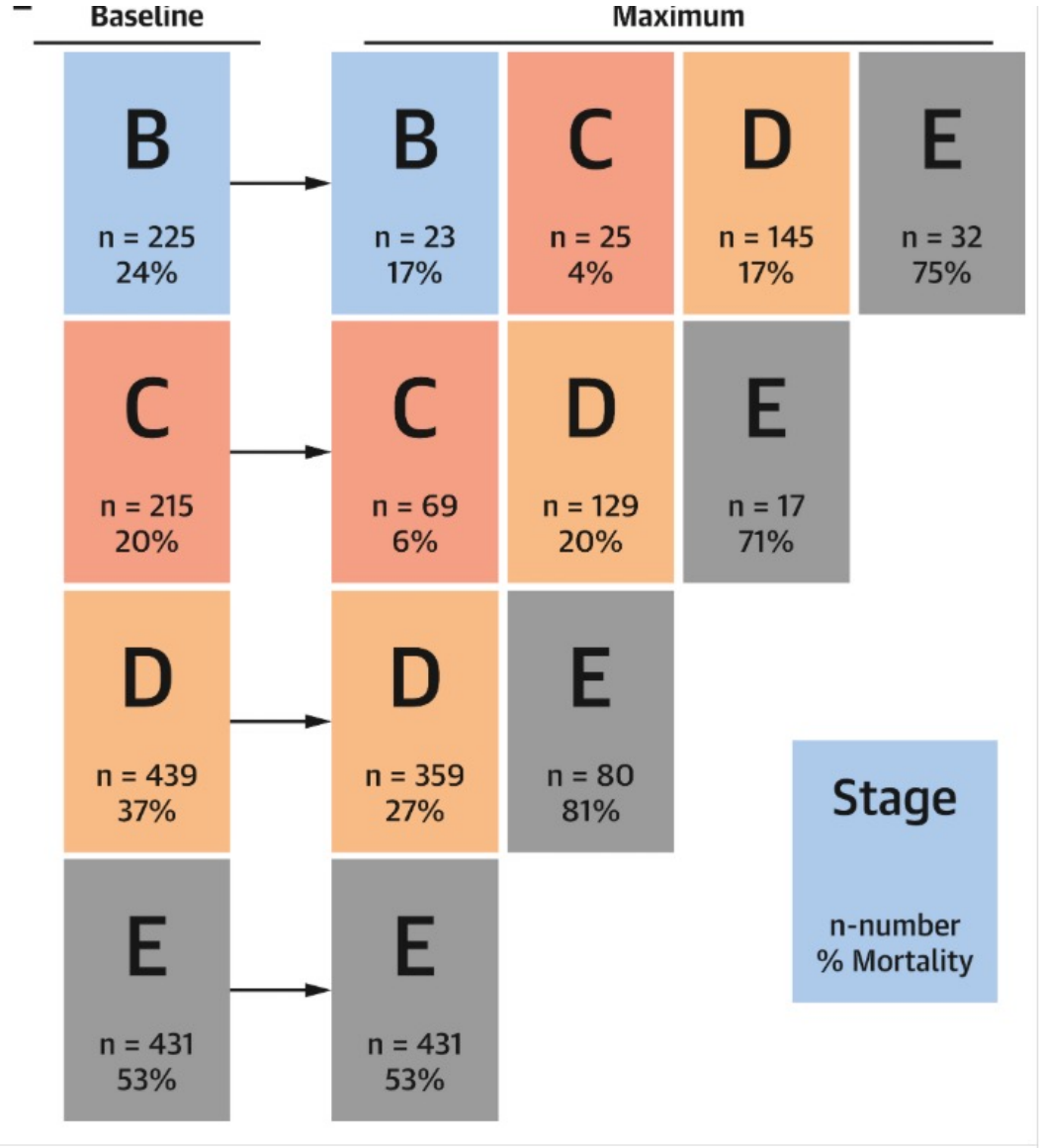
Jentzer, J.C. et al. J Am Coll Cardiol. 2019;74(17):2117-28.

Cardiac intensive care unit and hospital mortality increased as a function of higher Society for Cardiovascular Angiography and Intervention shock stage.



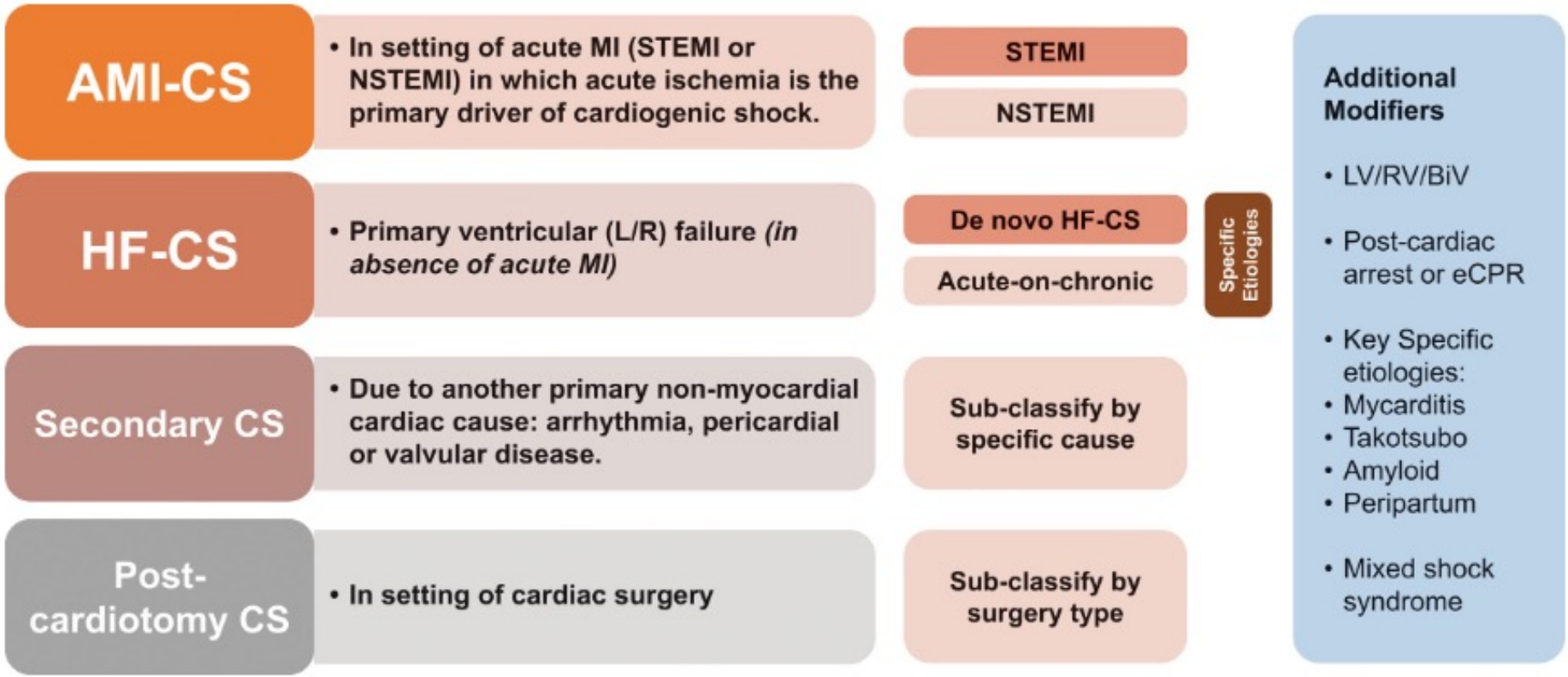
CARDIOGENIC SHOCK IS FLUID



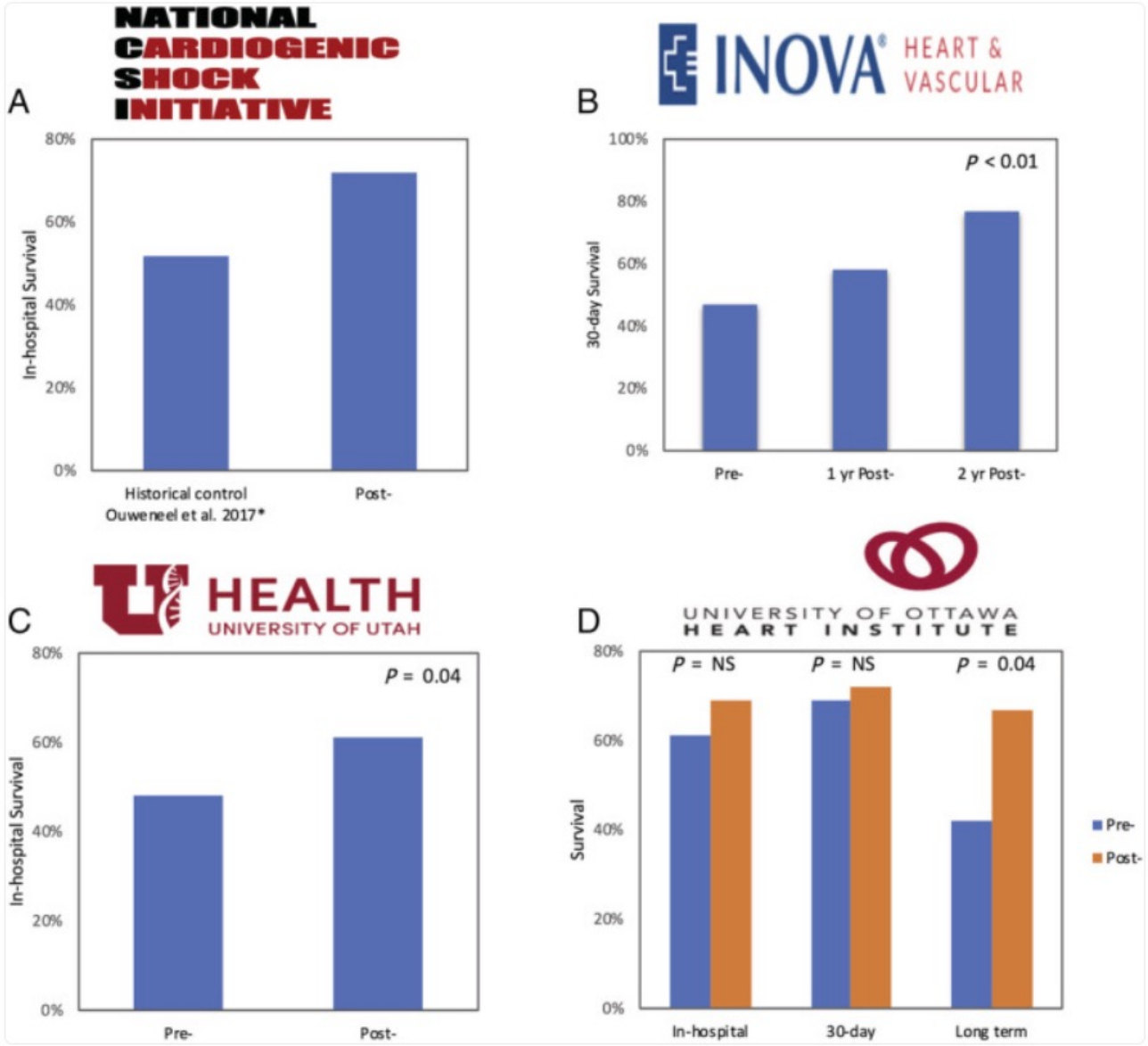


Kapur et al. JACC 2022

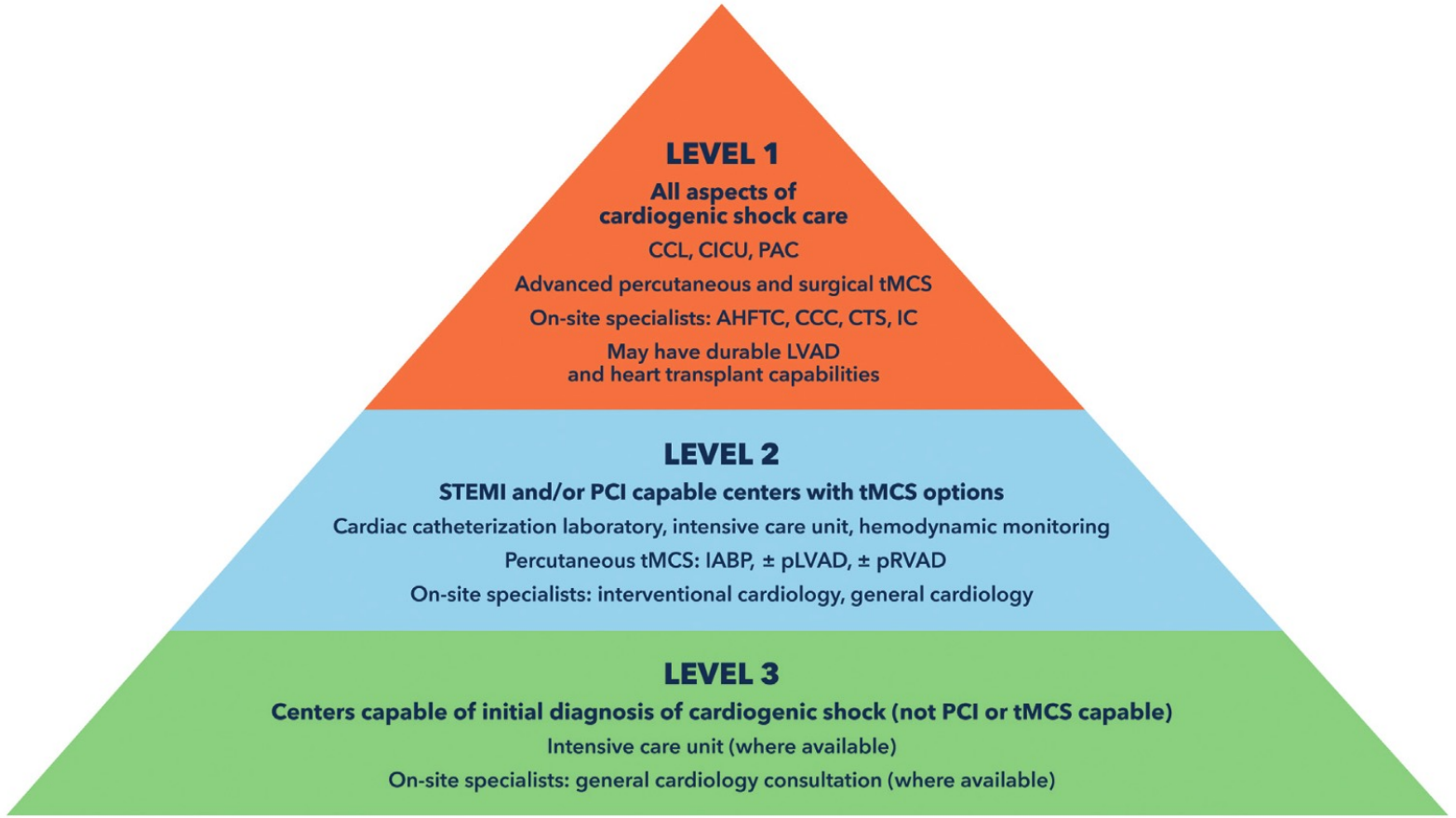

Teamwork
makes the
Dream work


AMI-CS
• In setting of acute MI (STEMI or NSTEMI) in which acute ischemia is the primary driver of cardiogenic shock.
STEMI
NSTEMI
HF-CS
• Primary ventricular (L/R) failure (in absence of acute MI)
De novo HF-CS
Acute-on-chronic
Specific Etiologies
Secondary CS
• Due to another primary non-myocardial cardiac cause: arrhythmia, pericardial or valvular disease.
Sub-classify by specific cause
Post-cardiotomy CS
• In setting of cardiac surgery
Sub-classify by surgery type
Additional Modifiers
• LV/RV/BiV
• Post-cardiac arrest or eCPR
• Key Specific etiologies:
• Mycarditis
• Takotsubo
• Amyloid
• Peripartum
• Mixed shock syndrome

AVENGERS ASSEMBLE



HUB AND SPOKE



National Cardiogenic Shock Initiative Algorithm

Inclusion Criteria

Acute Myocardial Infarction: STEMI or NSTEMI
- Ischemic Symptoms
- EKG and/or biomarker evidence of AMI (STEMI or NSTEMI)

Cardiogenic Shock
- Hypotension (<90/60) or the need for vasopressors or inotropes to maintain systolic blood pressure >90
- Evidence of end organ hypoperfusion (cool extremities, oliguria, lactic acidosis)

Exclusion Criteria
- Evidence of Anoxic Brain Injury
- Unwitnessed out of hospital cardiac arrest or any cardiac arrest in which ROSC is not achieved in 30 minutes
- IABP placed prior to Impella
- Septic, anaphylactic, hemorrhagic, and neurologic causes of shock
- Non-ischemic causes of shock/hypotension *(Pulmonary Embolism, Pneumothorax, Myocarditis, Tamponade, etc.)*
- Active Bleeding
- Recent major surgery
- Mechanical Complications of AMI
- Known left ventricular thrombus
- Patient who did not receive revascularization
- Contraindication to intravenous systemic anticoagulation
- Mechanical aortic valve

ACTIVATE CATH LAB

Access & Hemodynamic Support
- Obtain femoral arterial access (via direct visualization with use of ultrasound and fluoro)
- Obtain venous access (Femoral or Internal Jugular)
- Obtain either Fick calculated cardiac index or LVEDP

IF LVEDP >15 *or* Cardiac Index < 2.2 AND anatomy suitable, place IMPELLA

Coronary Angiography & PCI
- Attempt to provide TIMI III flow in all major epicardial vessels other than CTO
- If unable to obtain TIMI III flow, consider administration of intra-coronary vasodilators

Perform Post-PCI Hemodynamic Calculations

1. Cardiac Power Output (CPO): $\frac{\text{MAP x CO}}{451}$
2. Pulmonary Artery Pulsatility Index (PAPI): $\frac{\text{sPAP – dPAP}}{\text{RA}}$

Wean OFF Vasopressors and Inotropes

If CPO is >0.6 and PAPI >0.9, operators should wean vasopressors and inotropes and determine if Impella can be weaned and removed in the Cath Lab or left in place with transfer to ICU.

Escalation of Support

If CPO remains <0.6 operators should consider the following options:
- PAPI is <0.9 consider right sided hemodynamic support
- PAPI >0.9 consideration for additional hemodynamic support

Local practice patterns should dictate the next steps:
- Placement of more robust MCS device(s)
- Transfer to LVAD/Transplant center

If CPO is >0.6 and PAPI <0.9 consider providing right sided hemodynamic support if clinical suspicion for RV dysfunction/failure

Vascular Assessment
- Prior to discharge from the Cath Lab, a detailed vascular exam should be performed including femoral angiogram and Doppler assessment of the affected limb.
- If indicated, external bypass should be performed.

ICU Care
- Daily hemodynamic assessments should be performed, including detailed vascular assessment
- Monitor for signs of hemolysis and adjust Impella position as indicated

Device Weaning

Impella should only be considered for explantation once the following criteria are met:
- Weaning off from all inotropes and vasopressors
- CPO >0.6, and PAPI > 0.9

Bridge to Decision

Patients who do not regain myocardial recovery within 3-5 days, as clinically indicated, should be transferred to an LVAD/Transplant center. If patients are not candidates, palliative care options should be considered.

**** QUALITY MEASURES ****
- Impella Pre-PCI
- Door to Support Time < 90 minutes
- Establish TIMI III Flow
- Right Heart Cath
- Wean off Vasopressors & Inotropes
- Maintain CPO >0.6 Watts
- Improve survival to discharge to >80%

NATIONAL CARDIOGENIC SHOCK INITIATIVE

NationalCSI@hfhs.org

www.henryford.com/cardiogenicshock

NationalCSI – Algorithm – v1.4 – 10/2017

INOVA HEART AND VASCULAR INSTITUTE

Cardiogenic Shock Team Management

Call 703-776-5905 to activate Heart Team

Serial Assessment q4hr x 24hrs
- Lactate
- Fick CO/CI
- CPO and PAPi
- Continuous hemodynamics

***and* if PMCS:**
- LDH & Haptoglobin
- Neurovascular checks
- Limited Echo daily
- IVF to keep RA >10, PCWP >12

***Criteria for Refractory Shock**
- Lactate > 3
- UOP < 30cc/hr
- CPO < 0.6
- Increasing pressor requirement
- Evidence of organ hypo-perfusion

Criteria for RV Dysfunction
- PAPi < 1.0
- RA > 15mmHg
- RA/PCWP ratio > 0.63

CPO = MAP x CO/451
PAPi = (sPAP-dPAP)/RA

Revised March 6, 2019

Cardiogenic Shock Management in the CICU
- Wean vasopressors/inotropes
- Early escaation for refractory shock
- Heart recovery

Is there Refractory Shock?*

YES

Bi-V CS
CPO < 0.6
PAPi < 1.0
RA > 15
PCWP > 15

Hypoxemia?
- YES → TH + Oxygenator or VA-ECMO + LV vent
- NO → Bi-Pella or TH/Protek-Duo

LV-dominant CS
CPO < 0.6
PAPi > 1.0
RA < 15
PCWP > 15

Hypoxemia?
- YES → TH + Oxygenator or VA-ECMO + LV vent
- NO → Impella CP or Impella 5.0

RV-dominant CS
CPO < 0.6
PAPi < 1.0
RA > 15
PCWP < 15

Hypoxemia?
- YES → TH + Oxygenator or VA-ECMO +/- LV vent
- NO → Impella RP or ProtekDuo

NO
CPO > 0.6
PAPi > 1.5
RA < 15
PCWP < 15

→ Wean PMCS and Assess for heart recovery

Tehrani, Truesdale, and Sinha et al.

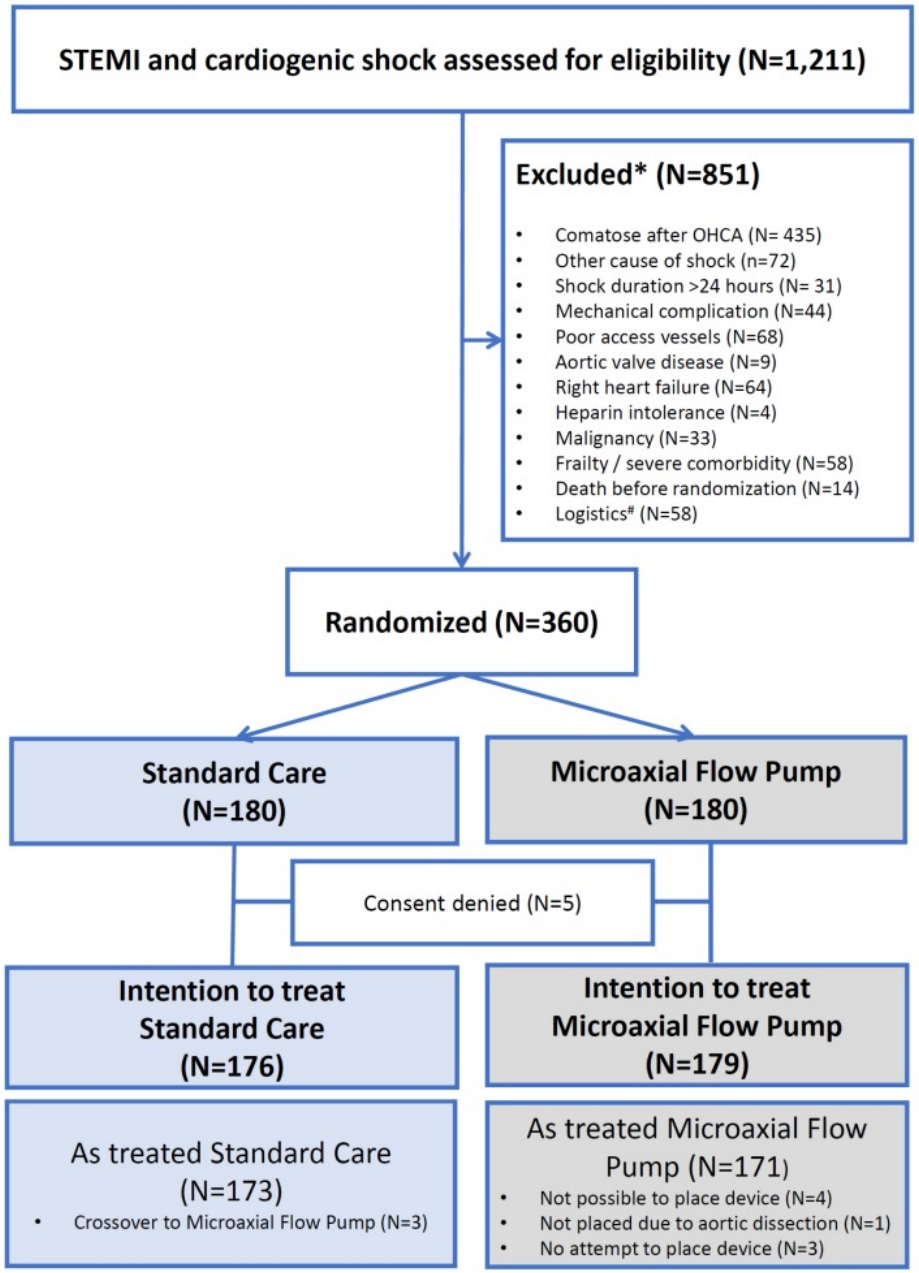
FINALLY A WIN

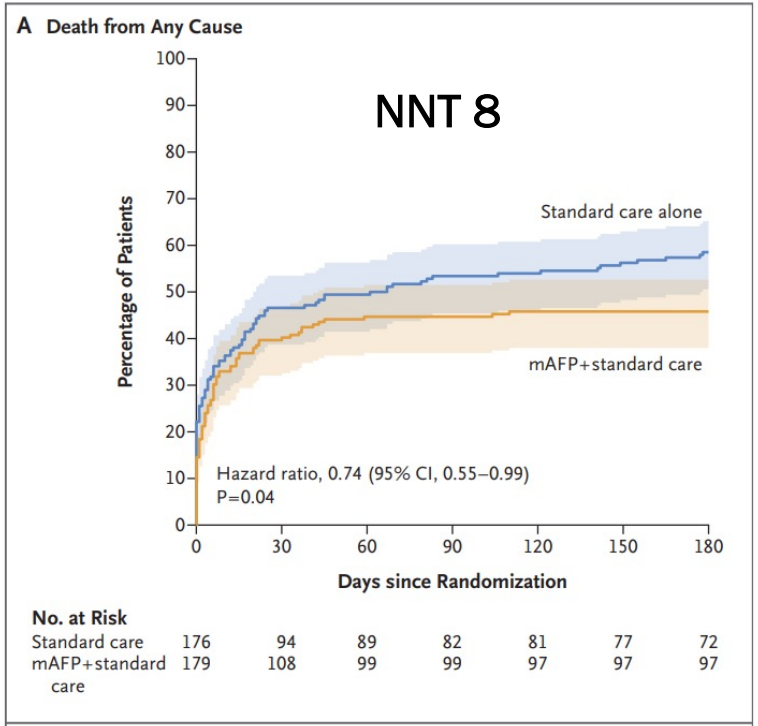
The NEW ENGLAND JOURNAL of MEDICINE

ORIGINAL ARTICLE

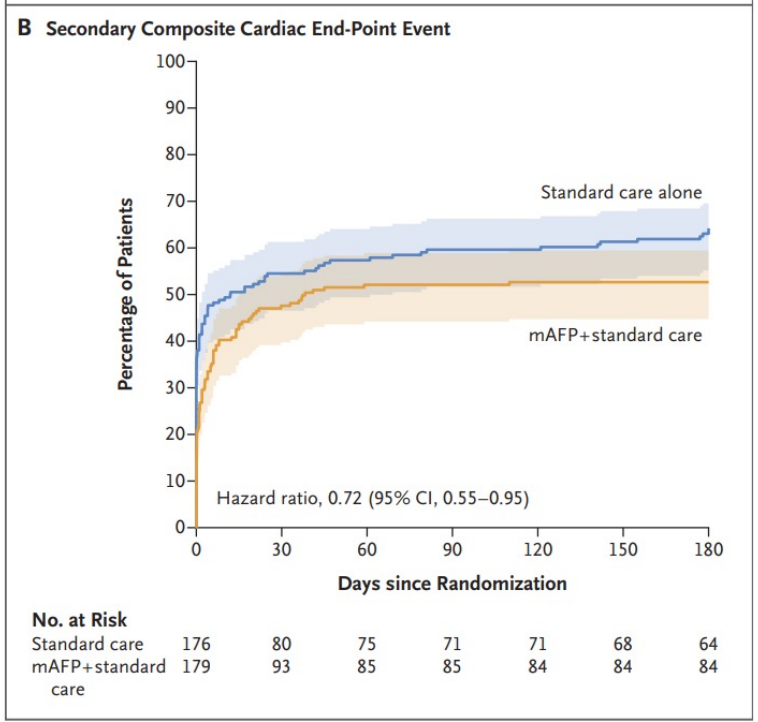
Microaxial Flow Pump or Standard Care in Infarct-Related Cardiogenic Shock

J.E. Møller, T. Engstrøm, L.O. Jensen, H. Eiskjær, N. Mangner, A. Polzin, P.C. Schulze, C. Skurk, P. Nordbeck, P. Clemmensen, V. Panoulas, S. Zimmer, A. Schäfer, N. Werner, M. Frydland, L. Holmvang, J. Kjærgaard, R. Sørensen, J. Lønborg, M.G. Lindholm, N.L.J. Udesen, A. Junker, H. Schmidt, C.J. Terkelsen, S. Christensen, E.H. Christiansen, A. Linke, F.J. Woitek, R. Westenfeld, S. Möbius-Winkler, K. Wachtell, H.B. Ravn, J.F. Lassen, S. Boesgaard, O. Gerke, and C. Hassager, for the DanGer Shock Investigators*

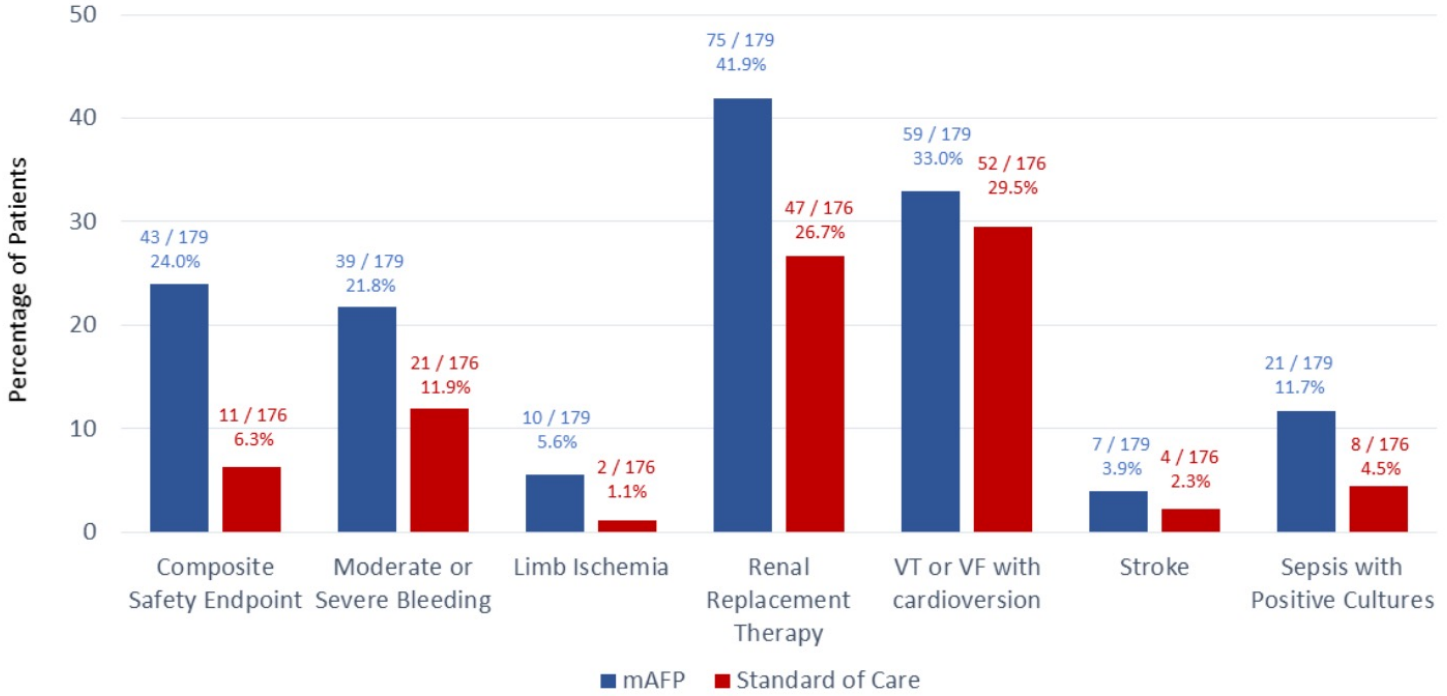

STEMI and cardiogenic shock assessed for eligibility (N=1,211)
Excluded* (N=851)
Comatose after OHCA (N= 435)
Other cause of shock (n=72)
Shock duration >24 hours (N= 31)
Mechanical complication (N=44)
Poor access vessels (N=68)
Aortic valve disease (N=9)
Right heart failure (N=64)
Heparin intolerance (N=4)
Malignancy (N=33)
Frailty / severe comorbidity (N=58)
Death before randomization (N=14)
Logistics# (N=58)
Randomized (N=360)
Standard Care (N=180)
Microaxial Flow Pump (N=180)
Consent denied (N=5)
Intention to treat Standard Care (N=176)
Intention to treat Microaxial Flow Pump (N=179)
As treated Standard Care (N=173)
Crossover to Microaxial Flow Pump (N=3)
As treated Microaxial Flow Pump (N=171)
Not possible to place device (N=4)
Not placed due to aortic dissection (N=1)
No attempt to place device (N=3)


A Death from Any Cause
Percentage of Patients
Standard care alone
mAFP+standard care
Hazard ratio, 0.74 (95% CI, 0.55–0.99)
P=0.04
Days since Randomization
No. at Risk
Standard care 176 94 89 82 81 77 72
mAFP+standard care 179 108 99 99 97 97 97

NNT 8


B Secondary Composite Cardiac End-Point Event
Percentage of Patients
Standard care alone
mAFP+standard care
Hazard ratio, 0.72 (95% CI, 0.55–0.95)
Days since Randomization
No. at Risk
Standard care 176 80 75 71 71 68 64
mAFP+standard care 179 93 85 85 84 84 84

NNH 6


Percentage of Patients
43 / 179 24.0%
11 / 176 6.3%
39 / 179 21.8%
21 / 176 11.9%
10 / 179 5.6%
2 / 176 1.1%
75 / 179 41.9%
47 / 176 26.7%
59 / 179 33.0%
52 / 176 29.5%
7 / 179 3.9%
4 / 176 2.3%
21 / 179 11.7%
8 / 176 4.5%
Composite Safety Endpoint
Moderate or Severe Bleeding
Limb Ischemia
Renal Replacement Therapy
VT or VF with cardioversion
Stroke
Sepsis with Positive Cultures
mAFP
Standard of Care

WHERE ARE WE TODAY?

AHA/ACC/HFSA CLINICAL PRACTICE GUIDELINE

2022 AHA/ACC/HFSA Guideline for the Management of Heart Failure: A Report of the American College of Cardiology/American Heart Association Joint Committee on Clinical Practice Guidelines

Paul A. Heidenreich, MD, MS, FACC, FAHA, FHFSA, Chair, Biykem Bozkurt, MD, PhD, FACC, FAHA, FHFSA, Vice Chair, David Aguilar, MD, MSc, FAHA, Larry A. Allen, MD, MHS, FACC, FAHA, FHFSA, Joni J. Byun, Monica M. Colvin, MD, MS, FAHA, Anita Deswal, MD, MPH, FACC, FAHA, FHFSA, Mark H. Drazner, MD, MSc, FACC, FAHA, FHFSA, Shannon M. Dunlay, MD, MS, FAHA, FHFSA, Linda R. Evers, JD, James C. Fang, MD, FACC, FAHA, FHFSA, Savitri E. Fedson, MD, MA, Gregg C. Fonarow, MD, FACC, FAHA, FHFSA, Salim S. Hayek, MD, FACC, Adrian F. Hernandez, MD, MHS, Prateeti Khazanie, MD, MPH, FHFSA, Michelle M. Kittleson, MD, PhD, Christopher S. Lee, PhD, RN, FAHA, FHFSA, Mark S. Link, MD, Carmelo A. Milano, MD, Lorraine C. Nnacheta, DrPH, MPH, Alexander T. Sandhu, MD, MS, Lynne Warner Stevenson, MD, FACC, FAHA, FHFSA, Orly Vardeny, PharmD, MS, FAHA, FHFSA, Amanda R. Vest, MBBS, MPH, FHFSA, and Clyde W. Yancy, MD, MSc, MACC, FAHA, FHFSA

JOURNAL OF THE AMERICAN COLLEGE OF CARDIOLOGY
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VOL. 85, NO. 22, 2025

CLINICAL PRACTICE GUIDELINE

2025 ACC/AHA/ACEP/NAEMSP/SCAI Guideline for the Management of Patients With Acute Coronary Syndromes

A Report of the American College of Cardiology/American Heart Association Joint Committee on Clinical Practice Guidelines

Developed in Collaboration With and Endorsed by the American College of Emergency Physicians, National Association of EMS Physicians, and Society for Cardiovascular Angiography and Interventions

Writing Committee Members*

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Michelle L. O'Donoghue, MD, MPH, FACC, FAHA, *Vice Chair*
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JACC
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PUBLISHED BY ELSEVIER

VOL. 85, NO. 16, 2025

CONCISE CLINICAL GUIDANCE

2025 Concise Clinical Guidance: An ACC Expert Consensus Statement on the Evaluation and Management of Cardiogenic Shock

A Report of the American College of Cardiology Solution Set Oversight Committee

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COR	LOE	Recommendations
1	B-NR	1. In patients with cardiogenic shock, intravenous inotropic support should be used to maintain systemic perfusion and preserve end-organ performance.[1–8]
2a	B-NR	2. In patients with cardiogenic shock, temporary MCS is reasonable when end-organ function cannot be maintained by pharmacologic means to support cardiac function.[9–17]
2a	B-NR	3. In patients with cardiogenic shock, management by a multidisciplinary team experienced in shock is reasonable.[17–22]
2b	B-NR	4. In patients presenting with cardiogenic shock, placement of a PA line may be considered to define hemodynamic subsets and appropriate management strategies.[23–27]
2b	C-LD	5. For patients who are not rapidly responding to initial shock measures, triage to centers that can provide temporary MCS may be considered to optimize management.[17–22]

Recommendations for MCS in Patients With ACS and Cardiogenic Shock
Referenced studies that support recommendations are summarized in the Evidence Table.

COR	LOE	Recommendations
2a	B-R	1. In selected* patients with STEMI and severe or refractory cardiogenic shock, insertion of a microaxial intravascular flow pump is reasonable to reduce death.[1]
2a	B-NR	2. In patients with mechanical complication of ACS, short-term MCS devices are reasonable for hemodynamic stabilization as a bridge to surgery.[2–4]
3: No benefit	B-R	3. In patients with AMI and cardiogenic shock, the routine use of intra-aortic balloon pump (IABP) or venoarterial extracorporeal membrane oxygenation (VA-ECMO) is not recommended due to a lack of survival benefit.[5–9]

KEY TAKEAWAYS

1. Cardiogenic shock is dynamic
2. Identify the problem early- Reassess, reassess, reassess
3. Cardiogenic shock care is a team sport
4. Keep in mind invasive hemodynamics and devices

THANK YOU