# Cardiogenic Shock Principles & Case Based Education

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# Outline

UT Southwestern Medical Center

Cardiogenic shock definitions

Cardiogenic shock fundamentals

Scales (SCAI vs INTERMACs)

Demographics & Outcomes

Management

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# Question 1

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A 35-year-old woman with a history of moderate-to-severe mitral stenosis presents with worsening shortness of breath, sinus tachycardia (HR 140 bpm), and a blood pressure of 150/80 mmHg. She is noted to have an acute kidney injury (creatinine 1.0 --> 2.5), elevated lactate and elevated liver function tests (previously normal). An echocardiogram is notable for normal right and left ventricular systolic function with significant mitral stenosis. The ***most appropriate immediate management*** of her cardiogenic shock includes:

A. Intravenous diuretics and therapeutic anticoagulation
B. Intravenous diuretics and ACE-inhibitor administration
C. Intravenous diuretics and hydralazine administration
D. Intravenous diuretics and beta-blocker administration
E. ACE-inhibitor administration and beta-blocker administration

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# Question 2

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A 45-year-old man with a history of CAD with myocardial infarction and ischemic cardiomyopathy presents with several days of lower extremity swelling, shortness of breath, chest pain and vomiting. At rest, he appears unwell, tachypneic (respiratory rate >20 breaths/minute), tachycardic (130 bpm) and hypotensive (BP 75/50). His labs are notable for a lactic acidosis, acute kidney injury and elevated liver function tests. A point of care cardiac ultrasound is notable for a left ventricular fraction <20%. An ECG does not demonstrate ST elevation or depression. The ***most appropriate immediate management*** of her cardiogenic shock includes:

A. Initiation of dobutamine and beta-blocker administration
B. Initiation of dobutamine and intravenous diuretics
C. Initiation of milrinone and intravenous diuretics
D. Intravenous diuretics and ACE-inhibitor administration
E. Intravenous diuretics and beta-blocker administration

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# Cardiogenic Shock Definition

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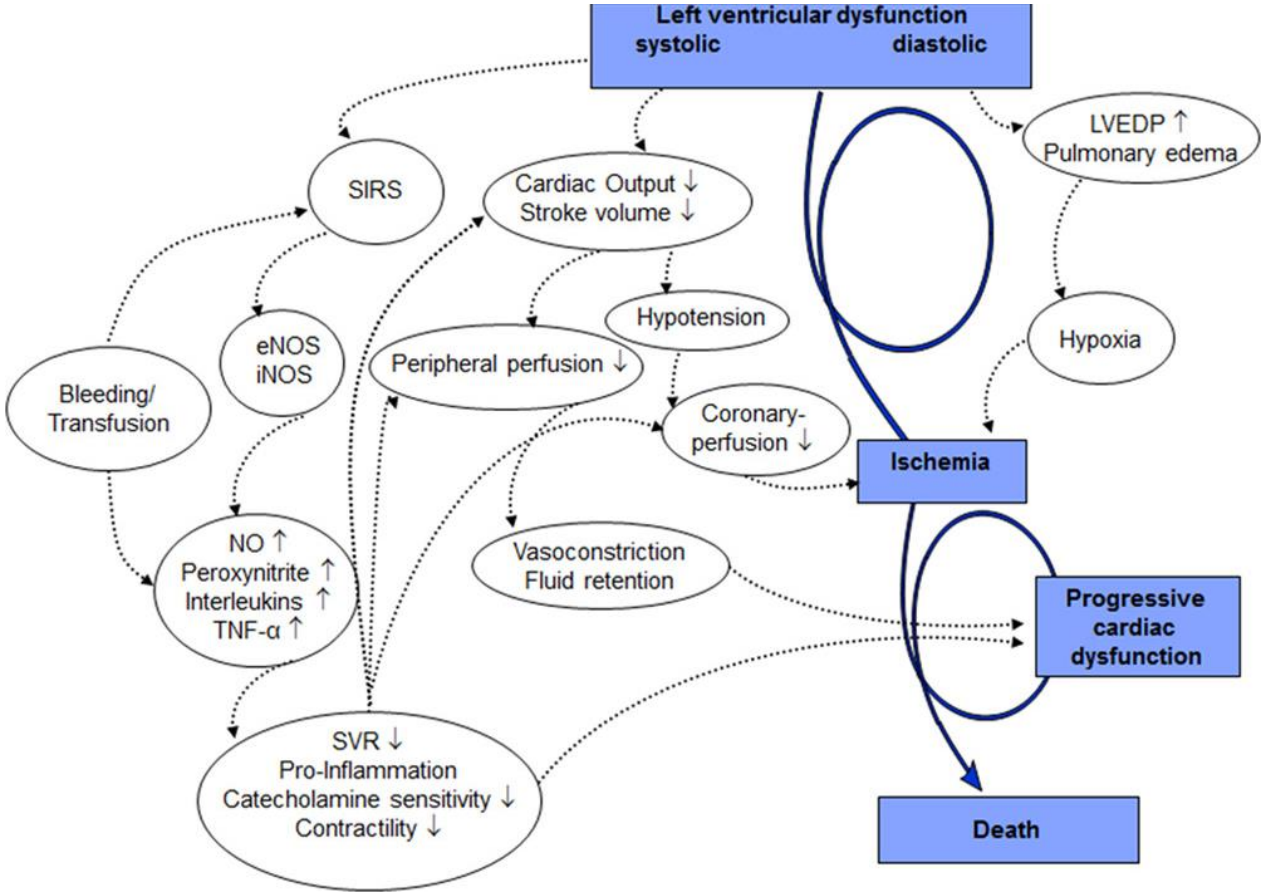
**Physiologic definition**: reduced cardiac output resulting in inadequate tissue perfusion, often with elevated intravascular filling pressures, resulting in end-organ injury.

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*Cardiogenic Shock Stage Classification*. SCAI 2021.

# Cardiogenic Shock Definition

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**Table 1**. Pragmatic and Clinical Trial Definitions of CS (Table view)

| 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 |

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*Cardiogenic Shock Stage Classification*. SCAI 2021.

# Cardiogenic Shock Definition

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**Clinical trial definition**: Cardiac index <1.8 (or <2.0 with support), LVEDP >18, and systolic blood pressure <90 mmHg for >30 minutes.

**Limitations (many)**:

Not a sensitive definition

Acute pathology is more likely present with hypotension

Patients on GDMT more likely to be hypotensive

There is no blood pressure that a patient cannot be in cardiogenic shock

*Note elevated lactate is *NOT* necessary

**There is no comprehensive definition of cardiogenic shock**

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# Management – Physical Exam

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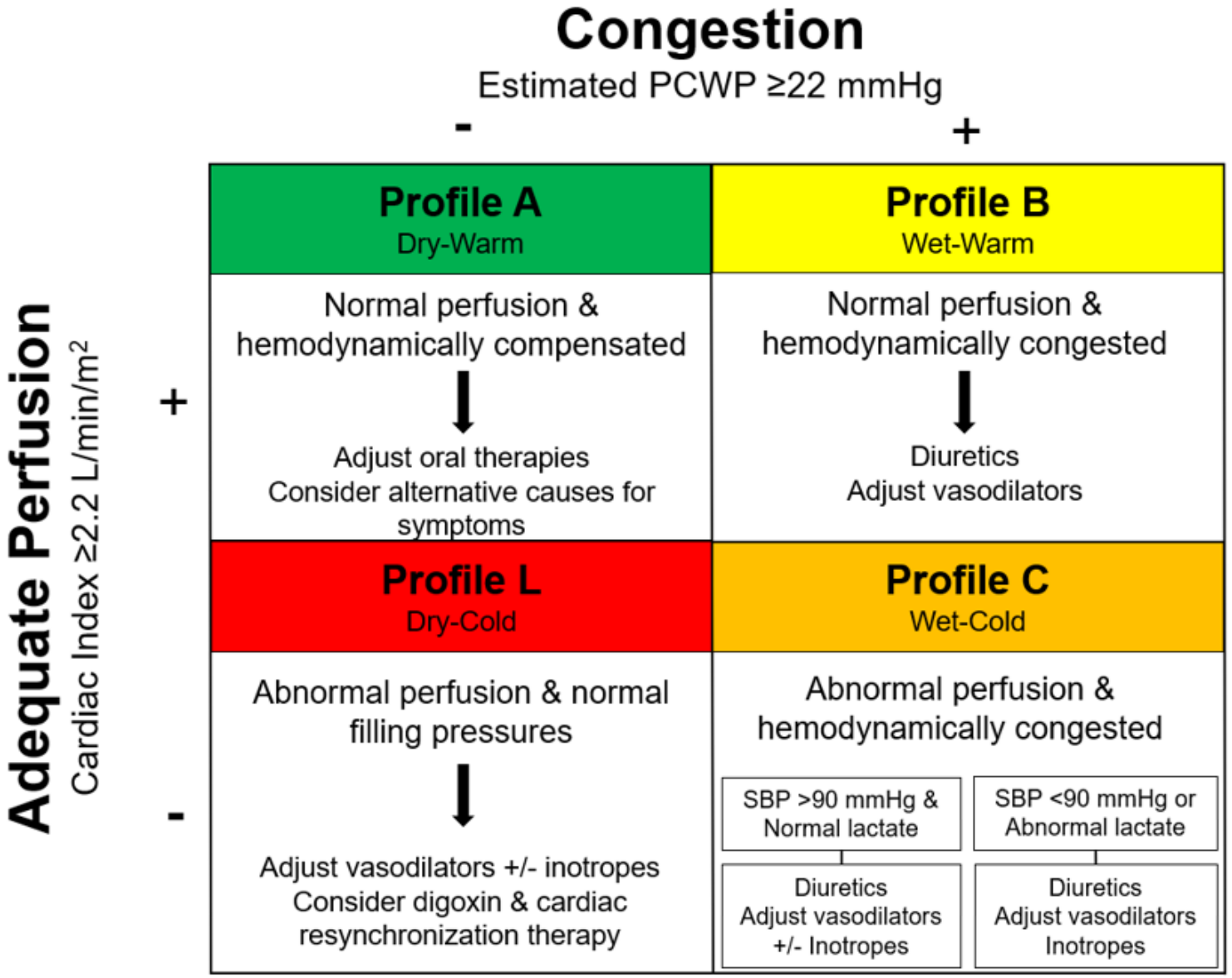


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# Cardiogenic shock – Physical Exam

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**Table 2:** Utility of Clinical Exam Findings in ADHF

| | Exam Finding | Sensitivity | Specificity | PPV | NPV | (+) LR | (-) LR |
|---|---|---|---|---|---|---|---|
| **Perfusion*** | S3 Gallop | 62 | 32 | 61 | 33 | 0.92 | 0.85 |
| | SBP <100 mmHg | 42 | 66 | 77 | 29 | 1.24 | 1.14 |
| | PPP <25% | 10 | 96 | 88 | 28 | 2.54 | 1.07 |
| | Cool Extremities | 20 | 88 | 82 | 28 | 1.68 | 1.10 |
| | "Cold" Profile | 33 | 86 | 87 | 32 | 2.33 | 1.28 |
| **Congestion**** | Ascites | 21 | 92 | 81 | 40 | 2.44 | 1.15 |
| | Rales >1/3 | 15 | 89 | 69 | 38 | 1.32 | 1.04 |
| | Edema >2+ | 41 | 66 | 67 | 40 | 1.20 | 1.11 |
| | Orthopnea >2 pillows | 86 | 25 | 66 | 51 | 1.15 | 1.80 |
| | JVP >12 mmHg | 65 | 64 | 75 | 52 | 1.79 | 1.82 |
| | HJR | 83 | 27 | 65 | 49 | 1.13 | 1.54 |

*Cardiac index <2.2 L/min/$m^2$.

**Pulmonary capillary wedge pressure >22 mmHg.

Abbreviations: HJR, hepatojugular reflux; JVP, jugular venous pressure; LR, likelihood ratio; NPV, negative predictive value; PPP; proportional pulse pressure; PPV, positive predictive value; SBP, systolic blood pressure.

Adapted with permission from Drazner et al. *Value of clinician assessment of hemodynamics in advanced heart failure: the ESCAPE trial.* Circ Heart Fail. 2008;1(3):170-7.

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# Clinical Diagnosis of Cardiogenic Shock

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## MAP – RAP = CO x SVR

Abnormal cardiac function (e.g., severe valvular disease, reduced systolic dysfunction, etc.)

Cardiac congestion – elevated left and/or right heart filling pressures (e.g., CXR with congestion, etc.)

Evidence of inadequate cardiac output – acute liver injury, acute kidney injury, elevated lactate, nausea, altered mental status, low central venous/PA saturation (at least 2)

ŧ Hypotension, sinus tachycardia, narrow pulse pressure

**Cardiac index <2.1 L/min/$m^2$

*MAP, mean arterial pressure; RAP, right atrial pressure; CO, cardiac output; SVR systemic vascular resistance. ŧ Supportive of shock, but not mandatory.

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# Classic Hemodynamics of Cardiogenic Shock

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**MAP – RAP = CO x SVR**

| | PCWP | CO | SVR |
|---|---|---|---|
| Distributive (septic, neurogenic) | ↓ | ↑ | ↓ |
| Cardiogenic | ↑ | ↓ | ↑ |
| Hemorrhagic | ↓ | ↓ | ↑ |

**Reality**:

BP 140/120 (126); JVP 20 mmHg → (126-20)/(3.5 L/min) = 2420

BP 75/50 (58); JVP 20 mmHg → (58-20)/(3.5 L/min) = 870

*ACEi/ARB/ARNI; obesity, liver disease, sepsis, advanced (deep) shock

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# Fundamentals

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**Support the body** ✚ **Optimize cardiac hemodynamics** ✚ **Optimize Coronary Flow**

| Maintain MAP<br>Maintain body perfusion<br>Vasopressors & inotropes<br>MCS | Diuretics versus fluids<br>Vasopressors, inotropes<br>MCS if necessary | PCI/tPA if necessary |
|---|---|---|

***Correct recipe depends on the patient in front of you***

(e.g. ACS vs critical AS vs ADHF)

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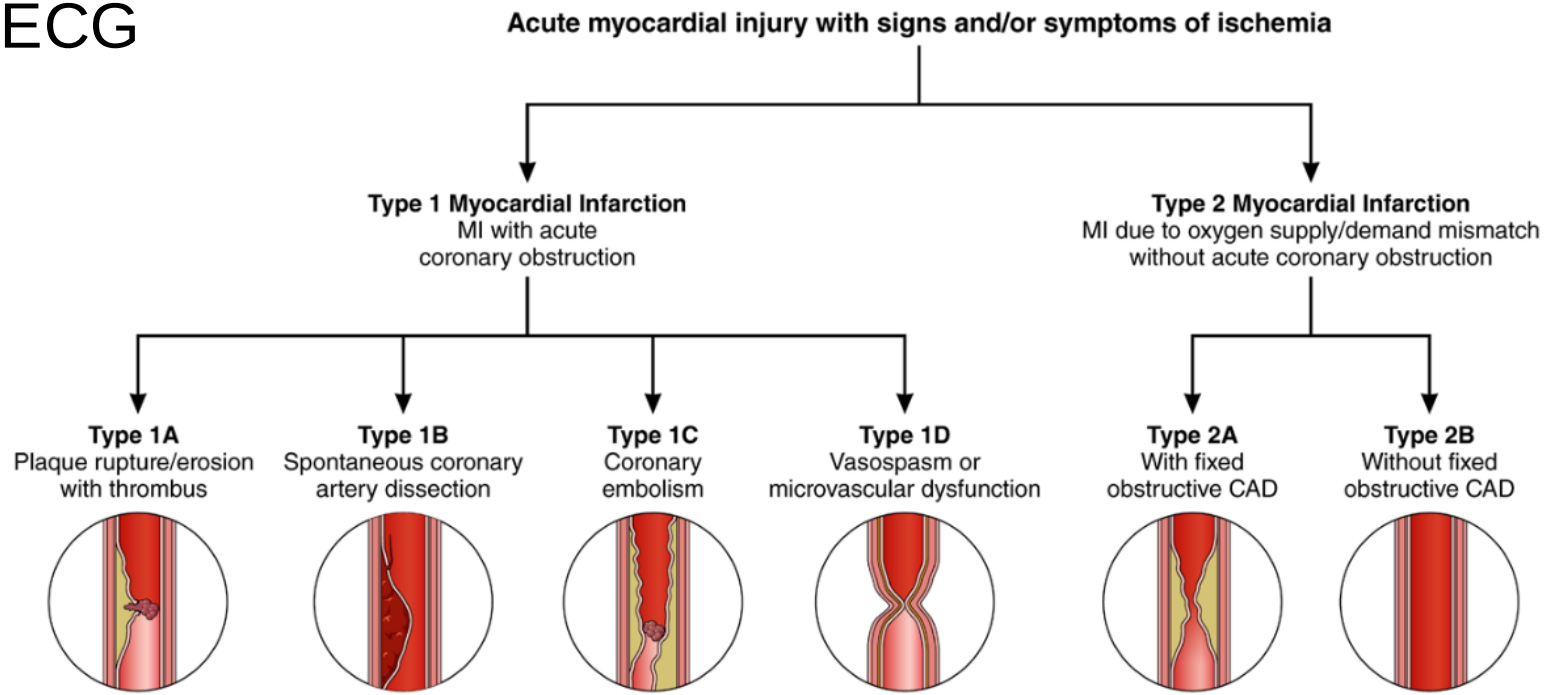
# Optimize coronary flow

**All patients with cardiogenic shock should be assessed for an acute coronary syndrome (e.g., STEMI, NSTEMI)**

- Trend troponin
- Assess for clinical symptoms of a myocardial infarction
- Obtain ECG




De Lemos et al. *Circulation* 2019. PMID 31765259.

# Optimize coronary flow

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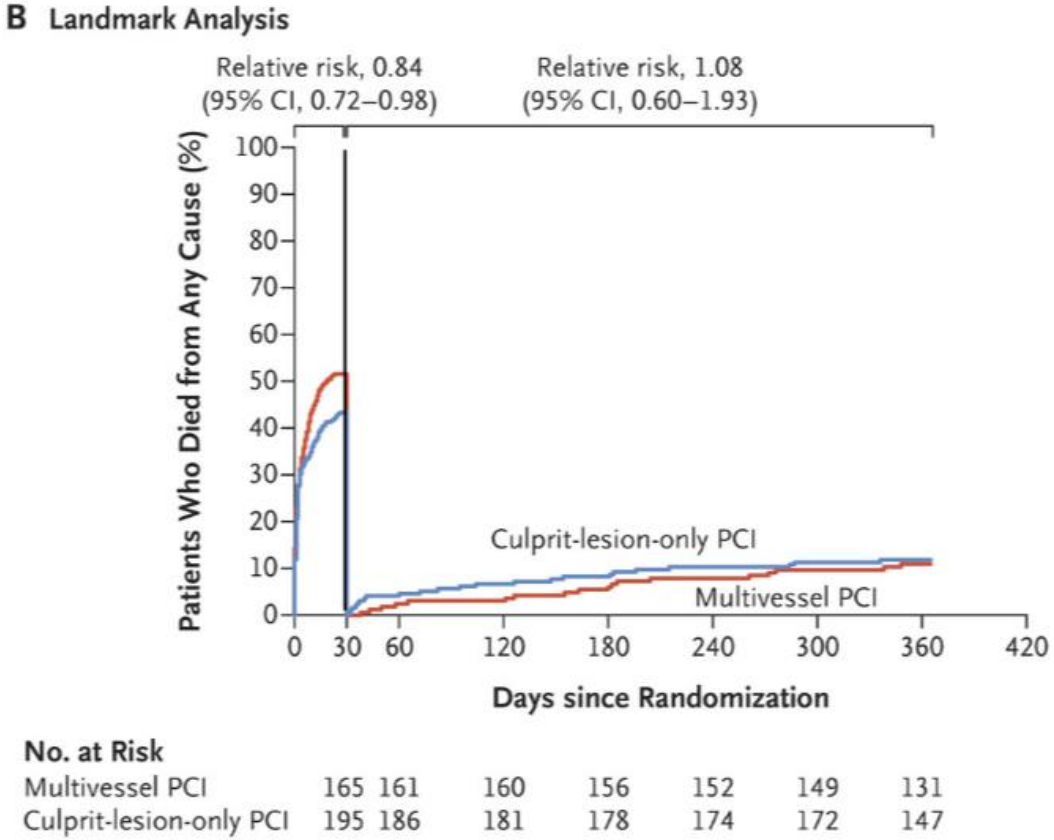
## Coronary revascularization for STEMI or NSTEMI in shock

### STEMI or NSTEMI

– Urgent revascularization of culprit lesion or tPA

– Address remaining lesions electively




**CULPRIT SHOCK**
N=706
Culprit-only PCI versus multivessel PCI

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Stahli et al. NEJM 2023. PMID 37634190.
Thiele et al. NEJM 2018. PMID 30145971

# Support the body

**MAP target** – generally 65-80 mmHg

- If >80 mmHg consider oral/IV reduction
- If <65 mmHg add vasoactive mediations

**MAP – RAP = CO x SVR**

**Cardiac output** – general goal >2.0 L/min/$m^2$

Inotropes

Mechanical support

**Oxygen delivery (Fick equation)**

Goal hemoglobin >7 g/dL (>8 if NSTEMI/STEMI)

Goal SPO2 >90% or PO2 80-120 (higher may be worse with myocardial infarction)

Adequate cardiac output (general goal >2.0 L/min/$m^2$)

# Support the body – Inotropes

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| | Perks | Limits |
|---|---|---|
| **Dobutamine** | Mixed clearance<br>Mild SVR reduction | Proarrhythmic |
| **Milrinone** | PVR & SVR reducing<br>8-hour half-life<br>***Concomitant BB use*** | Renal clearance<br>May cause hypotension<br>Proarrhythmic |
| **Epinephrine** | Supports SVR & CO | Proarrhythmic |
| **Dopamine** | Supports SVR & CO | Proarrhythmic |
| **Nitroprusside** | No increased mortality<br>Very short half-life<br>Not proarrhythmic | Requires ICU care<br>Limited use in advanced CKD<br>Coronary steal |

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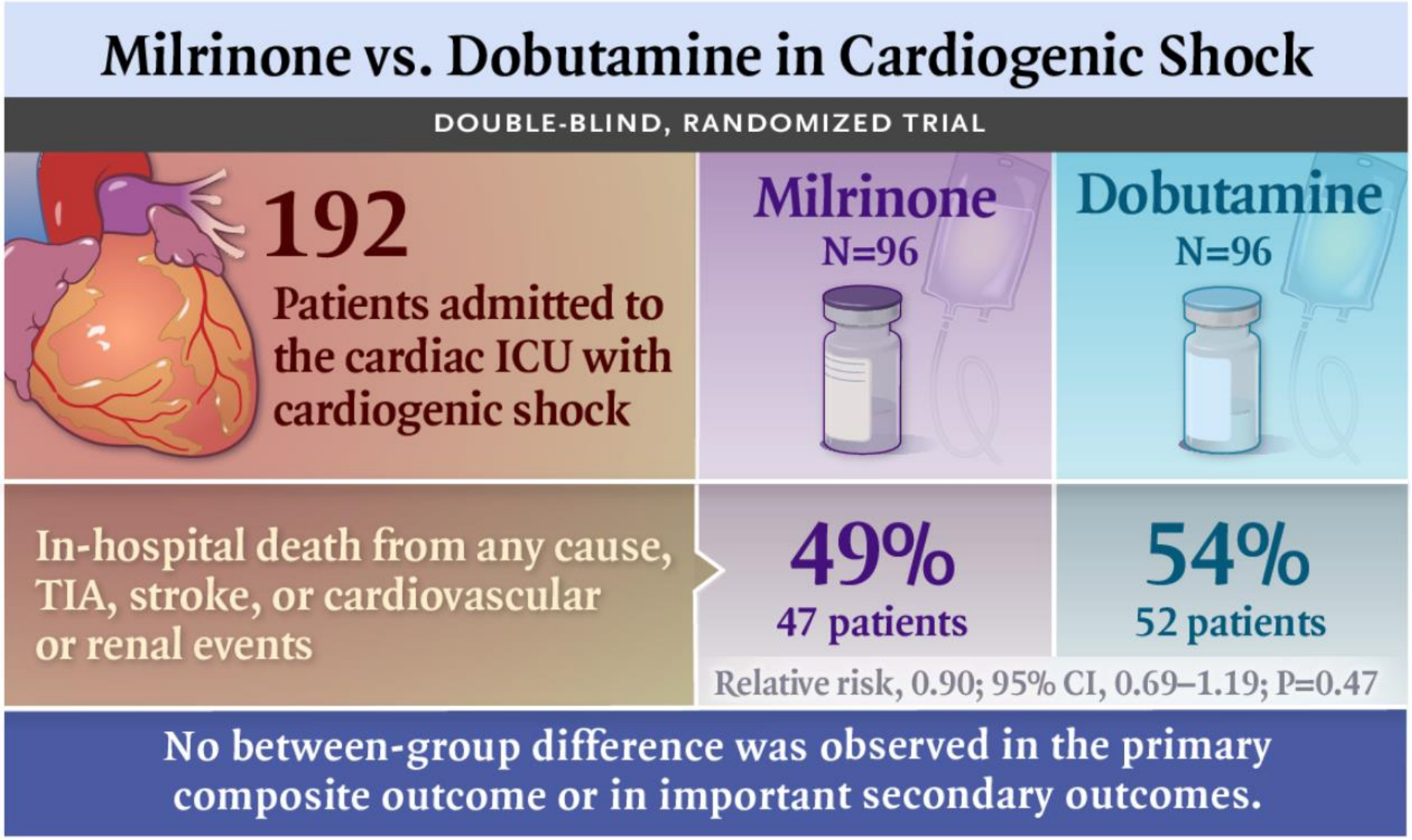
Thiele et al. *IABP for MI Shock*. NEJM 2012.

# Support the body - Inotrope




Mathew et al. *Milrinone vs Dobutamine for Shock*. NEJM 2021.

# Support the body – Inotrope

| End Point[a] | Milrinone (n=96) | Dobutamine (n=96) | Relative risk (95% CI) |
|---|---|---|---|
| Arrhythmia requiring medical team intervention[b] | 48 (50%) | 44 (46%) | 1.09 (0.81-1.47) |
| Atrial arrhythmia requiring medical team intervention | 43 (45%) | 36 (38%) | 1.19 (0.85-1.68) |
| Ventricular arrhythmia[c] | 14 (15%) | 17 (18%) | 0.82 (0.43-1.57) |
| Need for oral or intravenous anti-arrhythmic therapy | 43 (45%) | 41 (43%) | 1.05 (0.76-1.45) |
| Need for up-titration or addition of vasopressor therapy | 94 (98%) | 93 (97%) | 1.01 (0.97-1.06) |
| Sustained hypotension with systolic blood pressure less than 90mmHg for at least 30 minutes or requiring intervention | 96 (100%) | 96 (100%) | - |

a- Values are reported as no. (%). All analyses performed using the intention-to-treat principle. CI denotes confidence interval.
b- Defined as electrical/chemical cardioversion or any intravenous anti-arrhythmia medication administration
c- Defined as monomorphic or polymorphic ventricular tachycardia greater than 30 seconds, or hemodynamically unstable ventricular arrhythmia requiring intervention, or ventricular fibrillation

Mathew et al. *Milrinone vs Dobutamine for Shock*. NEJM 2021.

# Support the body – Mechanical Support

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| | Inotrope | IABP | Impella | VA-ECMO |
|---|---|---|---|---|
| **Cardiac Output** | 0.5-1.0 L/min | 0.5-1.0 L/min | 2.5-5.0 L/min | 3-6 L/min |
| **Myocardial oxygen demand** | Increase | Decrease | Decrease | Increase |
| **LV unloading** | Yes | Yes | Yes | No |
| **Complication Rate** | ** | ** | *** | **** |
| **Cost** | $ | $ | $$$$ | $$$ |

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All mechanical support devices lack high quality data supporting use for cardiogenic shock.

# Optimize cardiac hemodynamics

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**Cardiac output = heart rate x stroke volume**

Cardiac filling pressures

Heart rate

Stroke volume – severe valvular lesions

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# Frank-Starling Relationship

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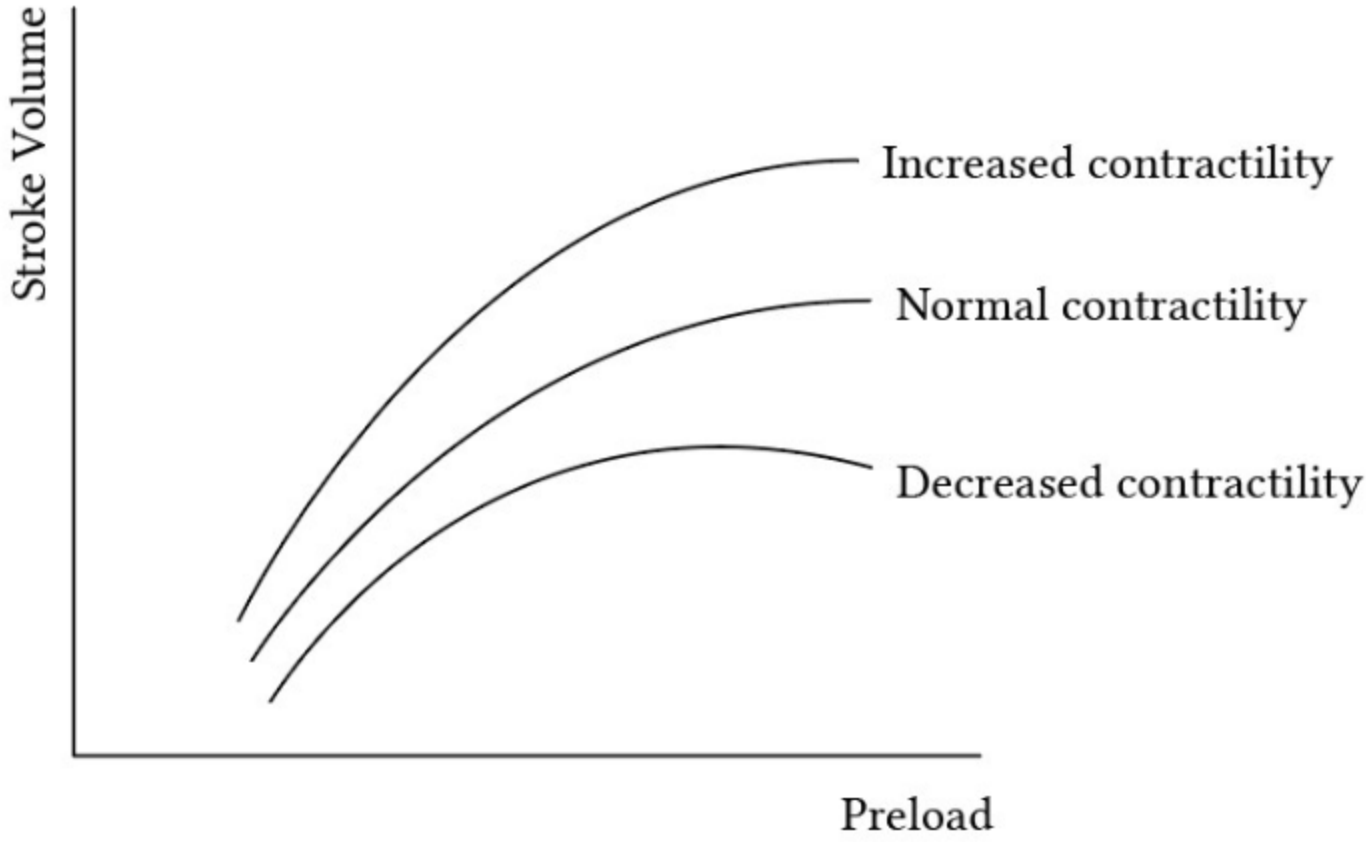
## Left ventricular end-diastolic pressure (PCWP) [Preload]

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# Frank-Starling Relationship

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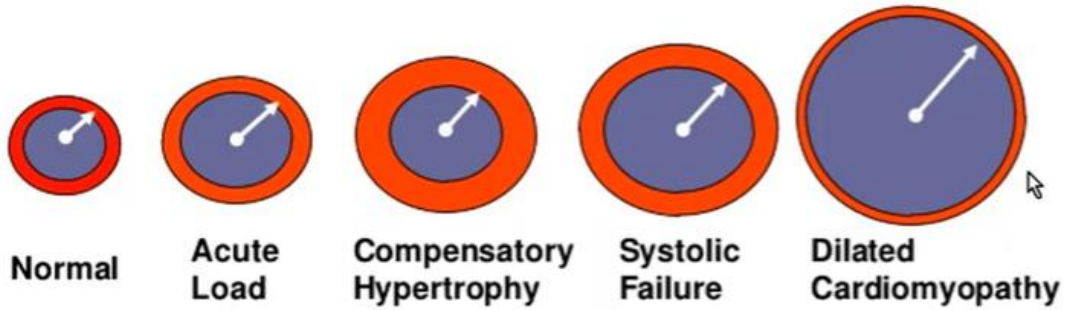
## Left ventricular end-diastolic pressure (PCWP) [Preload]

### La Place law of the heart

Pressure and Volume Govern Cardiac Function




La Place law for myocardial $O_2$ demand

$VO_2 \propto$ wall tension

Primary Target of Heart Failure Therapy: Reduce LV Wall Stress

$$\text{Laplace's Law: Wall stress} = \frac{\text{Pressure} \times \text{Radius}}{2 \times \text{Wall Thickness}} = \frac{\text{Pressure} \times \text{Volume}}{\text{LV Mass}}$$

Wall Stress

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Steve Selig. La Place law. Online 2019.

# Cardiac filling pressures

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**Left ventricular end-diastolic pressure (PCWP) [Preload]**

| | |
|---|---|
| Normal | <12 mmHg |
| Dilated cardiomyopathy | 10-18 mmHg |
| Restrictive cardiomyopathy | 15-20 mmHg |
| Severe aortic stenosis | 15-20 mmHg |

**Right ventricular end-diastolic pressure (CVP)**

| | |
|---|---|
| Normal | <8 mmHg |
| Goal | 5-10 mmHg |

**Use diuretics and blood pressure control to achieve goals**

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# Optimize cardiac hemodynamics – heart rate

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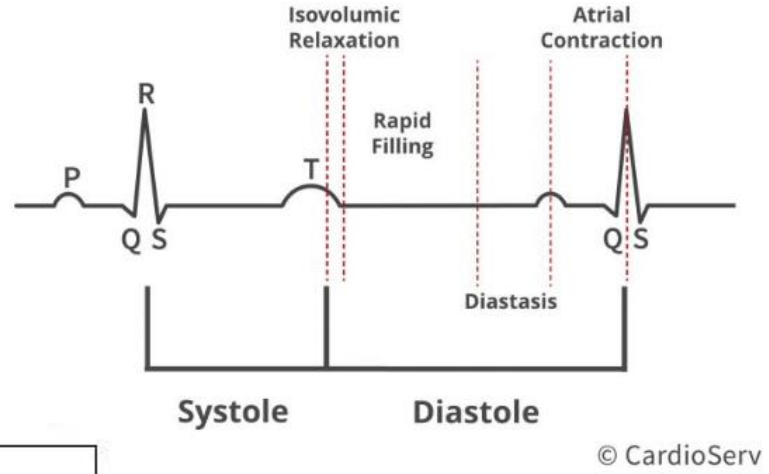
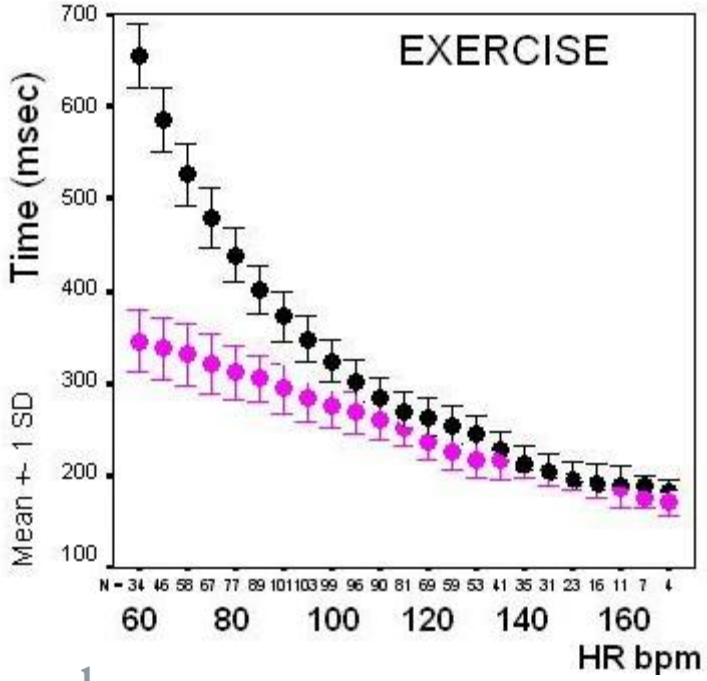
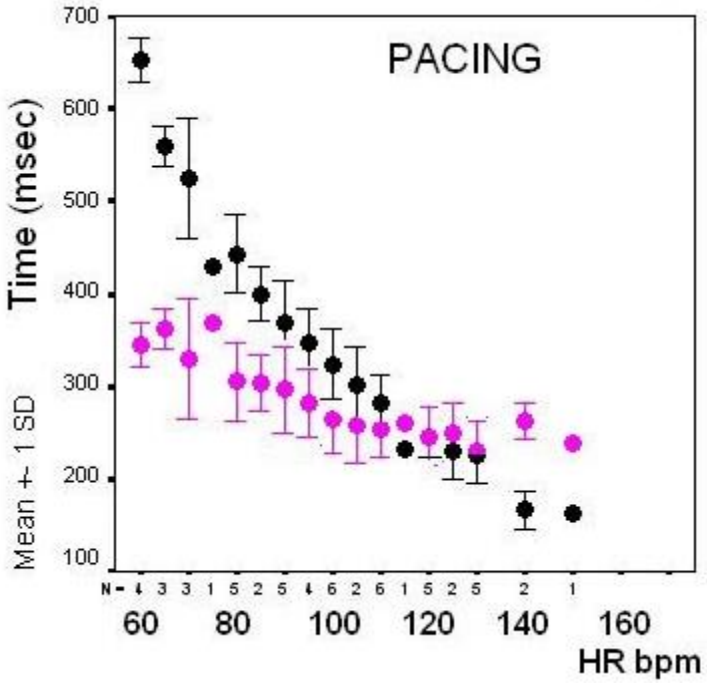
## Faster heart rate = less diastolic filling time

- Good for severe aortic regurgitation
- Bad for severe mitral stenosis




© CardioServ




Black = Diastolic filling time

Pink = Systolic filling time

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# Optimize cardiac hemodynamics – heart rate

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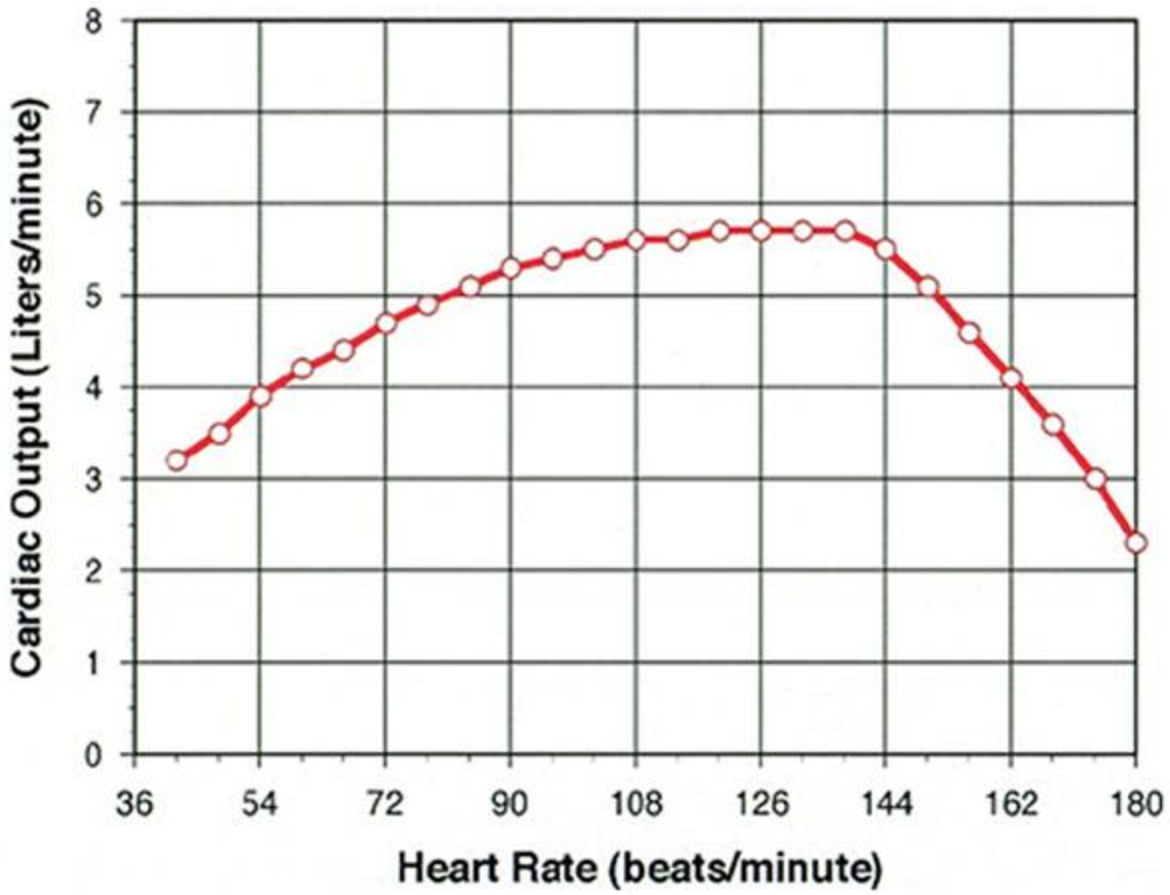
## Goal heart rate in shock – 70-120 bpm in sinus rhythm

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# Cardiogenic Shock Patients - Concepts

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**Acute Problems:**

Myocardial infarction (STEMI, NSTEMI)
Acute AR or MR
Myocarditis (viral, chemotherapy)
Stress cardiomyopathy

Cardiac Index: 3.0 → 1.8 (60%)

**Acute on Chronic Problems:**

Systolic heart failure
Chronic AS or MS
Chronic AR or MR

Cardiac Index: 2.0 → 1.8 (90%)

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# Concepts – Weaning Inotropes

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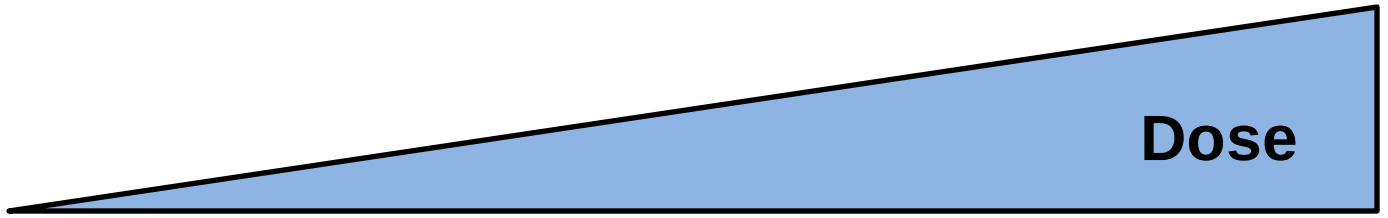
**MAP – RAP = CO x SVR**

Dobutamine, milrinone, or nitroprusside

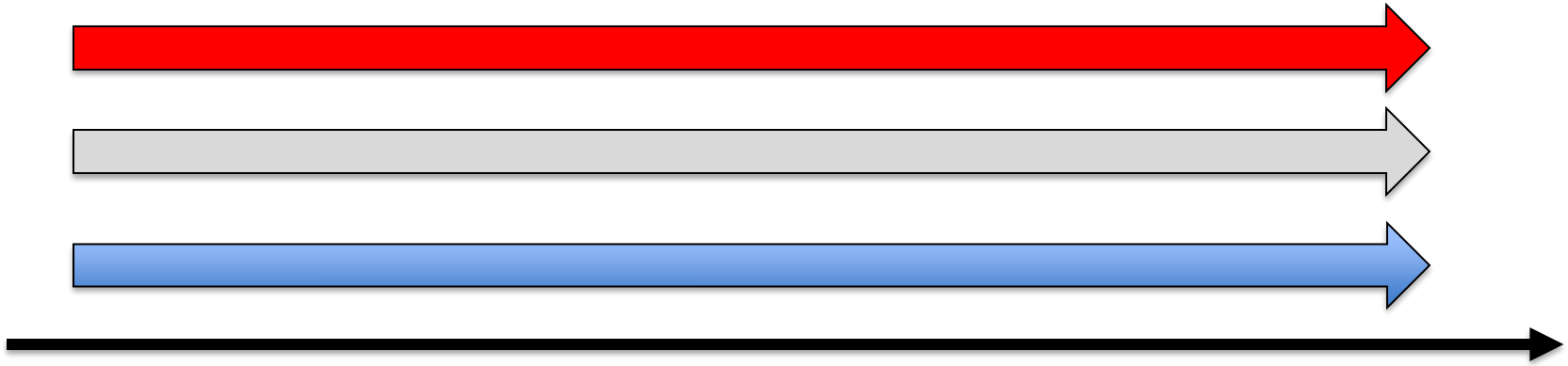

ACEi, ARB or hydralazine-isosorbide




CI (>2.0)

MAP (>65)

SVR

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# Concepts – Weaning Inotropes

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**MAP – RAP = CO x SVR**

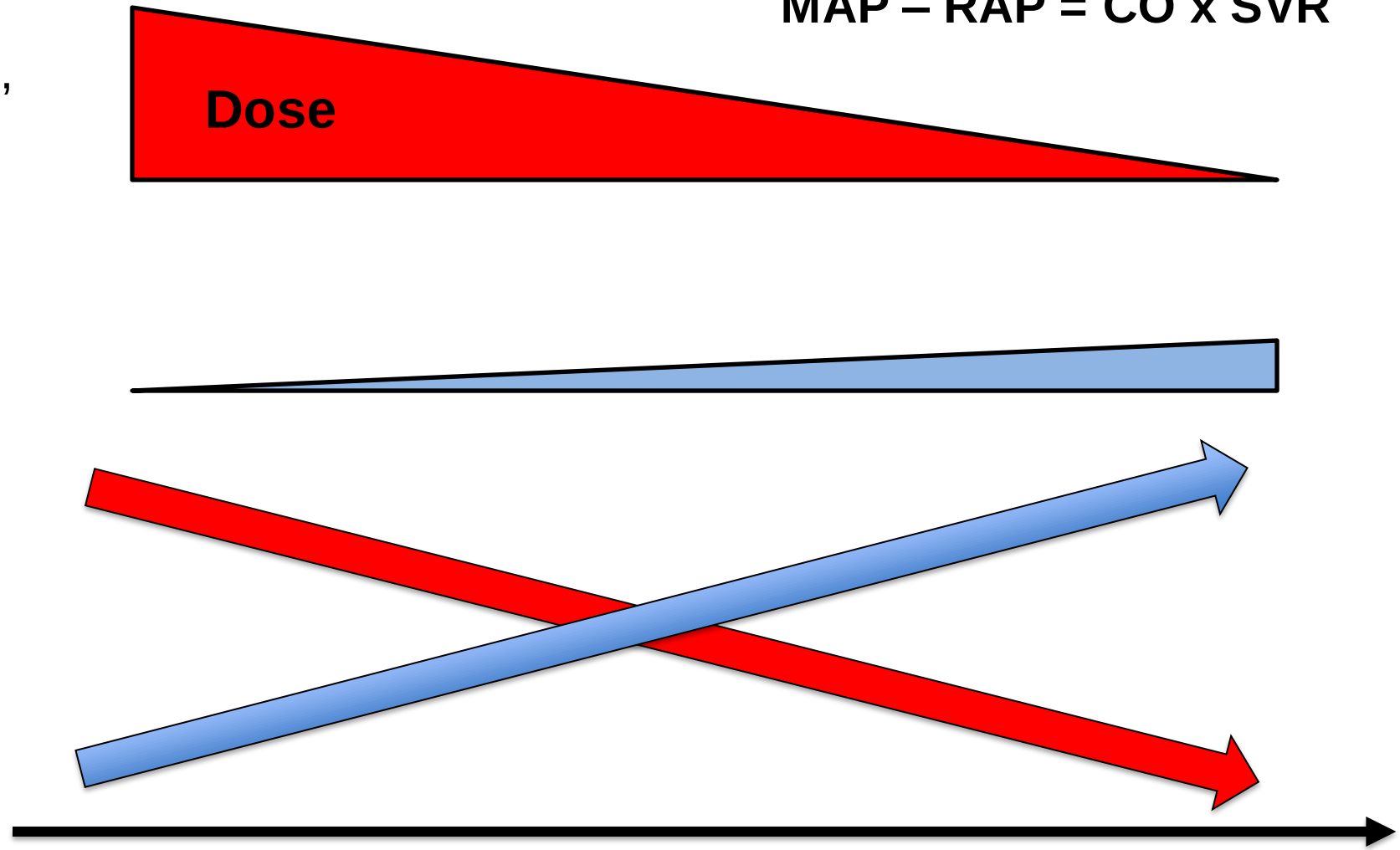
Dobutamine, milrinone, or nitroprusside

ACEi, ARB or hydralazine-isosorbide

CI (>2.0)

MAP (>65)

SVR

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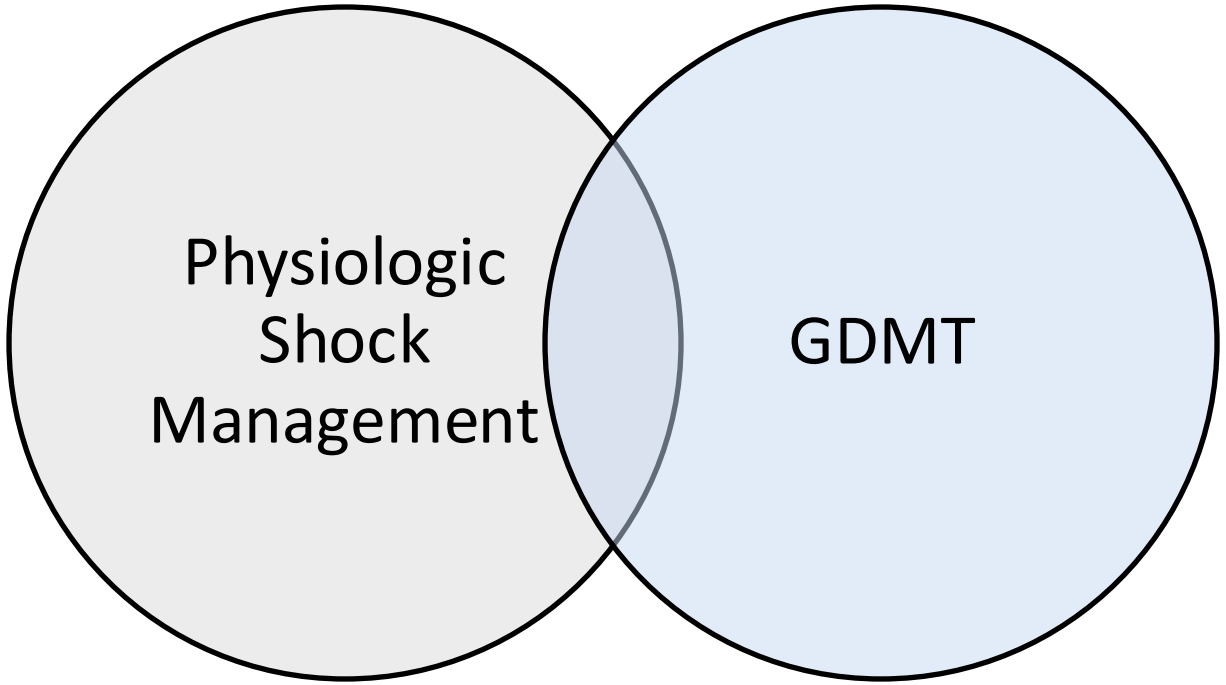
# Concepts – Weaning Inotropes



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# INTERMACs Stages of Shock

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| Profile | Description | Temporary circulatory support (TCS) | Arrhythmia (A) | Frequent flyer (FF) |
|---|---|---|---|---|
| 1. | Critical cardiogenic shock | X | X | |
| 2. | Progressive decline on inotropic support | X | X | |
| 3. | Stable but inotrope dependent | X (in hosp) | X | X (if home) |
| 4. | Resting symptoms home on oral therapy | | X | X |
| 5. | Exertion intolerant | | X | X |
| 6. | Exertion limited | | X | X |
| 7. | Advanced NYHA Class III symptoms | | X | |

NYHA, New York Heart Association Classification.

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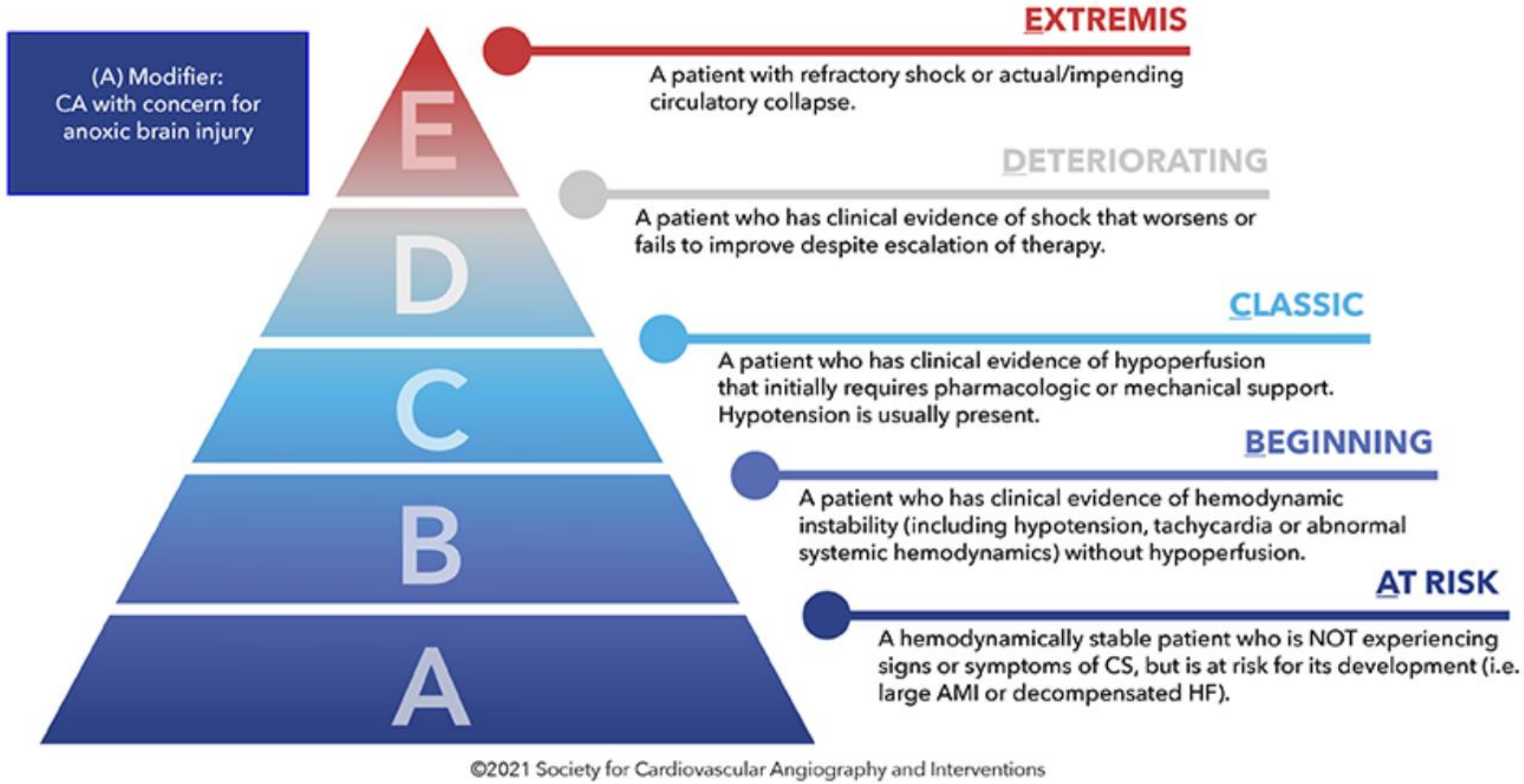
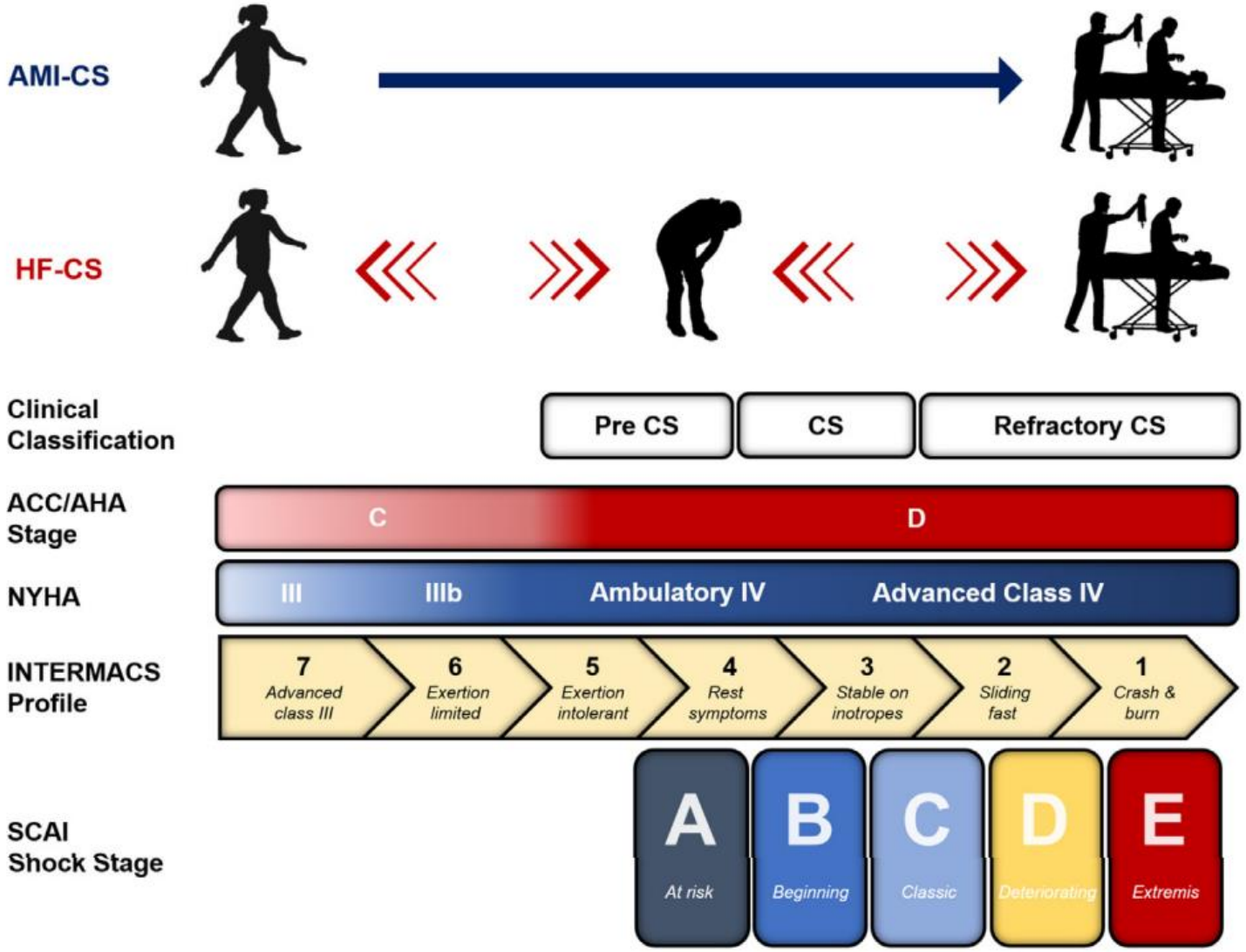
Stevenson et al. *INTERMACs Profiles*. ISHLT 2009.

# SCAI Stages of Shock



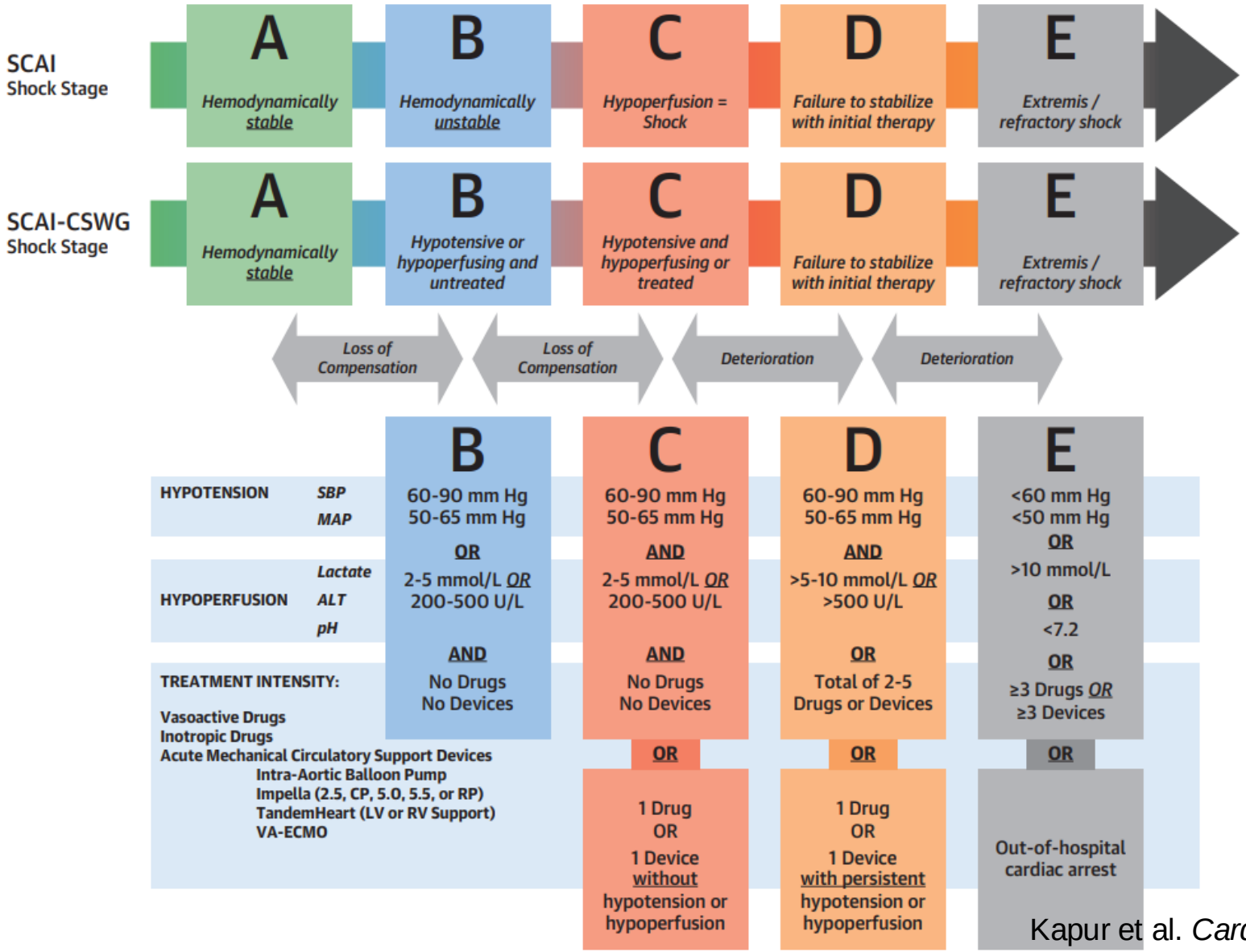

*Cardiogenic Shock Stage Classification*. SCAI 2021.

# SCAI Stages of Shock




Abraham et al. *HF Cardiogenic Shock*. JCF 2021.

# SCAI Stages of Shock




Kapur et al. *Cardiogenic Shock*. JACC 2022.

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# Hospitalized Heart Failure in Africa

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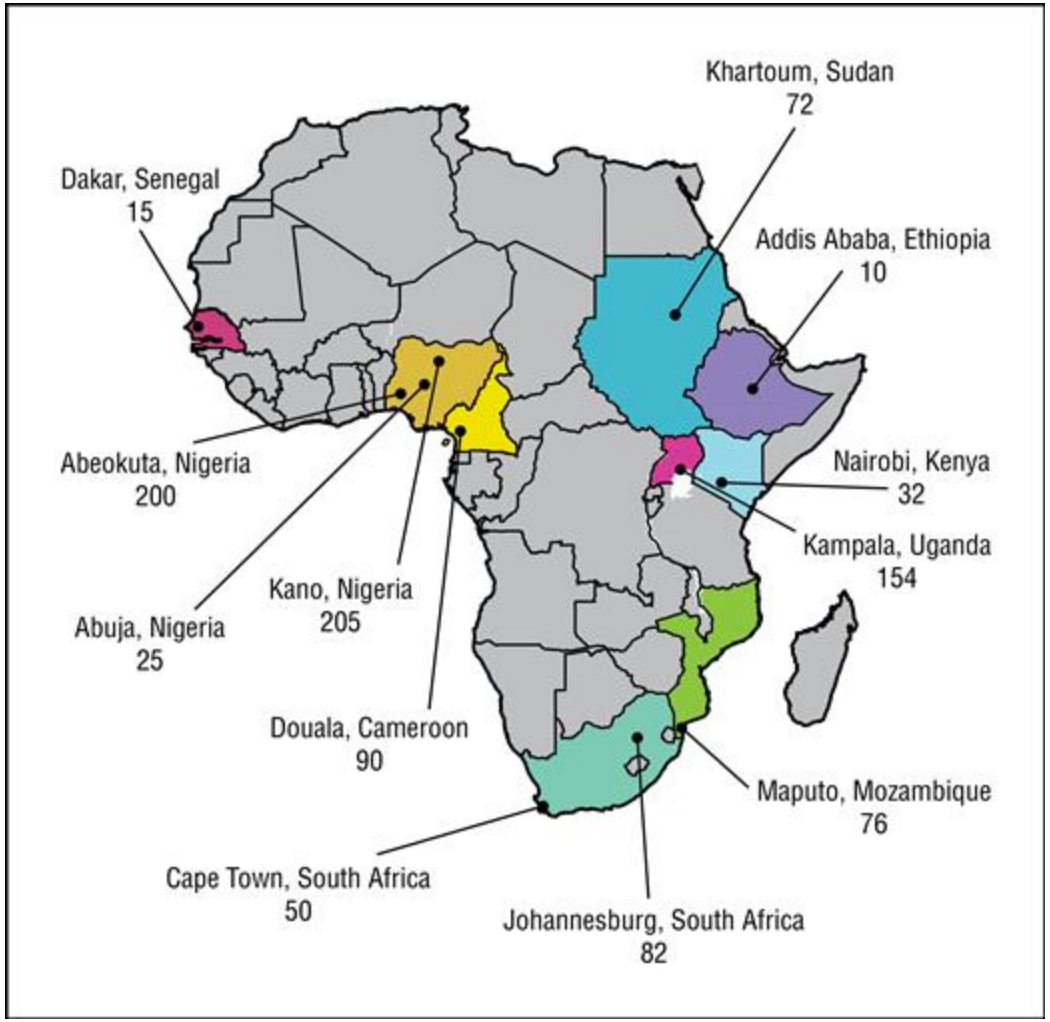
1006 Patients with acute heart failure

- 453 of 998 (45.4%) Hypertension
- 188 of 998 (18.8%) Idiopathic dilated cardiomyopathy
- 143 of 997 (14.3%) Rheumatic heart disease
- 77 of 999 (7.7%) Ischemic heart disease
- 77 of 1002 (7.7%) Peripartum cardiomyopathy
- 68 of 999 (6.8%) Pericardial effusion tamponade
- 39 of 986 (4.0%) Other endemic
- 34 of 986 (3.4%) Other emerging
- 26 of 1000 (2.6%) HIV cardiomyopathy
- 13 of 1000 (1.3%) Endomyocardial fibrosis

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Damasceno et al. THESUS-HF. JAMA 2012.

# Hospitalized Heart Failure in Africa

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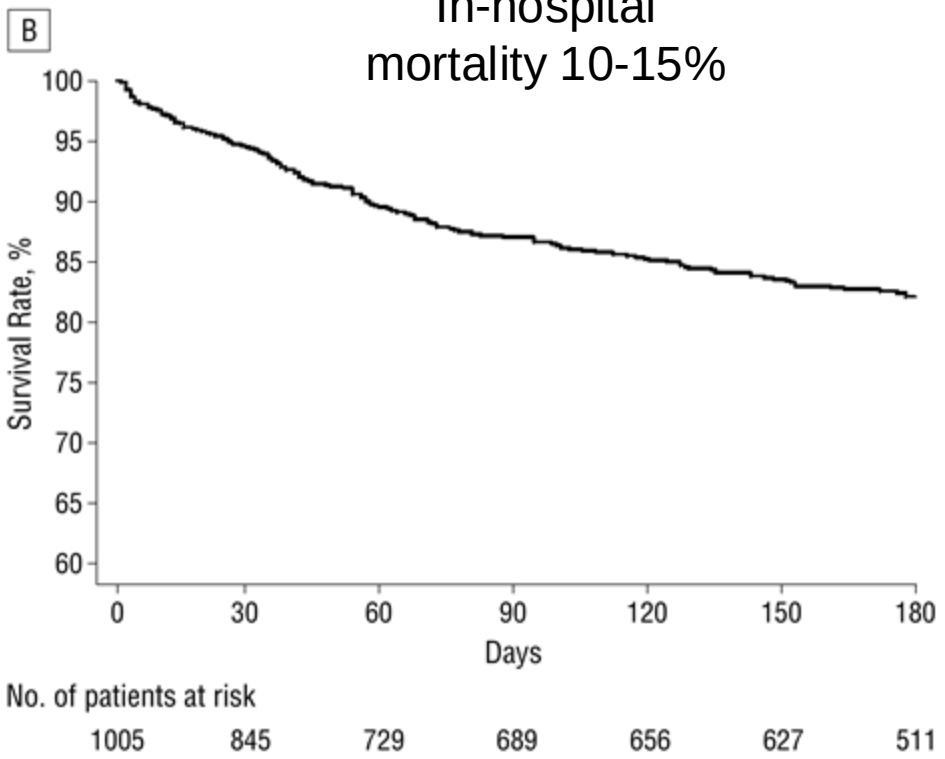
**Table 1. Demographic and Clinical Presentation[a]**

| Characteristic | All (N=1006) | Men (n=494) | Women (n=511) | P Value |
|---|---|---|---|---|
| Age, y | | | | |
| Mean (SD) | 52.3 (18.3) | 54.0 (16.9) | 50.7 (19.5) | .005 |
| Median (IQR) | 55.0 (39.0-67.0) | 55.0 (43.0-67.0) | 53.0 (33.0-67.0) | |
| Black African, No. (%) | 984 (98.5) | 486 (98.8) | 497 (98.2) | .47 |
| Atrial fibrillation, No. (%) | 184 (18.3) | 77 (15.7) | 107 (21.1) | .03 |
| No. of AHF admissions in last 12 mo | | | | |
| Mean (SD) | 0.37 (0.78) | 0.41 (0.77) | 0.34 (0.78) | .15 |
| Median (IQR) | 0 (0-0) | 0 (0-1) | 0 (0-0) | |
| Hyperlipidemia, No. (%)[b] | 90 (9.2) | 52 (10.8) | 38 (7.6) | .09 |
| History of smoking, No. (%) | 98 (9.8) | 85 (17.3) | 13 (2.6) | <.001 |
| History of hypertension, No. (%) | 556 (55.5) | 296 (60.0) | 259 (51.0) | .004 |
| History of diabetes mellitus, No. (%) | 114 (11.4) | 58 (11.8) | 56 (11.0) | .68 |
| Body mass index[c] | | | | |
| Mean (SD) | 25.2 (9.0) | 24.7 (4.9) | 25.7 (11.6) | .08 |
| Median (IQR) | 24.0 (20.9-28.1) | 24.0 (21.2-27.6) | 23.9 (20.5-28.6) | |
| Systolic blood pressure, mm Hg | | | | |
| Mean (SD) | 130.4 (33.5) | 132.4 (33.7) | 128.4 (33.3) | .06 |
| Median (IQR) | 126.5 (106.0-150.0) | 130.0 (110.0-151.0) | 120.0 (102.0-150.0) | |
| Diastolic blood pressure, mm Hg | | | | |
| Mean (SD) | 84.3 (20.9) | 85.5 (21.2) | 83.2 (20.7) | .08 |
| Median (IQR) | 80.0 (70.0-100.0) | 82.0 (70.0-100.0) | 80.0 (70.0-96.0) | |
| Heart rate, bpm | | | | |
| Mean (SD) | 103.7 (21.6) | 101.6 (21.4) | 105.7 (21.6) | .003 |
| Median (IQR) | 104.0 (90.0-116.0) | 100.0 (88.0-112.0) | 108.0 (90.0-120.0) | |
| LVEF, % | | | | |
| Mean (SD) | 39.5 (16.5) | 37.8 (16.2) | 41.1 (16.6) | .002 |
| Median (IQR) | 38.0 (27.0-50.0) | 37.0 (25.0-112.0) | 40.0 (28.4-53.0) | |

In-hospital mortality 10-15%

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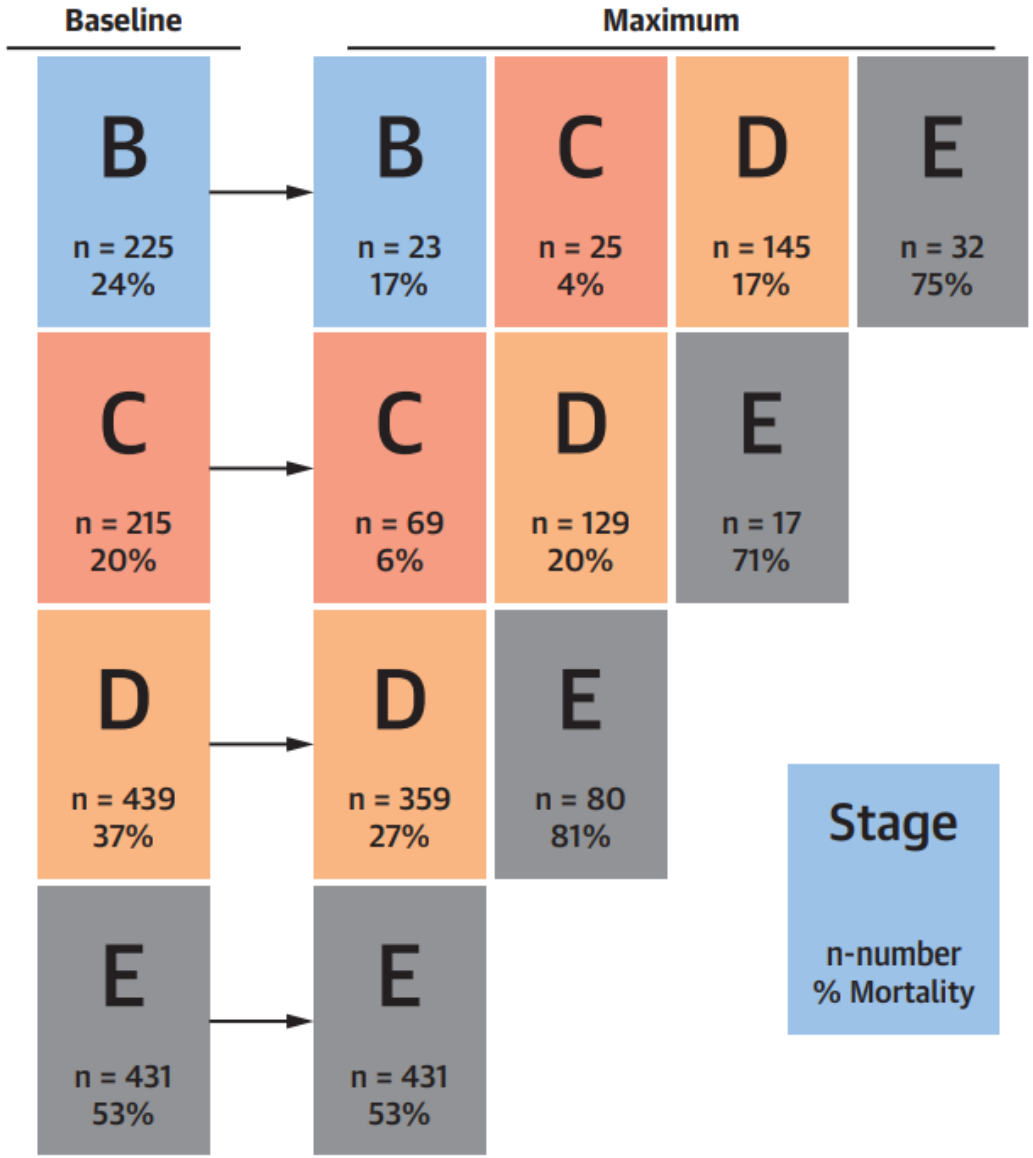
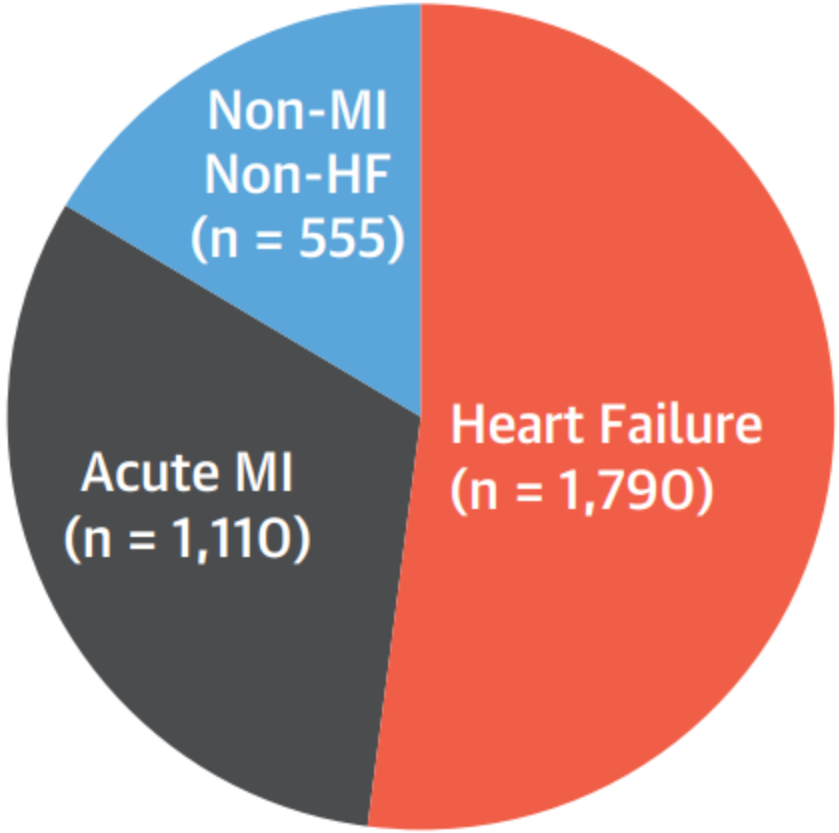
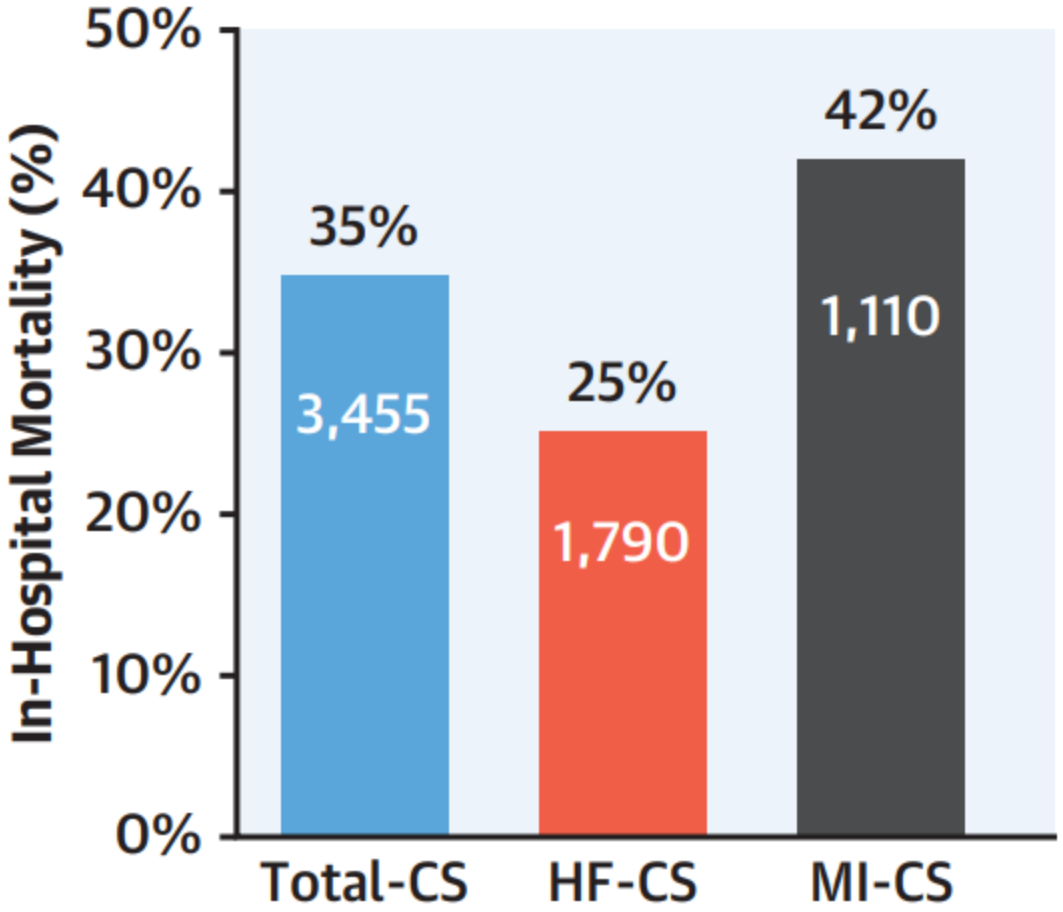
Damasceno et al. THESUS-HF. JAMA 2012.

# Management – Dynamic Process



# Demographics – CSWR




Kapur et al. *Cardiogenic Shock*. JACC 2022.

# Demographics – CSWR

UT Southwestern Medical Center

| | Overall (N = 3,455) | Shock Cause | |
|---|---|---|---|
| | | MI (n = 1,110) | HF (n = 1,790) |
| Nonsurvivors | 1,055 (30.5) | 449 (40.5) | 441 (24.6) |
| Male | 2,436 (70.5) | 775 (69.8) | 1,296 (72.4) |
| Race | | | |
| White | 2,043 (59.1) | 636 (57.3) | 1,043 (58.3) |
| Black | 291 (8.4) | 42 (3.8) | 210 (11.7) |
| Asian | 111 (3.2) | 53 (4.8) | 38 (2.1) |
| Other | 120 (3.5) | 23 (2.1) | 73 (4.1) |
| Medical history | | | |
| HTN | 1,872 (54.2) | 721 (65.0) | 914 (51.1) |
| DM | 1,245 (36.0) | 482 (43.4) | 631 (35.3) |
| Atrial fibrillation/flutter | 898 (26.0) | 125 (11.3) | 681 (38.0) |
| CKD, any stage | 538 (15.6) | 106 (9.6) | 391 (21.8) |
| PVD | 236 (6.8) | 86 (7.8) | 116 (6.5) |
| COPD | 380 (11.0) | 104 (9.4) | 232 (13.0) |
| CVA/TIA | 409 (11.8) | 123 (11.1) | 249 (13.9) |
| Valvular disease | 654 (18.9) | 80 (7.2) | 475 (26.5) |
| PCI | 673 (19.5) | 297 (26.8) | 308 (17.2) |
| CABG | 369 (10.7) | 92 (8.3) | 217 (12.1) |
| ICD | 763 (22.1) | 44 (4.0) | 665 (37.2) |
| OHCA | 293 (8.5) | 147 (13.2) | 103 (5.8) |

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# Demographics – CSWR

UT Southwestern Medical Center

| | Overall (N = 3,455) | Shock Cause | |
|---|---|---|---|
| | | MI (n = 1,110) | HF (n = 1,790) |
| Demographics | | | |
| Age, y | 61.6 ± 14.6 (3,450) | 65.6 ± 12.5 (1,109) | 60.3 ± 14.5 (1,790) |
| Weight, kg | 84.4 [71.0-100.6] (1,883) | 82.6 [71.5-98.9] (593) | 85.0 [70.8-102.1] (1,051) |
| BMI, kg/m$^2$ | 28.4 [24.4-33.1] (1,872) | 28.2 [24.6-32.3] (588) | 28.4 [24.0-33.2] (1,047) |
| Metabolic | | | |
| ALT, /L | 46.0 [22.0-141.0] (2,443) | 64.0 [29.0-153.0] (858) | 35.0 [19.0-114.0] (1,268) |
| BUN, mg/dL | 27.0 [19.0-43.0] (2,960) | 23.0 [17.0-35.0] (1,017) | 32.0 [21.0-48.0] (1,518) |
| Lactate, mmol/L | 2.6 [1.5-5.7] (1,942) | 3.0 [1.7-6.3] (703) | 2.2 [1.4-4.5] (986) |
| HCO3, mEq/L | 22.0 [18.0-26.0] (2,147) | 20.0 [17.0-23.0] (819) | 24.0 [20.0-27.0] (1,020) |
| SCr, mg/dL | 1.5 [1.1-2.1] (3,232) | 1.3 [1.0-1.9] (1,050) | 1.6 [1.2-2.3] (1,750) |
| pH | 7.3 [7.2-7.4] (1,541) | 7.3 [7.2-7.4] (652) | 7.4 [7.3-7.4] (634) |

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# Demographics – CSWR

UT Southwestern Medical Center

| | Overall (N = 3,455) | Shock Cause | |
|---|---|---|---|
| | | MI (n = 1,110) | HF (n = 1,790) |
| Hemodynamic | | | |
| EF, % | 22.5 [15.0-37.0] (2,490) | 27.5 [17.5-40.0] (803) | 20.0 [14.0-30.0] (1,379) |
| RAP, mm Hg | 14.0 [9.0-18.0] (1,261) | 14.0 [10.0-17.0] (403) | 14.0 [9.0-18.0] (724) |
| PCWP, mm Hg | 24.4 ± 8.8 (912) | 24.0 ± 9.2 (300) | 24.8 ± 8.7 (517) |
| Mean PAP, mm Hg | 31.7 [25.7-38.7] (1,312) | 29.0 [23.3-35.0] (439) | 34.3 [27.3-41.0] (733) |
| CO, L/min | 3.6 [2.9-4.4] (1,243) | 3.6 [2.9-4.6] (412) | 3.6 [2.8-4.3] (714) |
| CPO, W | 0.6 [0.5-0.8] (1,177) | 0.6 [0.5-0.8] (396) | 0.6 [0.5-0.7] (667) |
| Heart rate, beats/min | 91.0 [76.0-107.0] (3,213) | 90.0 [74.0-107.0] (1,015) | 92.0 [77.0-108.0] (1,724) |
| Cardiac index | 1.9 [1.5-2.2] (1,251) | 1.9 [1.6-2.3] (415) | 1.8 [1.4-2.1] (722) |
| MAP, mm Hg | 80.5 ± 18.0 (3,272) | 81.5 ± 20.5 (1,053) | 80.1 ± 16.0 (1,737) |
| SBP, mm Hg | 106.9 ± 24.4 (3,185) | 109.6 ± 28.4 (1,002) | 104.9 ± 20.9 (1,714) |
| PAPi | 1.3 [0.8-2.0] (188) | 1.4 [1.0-2.1] (80) | 1.4 [0.8-2.1] (86) |

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Kapur et al. *Cardiogenic Shock*. JACC 2022.

# Demographics – Cardiogenic Shock

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**Table 2**. In-Hospital Device Therapy and Outcomes in Cardiogenic Shock Patients (Table view)

| Parameter | AMI-CS; N=219 | HF-CS; N=301 | Total; N=520 | *P* value |
|---|---|---|---|---|
| AMI-CS management | | | | |
| Percutaneous revascularization | 150 (68.5%) | N/A | N/A | |
| Culprit/single-vessel | 123 (82.0%) | N/A | N/A | |
| Multivessel | 27 (18.0%) | N/A | N/A | |
| Surgical revascularization | 30 (13.7%) | N/A | N/A | |
| Medical management | 39 (17.8%) | N/A | N/A | |
| MCS utilization | 167 (76.3%) | 105 (34.9%) | 272 (52.3%) | <0.001 |
| IABP | 98 (44.8%) | 34 (11.3%) | 132 (25.4%) | <0.001 |
| Escalation from IABP | 40 (40.8%) | 10 (29.4%) | 50 (37.9%) | 0.31 |
| pVAD only | 79 (36.1%) | 43 (14.3%) | 122 (23.5%) | <0.001 |
| VA-ECMO only | 15 (6.9%) | 19 (6.3%) | 34 (6.5%) | 0.86 |
| pVAD+VA-ECMO | 33 (15.1%) | 22 (7.3%) | 55 (10.6%) | 0.156 |
| Impella 5.0+VA-ECMO | 0 (0.00%) | 2 (9.1%) | 2 (3.6%) | |
| Impella CP+VA-ECMO | 33 (100%) | 20 (90.9%) | 53 (96.4%) | |

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Sinha et al. *Cardiogenic Shock*. Circ HF 2022.

# Outcomes – Cardiogenic Shock

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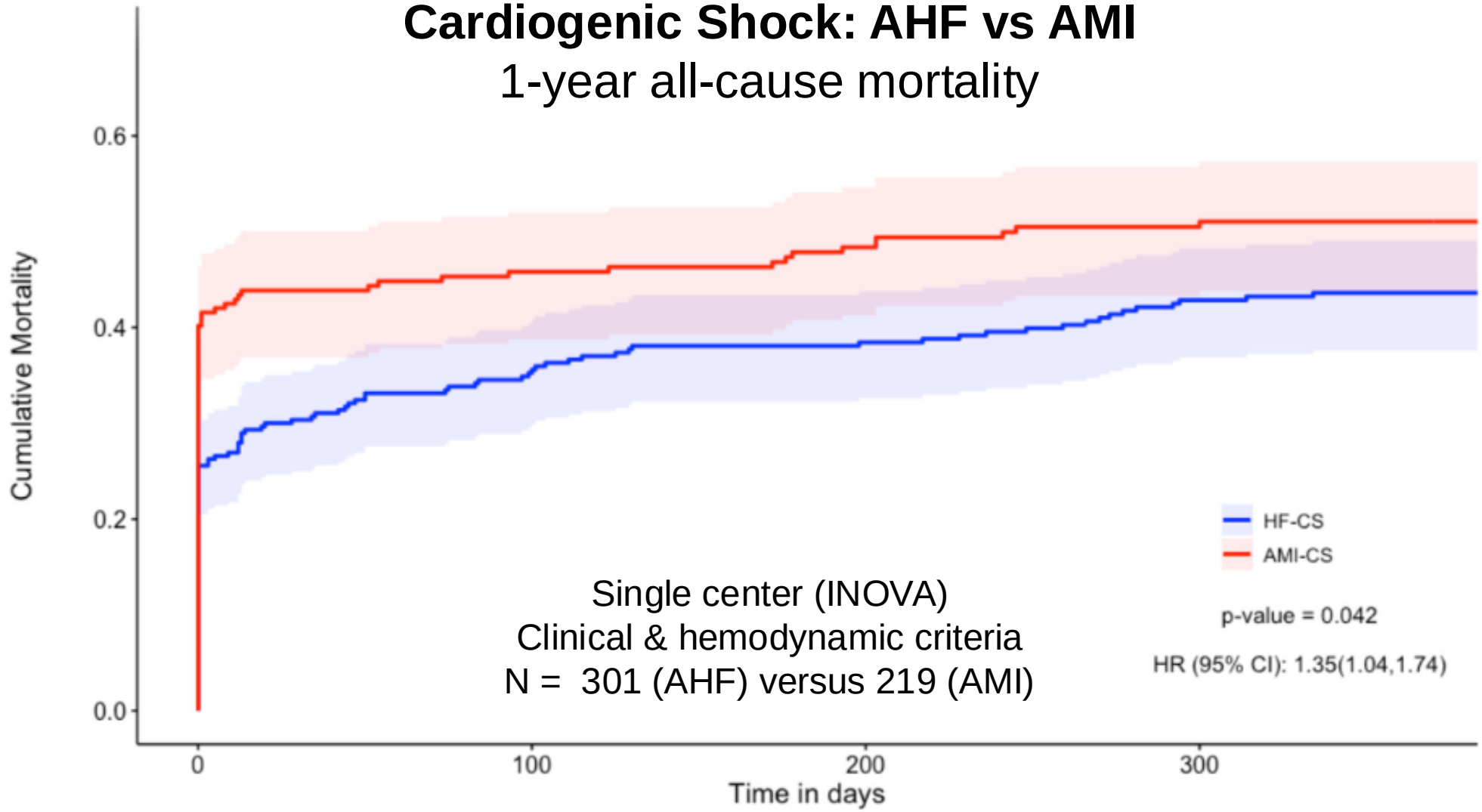


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Sinha et al. *Cardiogenic Shock*. Circ HF 2022.

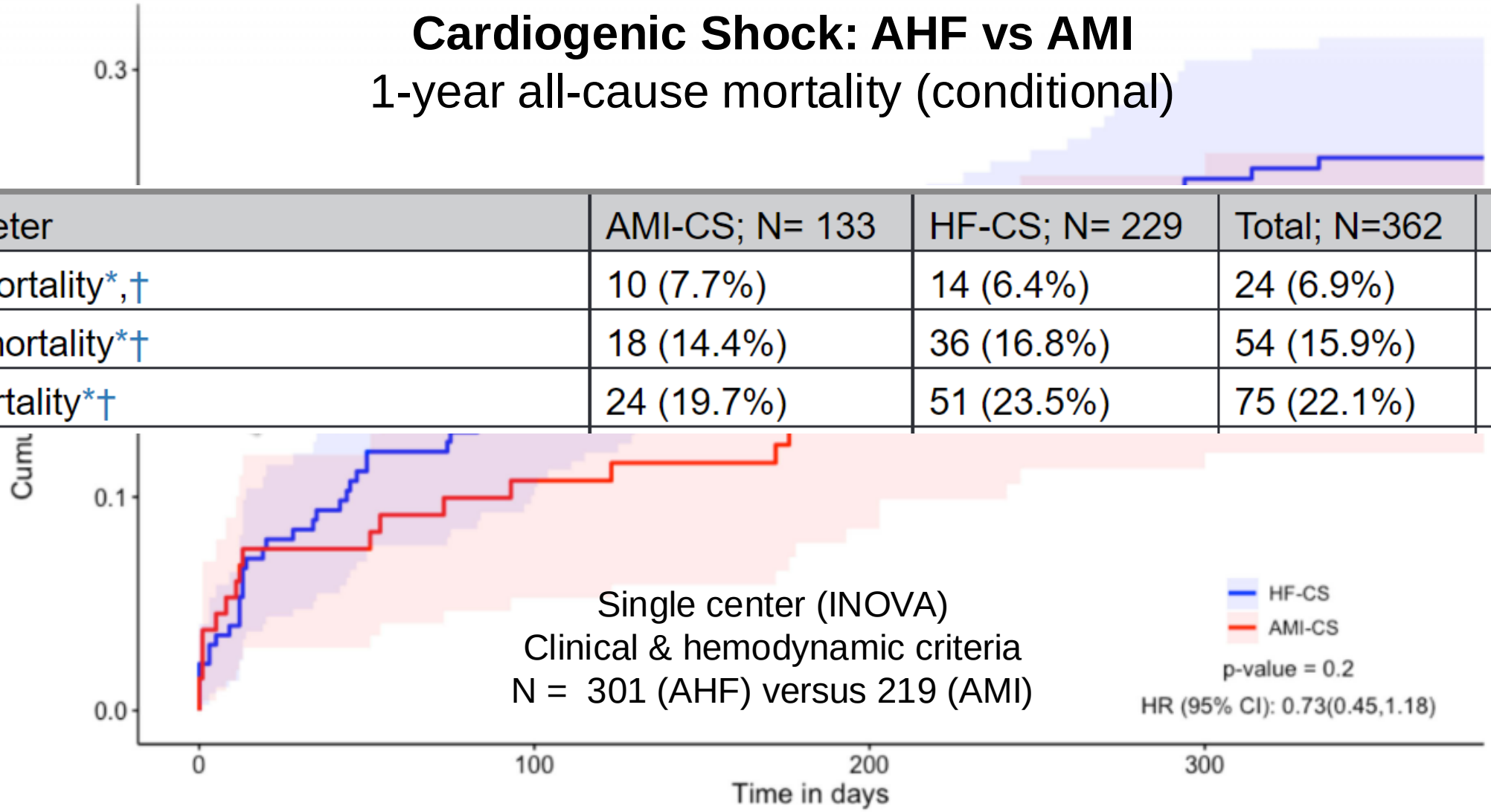
# Outcomes – Cardiogenic Shock

UT Southwestern Medical Center

## Cardiogenic Shock: AHF vs AMI

1-year all-cause mortality (conditional)

| Parameter | AMI-CS; N= 133 | HF-CS; N= 229 | Total; N=362 | *P* value |
|---|---|---|---|---|
| 30-d mortality*,† | 10 (7.7%) | 14 (6.4%) | 24 (6.9%) | 0.67 |
| 6-mo mortality*† | 18 (14.4%) | 36 (16.8%) | 54 (15.9%) | 0.65 |
| 1-y mortality*† | 24 (19.7%) | 51 (23.5%) | 75 (22.1%) | 0.41 |




Single center (INOVA)
Clinical & hemodynamic criteria
N = 301 (AHF) versus 219 (AMI)

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# Outcomes – CSWR

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## Total CS (MI + HF)

**Number of Devices**

| Number of Drugs: % Mortality (n-number) | 0 | 1 | 2 | 3 | 4+ |
|---|---|---|---|---|---|
| 0 | 7.4% (95) | 12.6% (206) | 26.1% (23) | N/A | N/A |
| 1 | 11.0% (620) | 19.3% (462) | 29.4% (102) | 21.4% (14) | N/A |
| 2 | 37.6% (173) | 31.5% (365) | 40.3% (149) | 40.9% (22) | 44.4% (9) |
| 3 | 59.1% (93) | 44.9% (225) | 50.9% (169) | 59.2% (49) | 40.0% (5) |
| 4+ | 85.1% (47) | 60.9% (161) | 68.0% (122) | 79.6% (44) | 66.7% (12) |
| | * | * | * | * | |

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# Outcomes – CSWR

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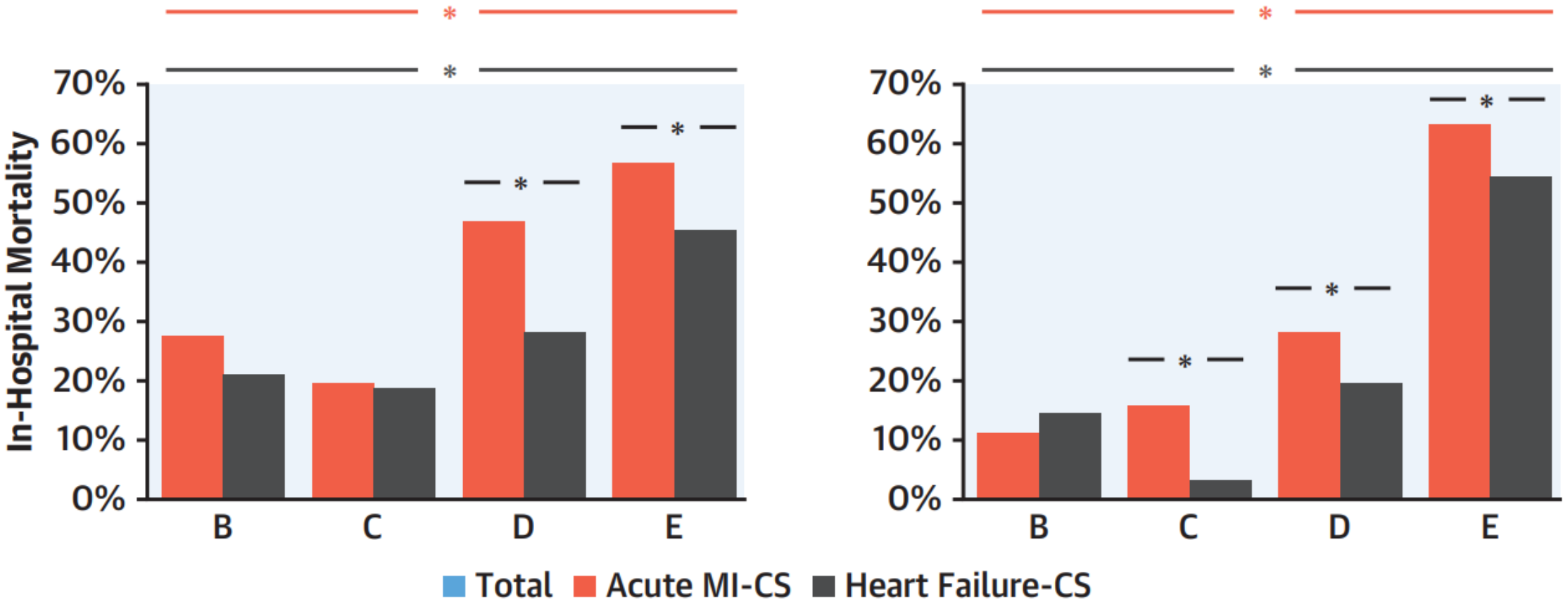
## In-hospital mortality by initial (left) and maximal (right) SCAI shock stage

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# Outline

UT Southwestern Medical Center

Cardiogenic shock definitions

Cardiogenic shock fundamentals

Scales (SCAI vs INTERMACs)

Demographics & Outcomes

**Management**

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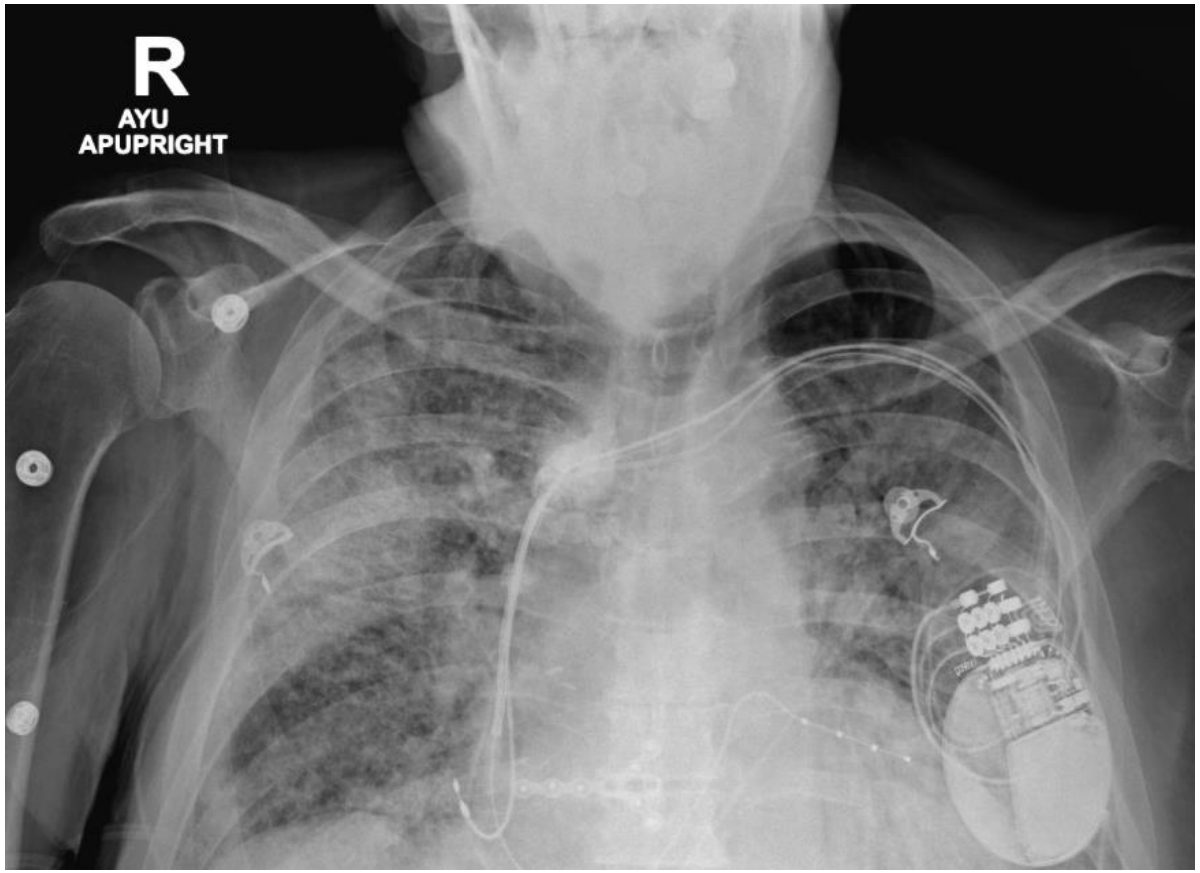
# Case 1 –

A 45-year-old man with a history of CAD with myocardial infarction presents with several days of lower extremity swelling, shortness of breath, chest pain and vomiting.

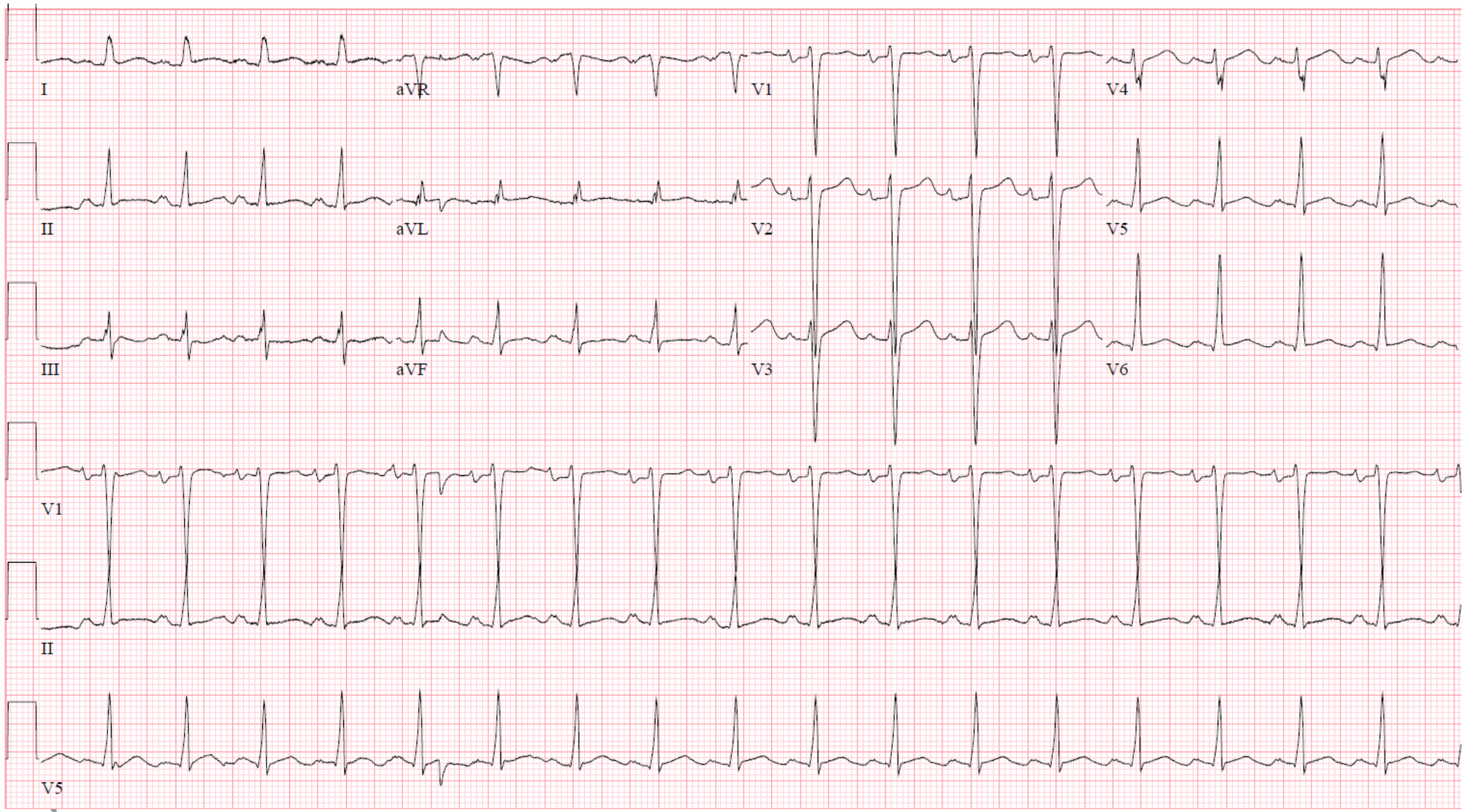
At rest, he appears unwell, tachypneic (RR >20 breaths/minute), tachycardic (130 bpm) and hypotensive (BP 75/50). 3+ lower extremity swelling and elevated JVP.

His labs are notable for a lactic acidosis, acute kidney injury and elevated liver function tests.



# Case 1 – ECG

UT Southwestern Medical Center

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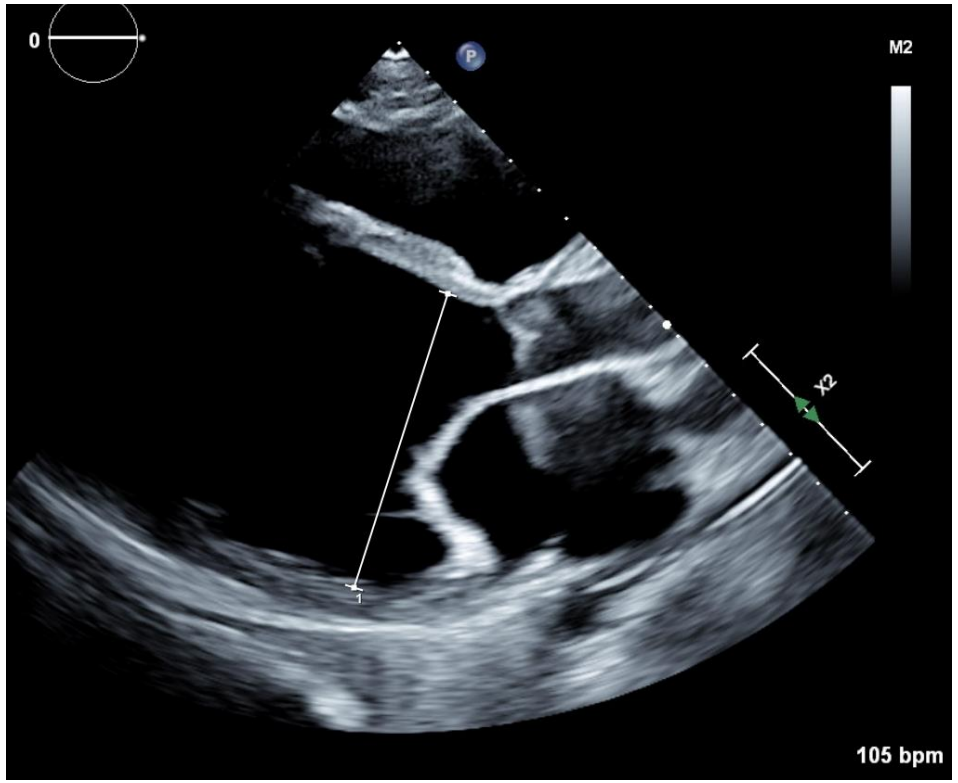
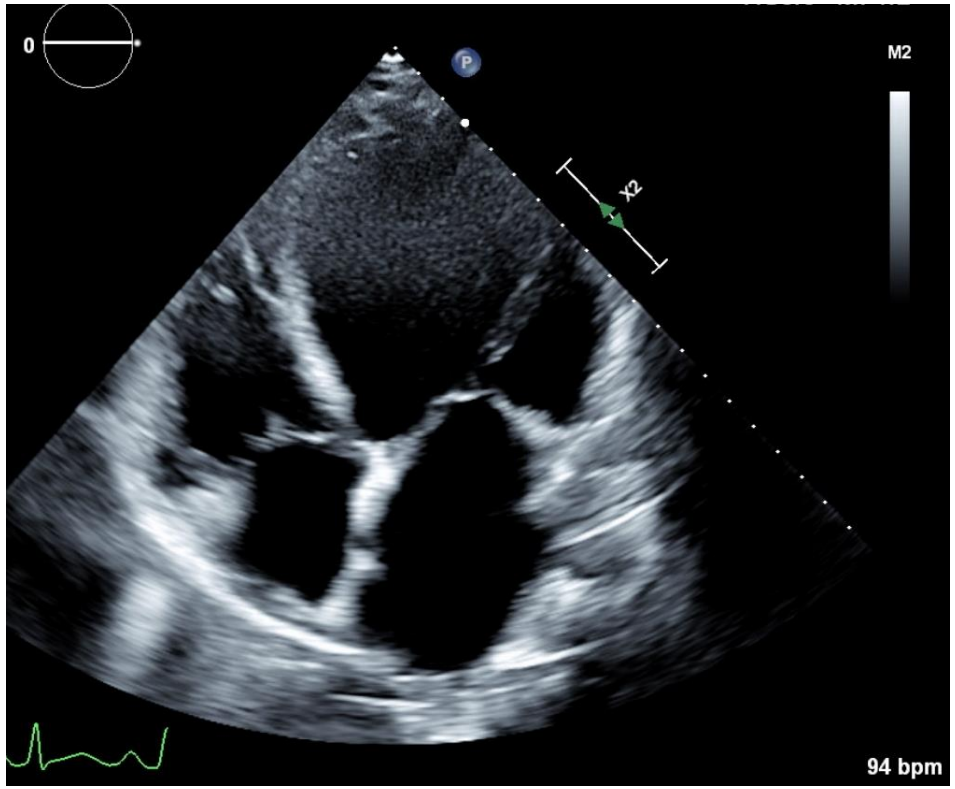
# Case 1 –

Point of care cardiac ultrasound

LVEF ~15%, severely dilated (7.5 cm LVEDD)

Aortic and mitral valve open well



# Case 1 –

**Diagnosis** – Dilated cardiomyopathy with cardiogenic shock

**Immediate treatment**

IV diuretics

Start IV dobutamine

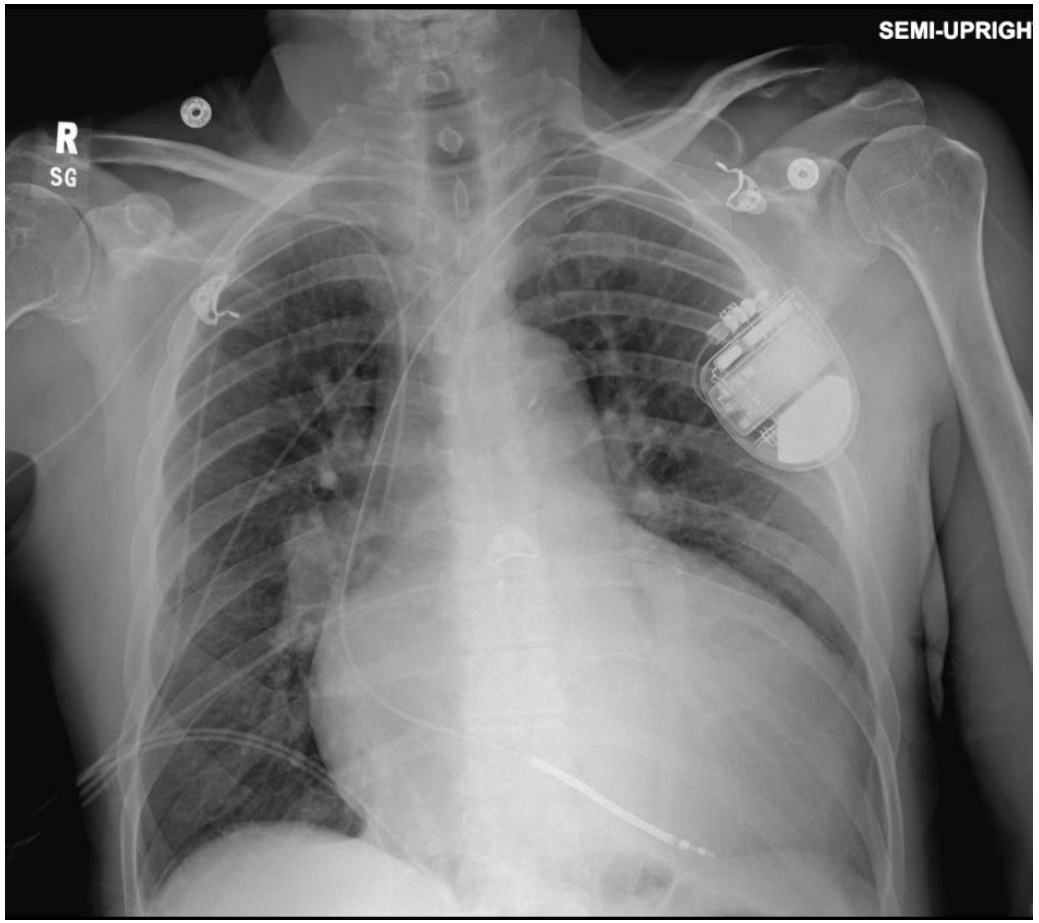
Add norepinephrine or vasopressin if MAP is <65 mmHg

# Cases 2 –

A 65-year-old man with a history of hypertension presents with several weeks of lower extremity swelling, shortness of breath, chest pain and abdominal pain.

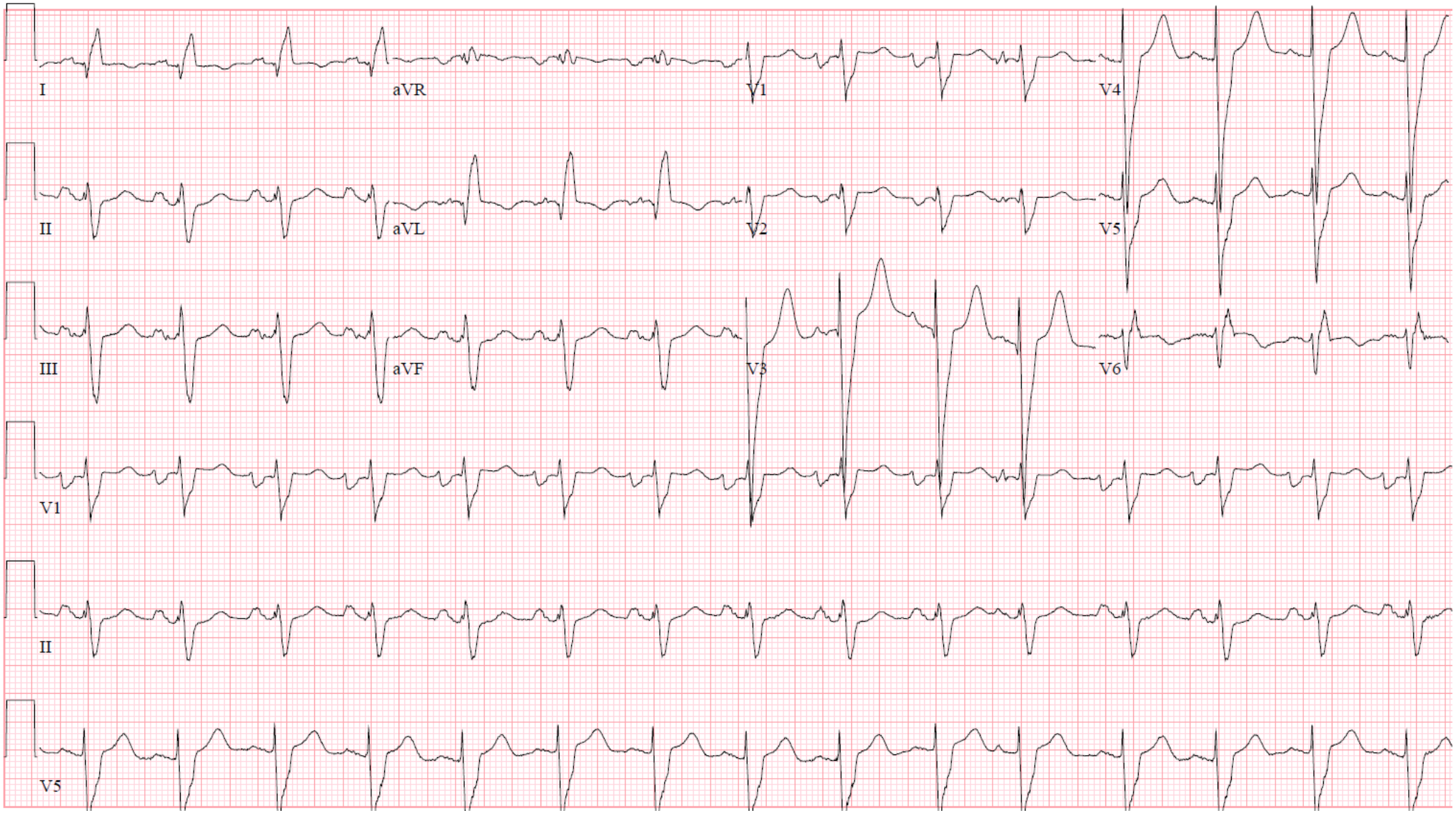
At rest, he appears restless, tachypneic (RR >20 breaths/minute), tachycardic (110 bpm) and normotensive (BP 175/130). +S4, lower extremity swelling and elevated JVP.

His labs are notable for an acute kidney injury and elevated liver function tests.



# Case 2 – ECG

UT Southwestern Medical Center

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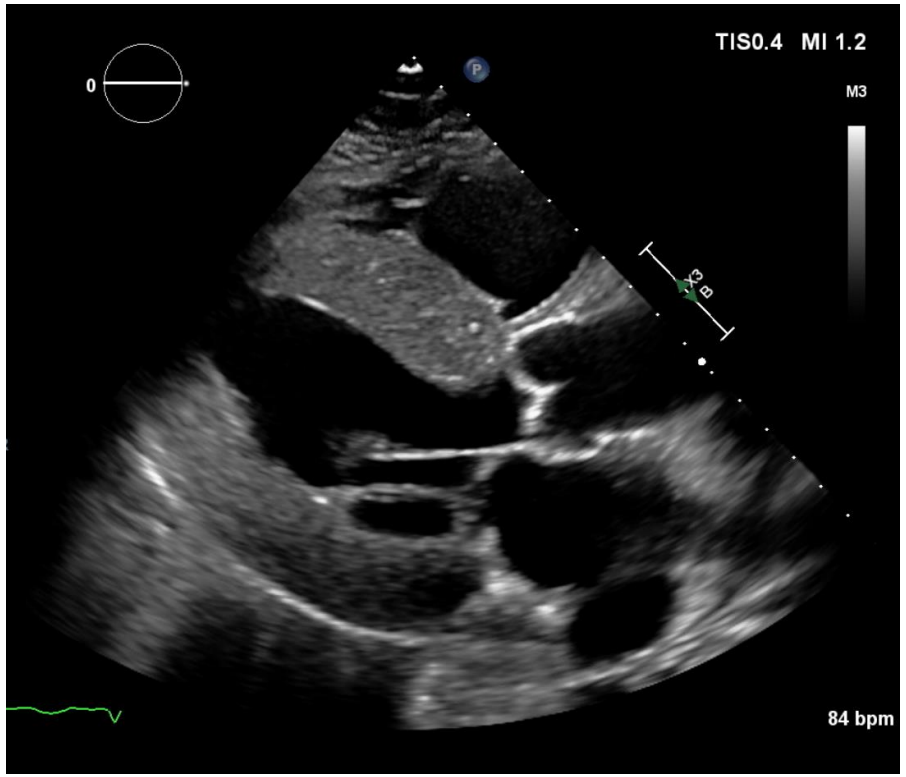
# Case 2 –

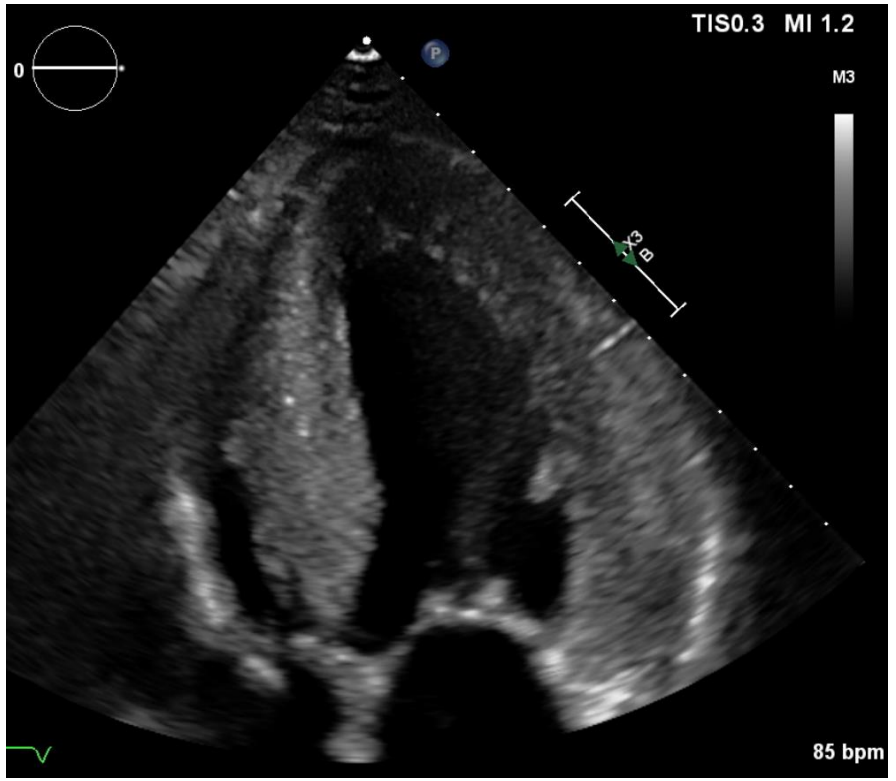
UT Southwestern Medical Center

**Point of care cardiac ultrasound**

LVEF ~30%, severe concentric hypertrophy (thickening)

Aortic and mitral valve open well

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# Case 2 –

UT Southwestern Medical Center

**Diagnosis** – Restrictive cardiomyopathy (severe thickening)
Related to hypertension or hATTR

**Immediate treatment**

IV diuretics

Medications to reduce blood pressure (ACE/ARB)

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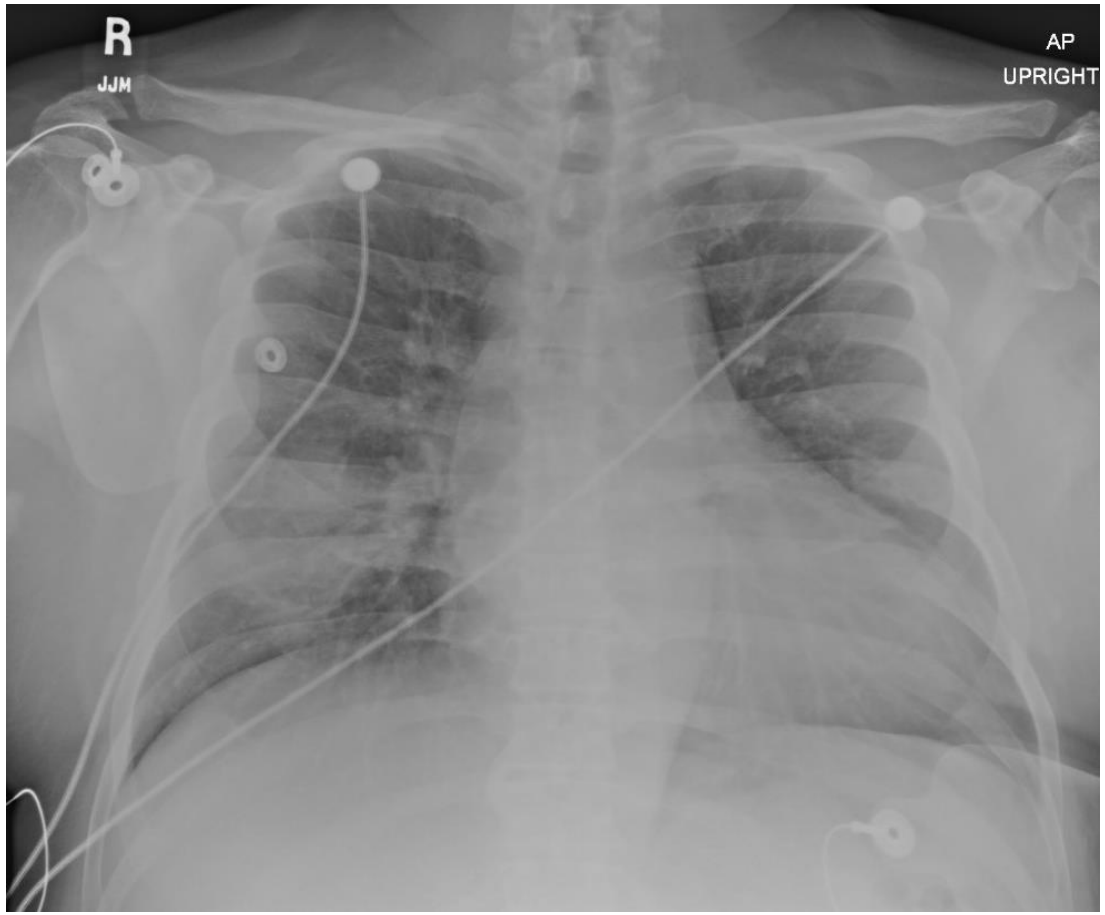
# Case 3 –

A 55-year-old man with a history of hypertension and smoking presents with 2 hours of chest pain, shortness of breath, and nausea.

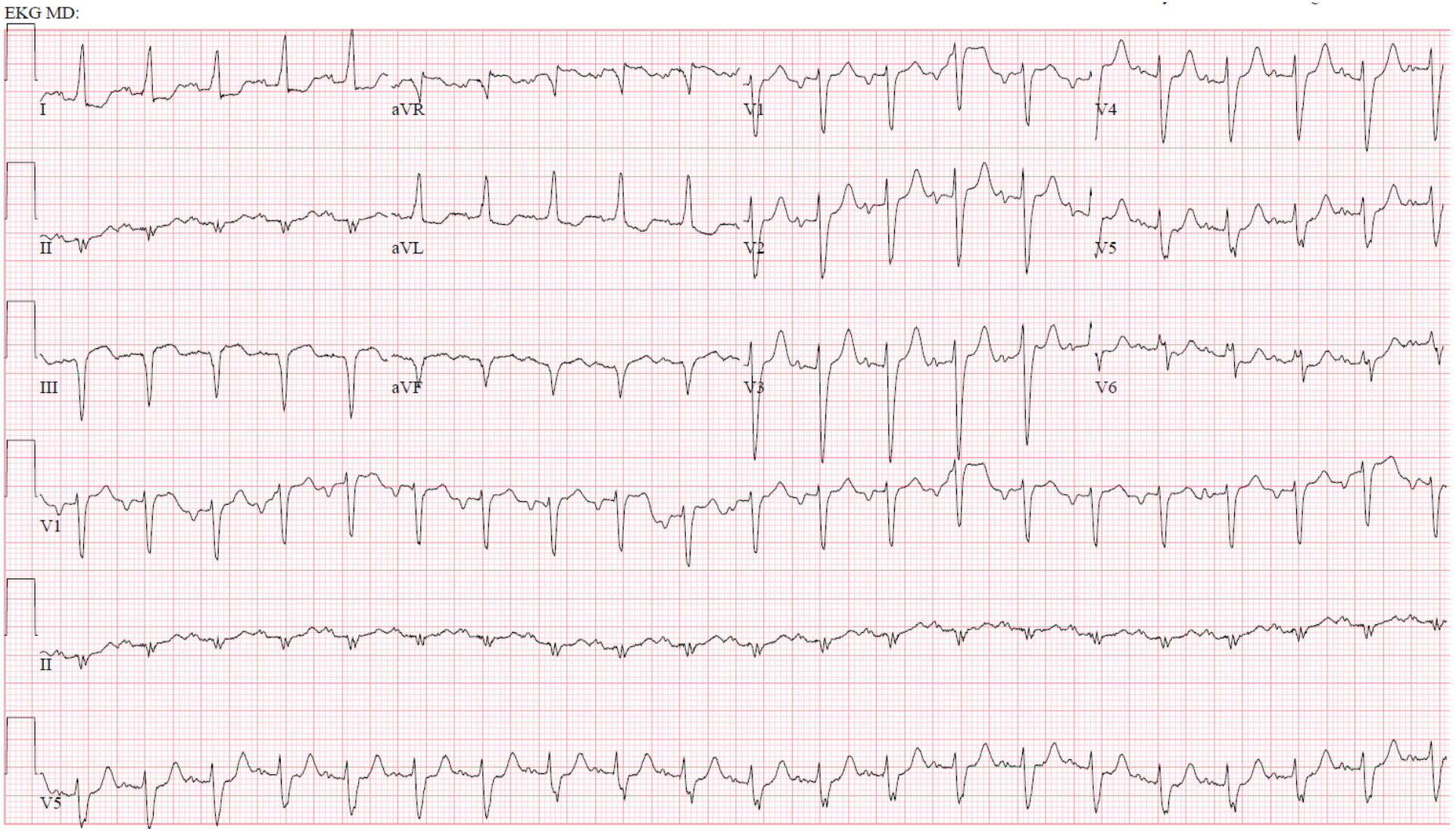
At rest, he appears uncomfortable with normal sinus rhythm (HR 80 BPM), and hypotensive (BP 75/30). +Rales, no lower extremity swelling and normal JVP.

His labs are pending.



# Case 3 – ECG

UT Southwestern Medical Center

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# Case 3 – Coronary angiography

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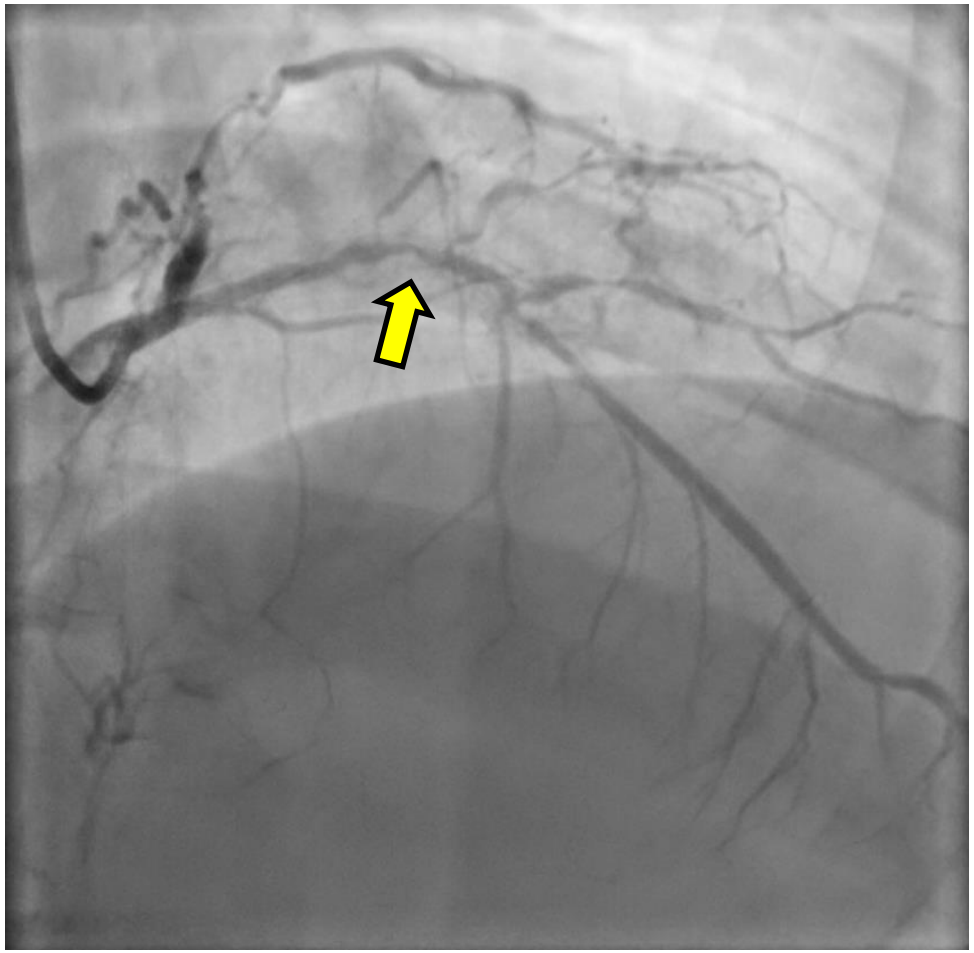
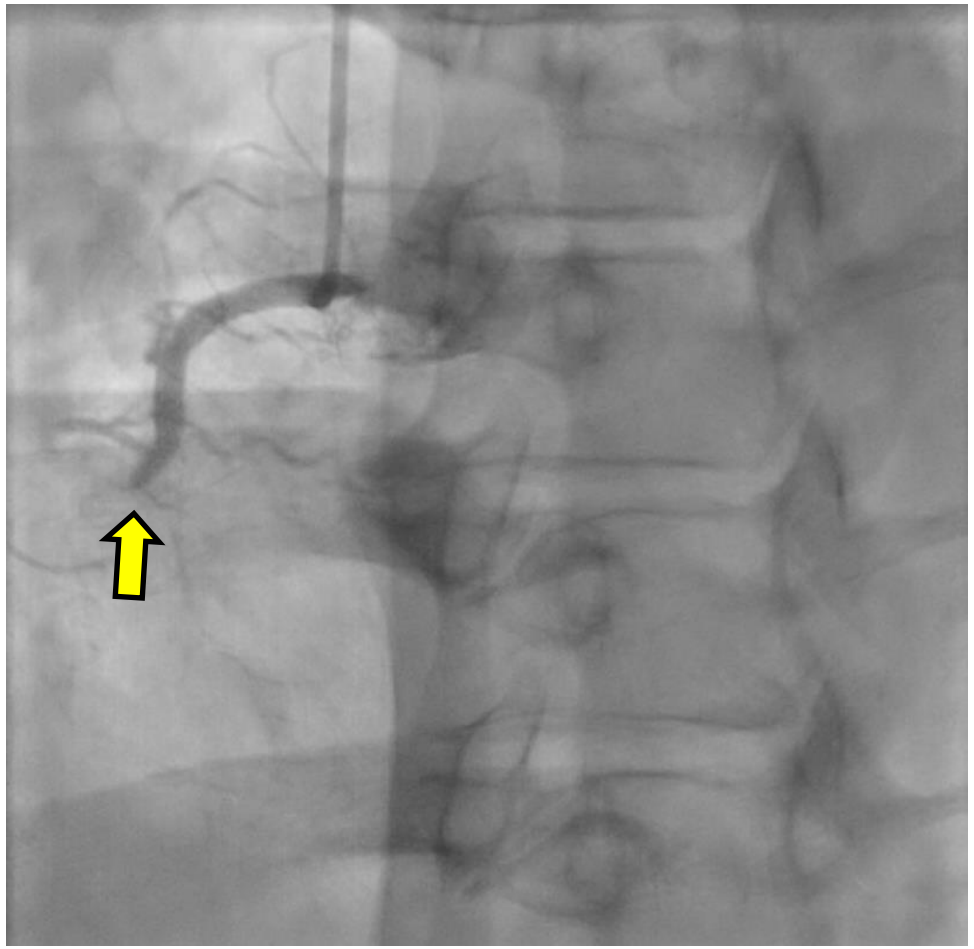
LAD with severe stenosis in mid portion (left image)
Right coronary artery totally occluded (right image)





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# Case 3 –

**Diagnosis** – ST elevation myocardial infarction

**Immediate treatment**

Emergent reperfusion – left heart catheterization or tPA

IV diuretics (rales)

Norepinephrine or vasopressin if MAP <65 mmHg

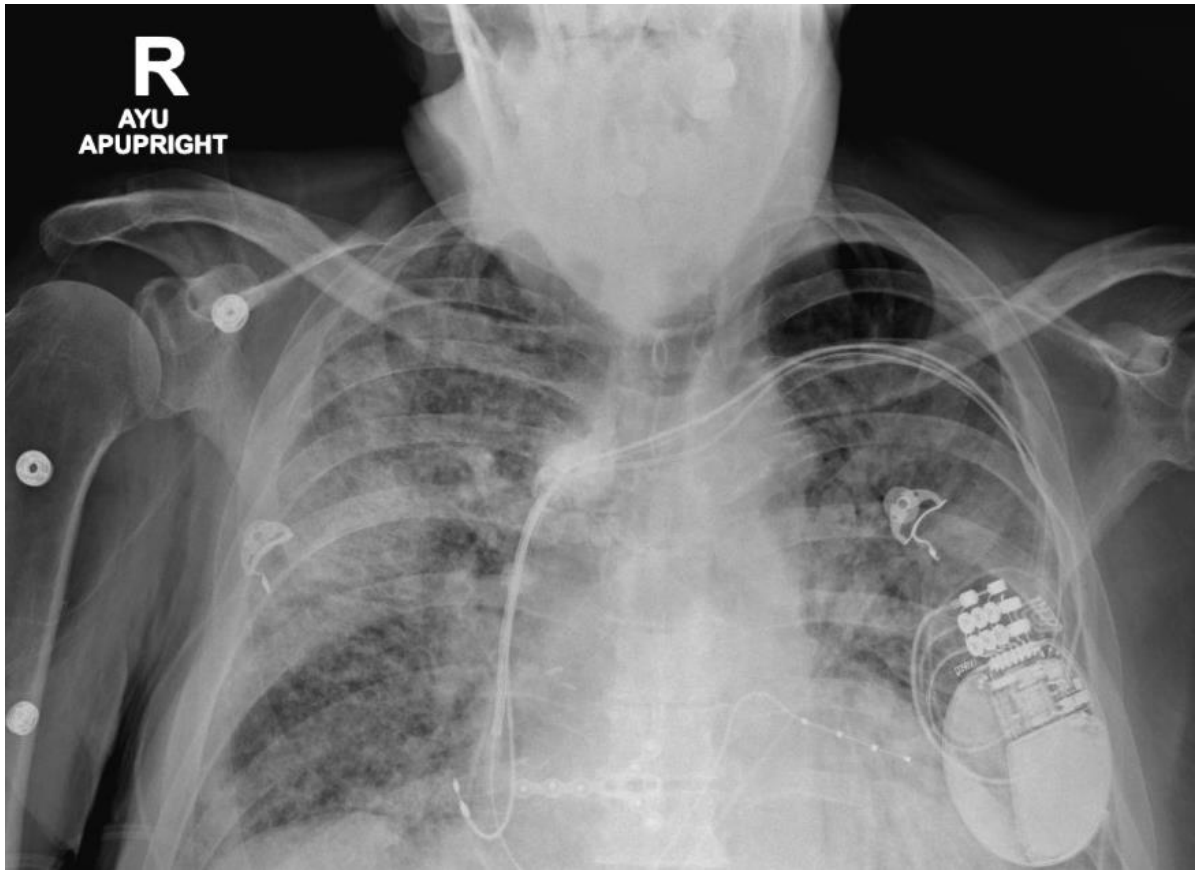
If shock post reperfusion, dobutamine or intra-aortic balloon pump

# Case 4 –

A 60-year-old woman with a history of hypertension presents with 2 months of chest pain, shortness of breath, and nausea.

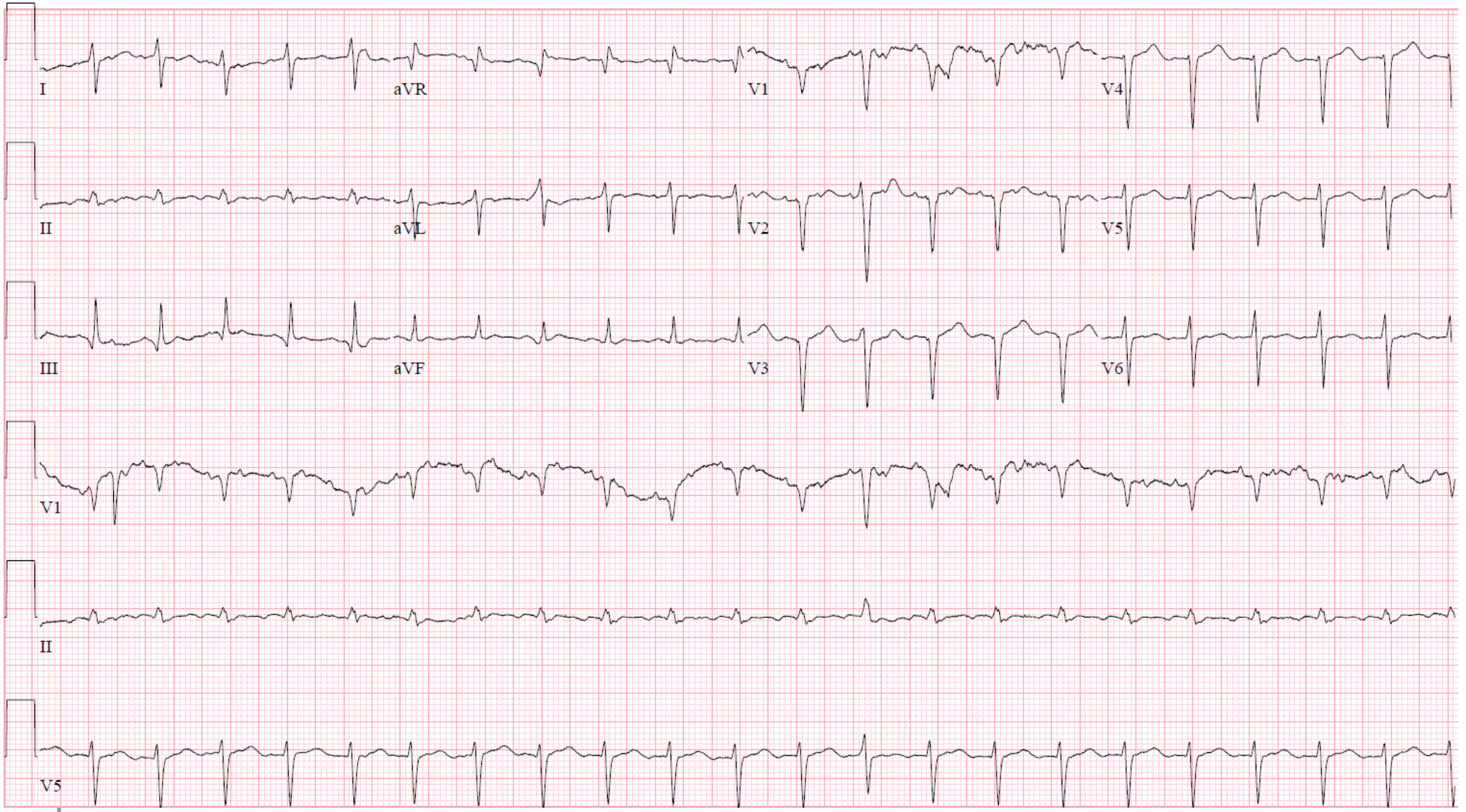
At rest, she appears uncomfortable with atrial flutter at 2:1 (HR 145 BPM), and normotensive (BP 115/95). +Rales, 2+ lower extremity swelling and elevated JVP.

His labs are notable for lactate of 2.5, acute liver injury and elevated creatinine (~2.5).



# Case 4 – ECG

UT Southwestern Medical Center

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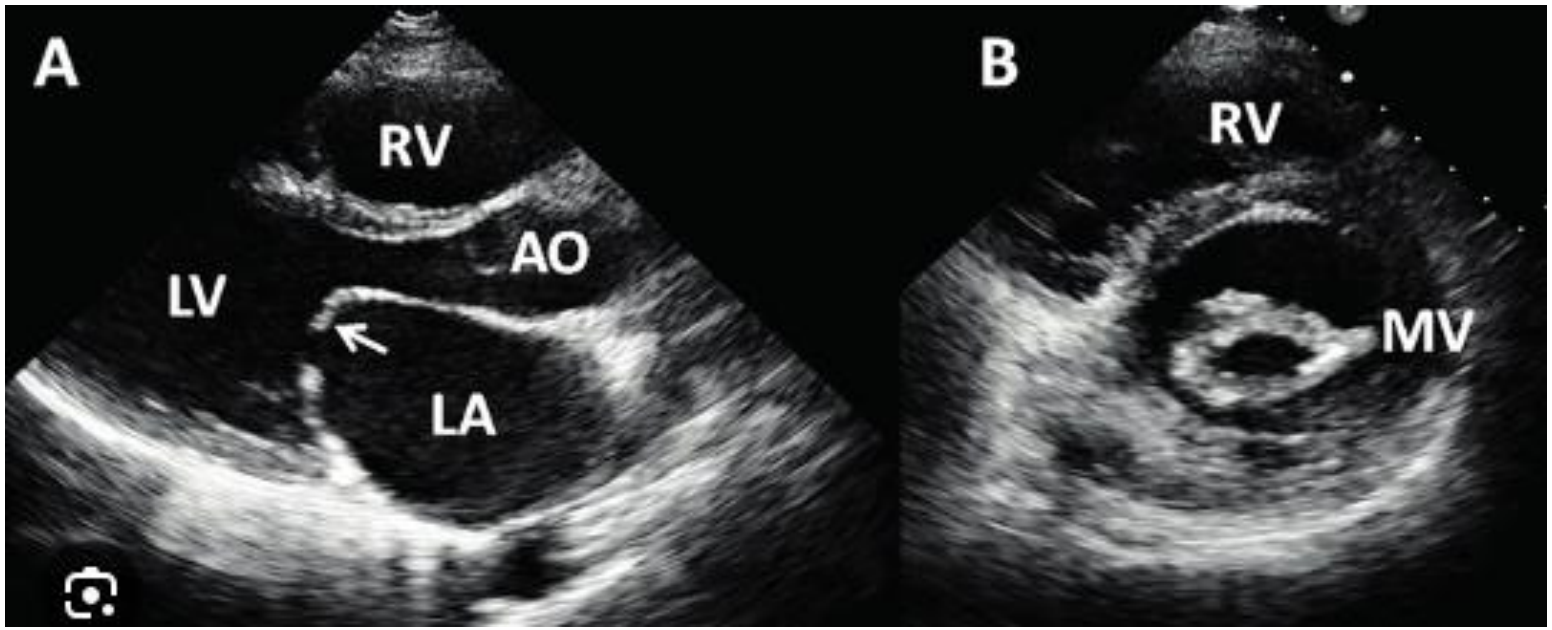
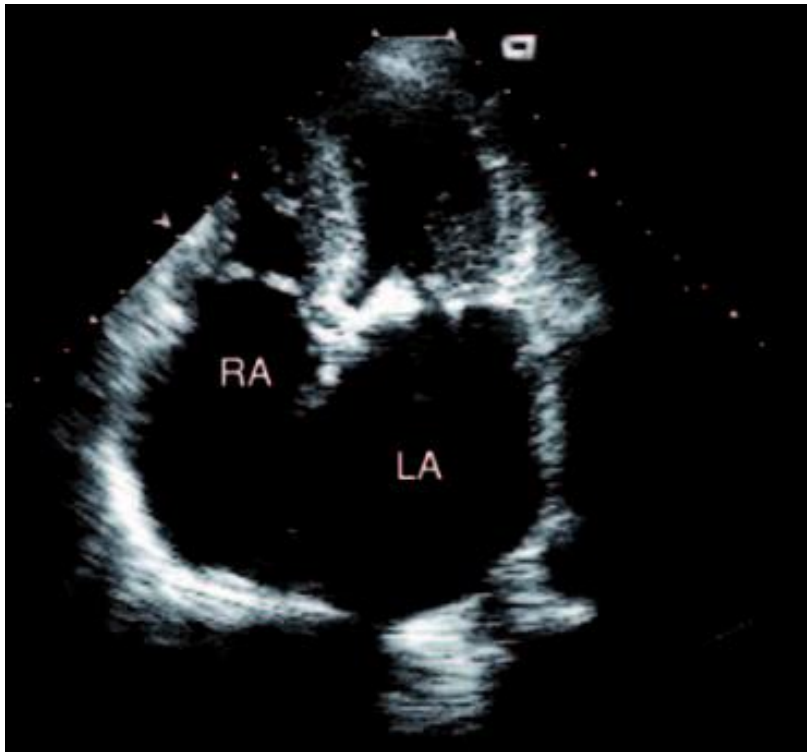
# Case 4 –

UT Southwestern Medical Center

## Point of care cardiac ultrasound

LVEF ~50%, concentric hypertrophy (thickening)
Aortic valve opens well. Mitral valve is heavily calcified with small opening
Massive left atrium

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# Case 4 –

**Diagnosis** – Severe mitral stenosis with cardiogenic shock (rheumatic valve)

**Immediate treatment**

IV diuretics

Beta-blockers to slow heart rate

Amiodarone to slow heart rate & rhythm control (ideally <70 bpm)

Therapeutic anticoagulation (for possible cardioversion)

Consider cardioversion

# Outline

UT Southwestern Medical Center

Cardiogenic shock definitions

Cardiogenic shock fundamentals

Scales (SCAI vs INTERMACs)

Demographics & Outcomes

Management

Parkland

# Summary

Diagnosis of cardiogenic shock can be tricky

Relying on lactate is a sometimes fool's errand (it can be helpful)

Recipe to shock management highly dependent on the patient

Urgent *correct* treatment (within 2 hours) is needed

ACS shock carriers a higher mortality relative to ADHF

In-patient shock mortality ~40-50%

# Question 1

UT Southwestern Medical Center

A 35-year-old woman with a history of moderate-to-severe mitral stenosis presents with worsening shortness of breath, sinus tachycardia (HR 140 bpm), and a blood pressure of 150/80 mmHg. She is noted to have an acute kidney injury (creatinine 1.0 --> 2.5), elevated lactate and elevated liver function tests (previously normal). An echocardiogram is notable for normal right and left ventricular systolic function with significant mitral stenosis. The ***most appropriate immediate management*** of her cardiogenic shock includes:

A. Intravenous diuretics and therapeutic anticoagulation
B. Intravenous diuretics and ACE-inhibitor administration
C. Intravenous diuretics and hydralazine administration
D. Intravenous diuretics and beta-blocker administration
E. ACE-inhibitor administration and beta-blocker administration

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# Question 2

UT Southwestern Medical Center

A 45-year-old man with a history of CAD with myocardial infarction and ischemic cardiomyopathy presents with several days of lower extremity swelling, shortness of breath, chest pain and vomiting. At rest, he appears unwell, tachypneic (respiratory rate >20 breaths/minute), tachycardic (130 bpm) and hypotensive (BP 75/50). His labs are notable for a lactic acidosis, acute kidney injury and elevated liver function tests. A point of care cardiac ultrasound is notable for a left ventricular fraction <20%. An ECG does not demonstrate ST elevation or depression. The ***most appropriate immediate management*** of her cardiogenic shock includes:

A. Initiation of dobutamine and beta-blocker administration
B. Initiation of dobutamine and intravenous diuretics
C. Initiation of milrinone and intravenous diuretics
D. Intravenous diuretics and ACE-inhibitor administration
E. Intravenous diuretics and beta-blocker administration

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Parkland

UT Southwestern Medical Center

# Questions or Comments?!