Mechanical Circulatory Support

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Core Curriculum Conference

July 31, 2018

UNIVERSITY of MARYLAND
MEDICAL CENTER

Objectives

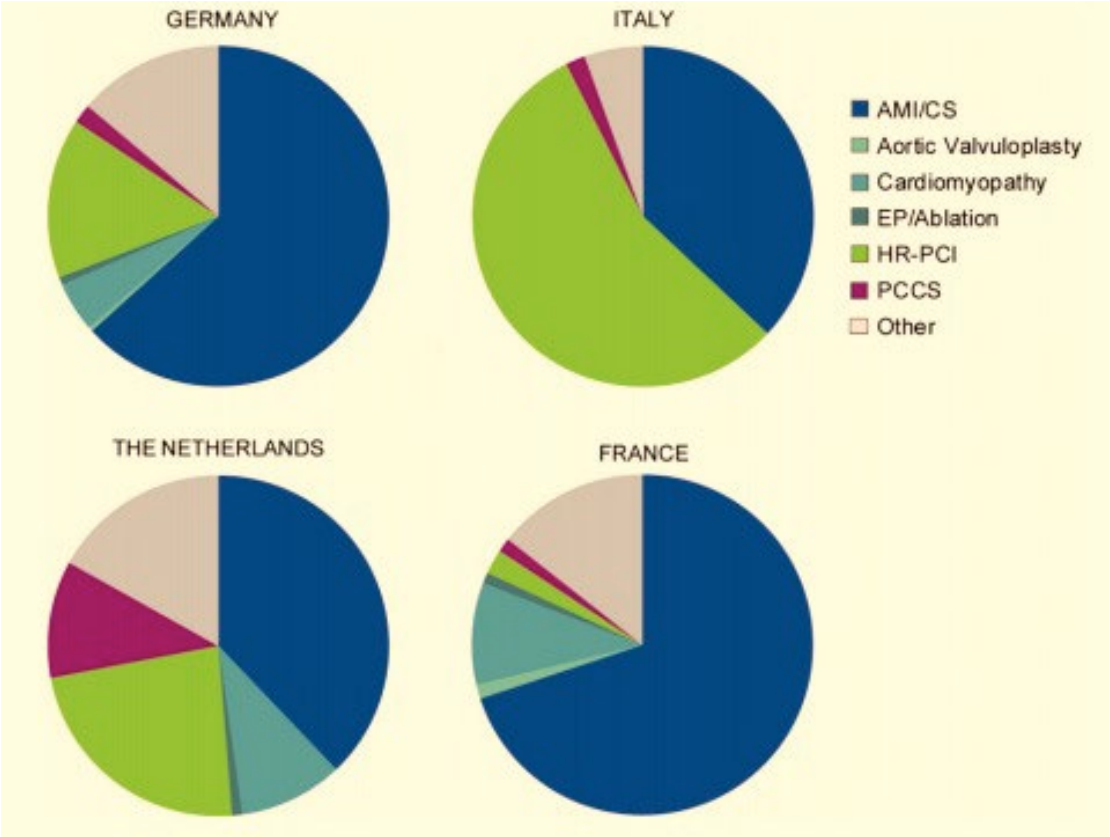
- *Define the candidate population for MCS*
- *Review physiological goals of MCS*
- *Review MCS modalities*
- *Review literature*
- *Cases*

Indications

- ***Cardiogenic Shock***
  - ***AMI***
  - ***Acute decompensated HF***
  - ***Fulminant myocarditis***
  - ***Cardiac allograft failure***
  - ***Post-cardiotomy shock***
  - ***Refractory arrhythmias***
- ***Elective***
  - ***HR-PCI***
  - ***HR-EP procedure***

JACC 2015; 65(19)

Geographic Distribution of Impella Indication



Burzotta et al. Intl J of Cardiol (201). 2015

Who needs MCS?

- **Clinical Features**
  - **Cardiac index < 2.2 on pressors or < 1.9**
  - **Elevated PCWP/Pulmonary edema**
  - **Pressor requirement**
  - **End-organ Damage**
    - **AKI/Mental status/Elevated LFTs/Lactic Acidosis**

J Am Coll Cardiol Intv 2015;8:229-44
J of Thoracic Disease 2018;10(Suppl 15):S1811-S1818

Who needs Elective MCS?

- ***HR-PCI***
  - LM or LM equivalent
  - MVD
  - Bifurcation lesions
  - Degenerated SVG
  - Target vessel subtending > 40% of myocardium
- ***HR-Ablation***
  - Incessant VT
- ***Inability to withstand:***
  - Dysrhythmia
  - Transient intervals of ischemia-reperfusion injury
  - No Re-flow

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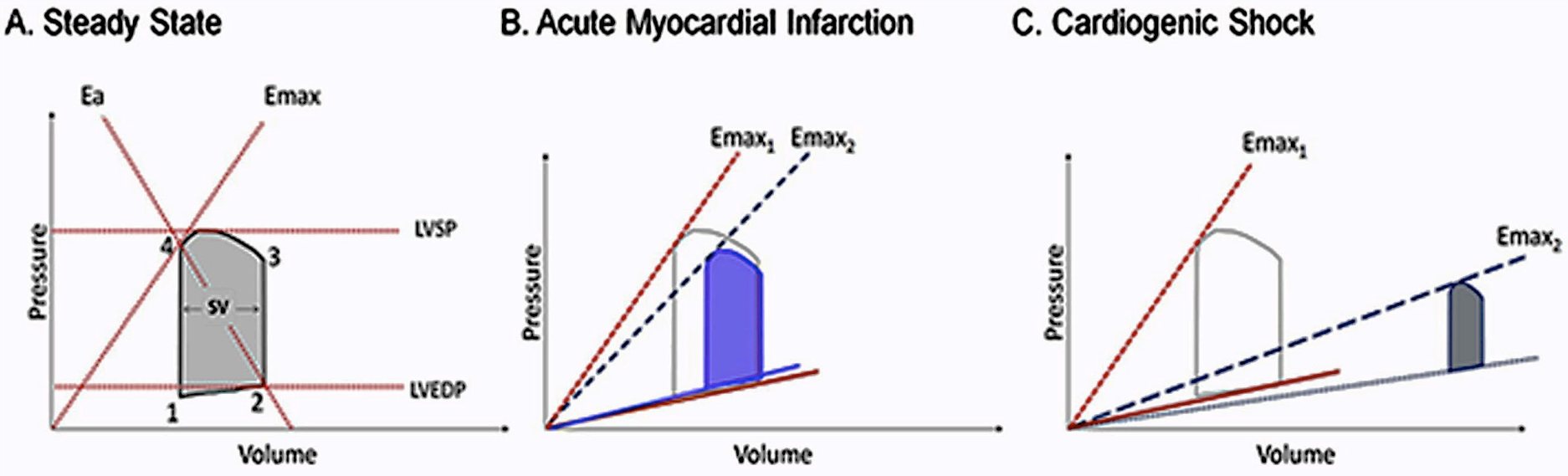
Cardiogenic Shock Physiology



- ⑩🡻 CBF
- ⑩🡻 LV contractile function -> 🡻SV -> Reduced MAP/CO
- Diastolic dysfunction -> 🡹 LVEDP -> 🡹 LV work/MVO_2

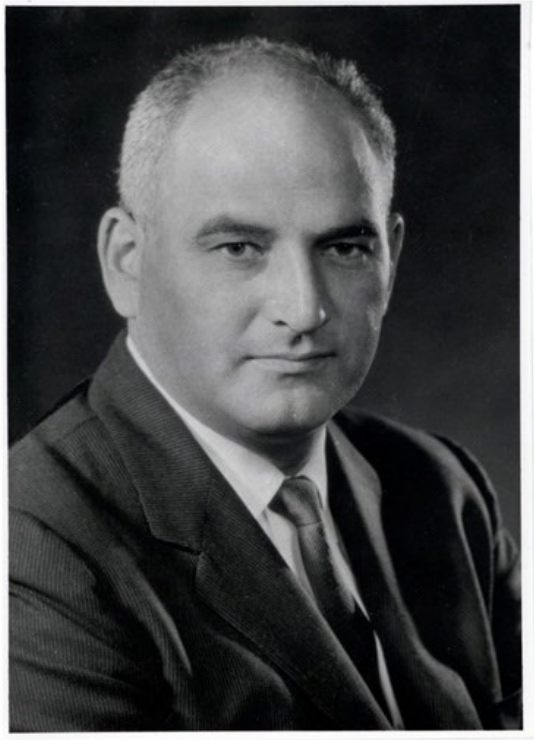
MCS Physiology

- ***Augment Cardiac Power (MAP*CO/451)***
  - **Maintain vital organ perfusion (MAP/CO)**
- ***Improve coronary perfusion***
- ***Reduce intra-cardiac filling pressures (LVEDP/PCWP)***
  - **Reduce LV wall stress/MVO_2**

JACC 2015; 65(19)

MCS Physiology

- ***Adrian Kantrowitz placed 1st IABP in 1968***
  - **Effective efficient insertion**
  - **Simplicity of maintenance**
  - **Ability to institute for several days**



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N Engl J Med 1999; 341:625-34

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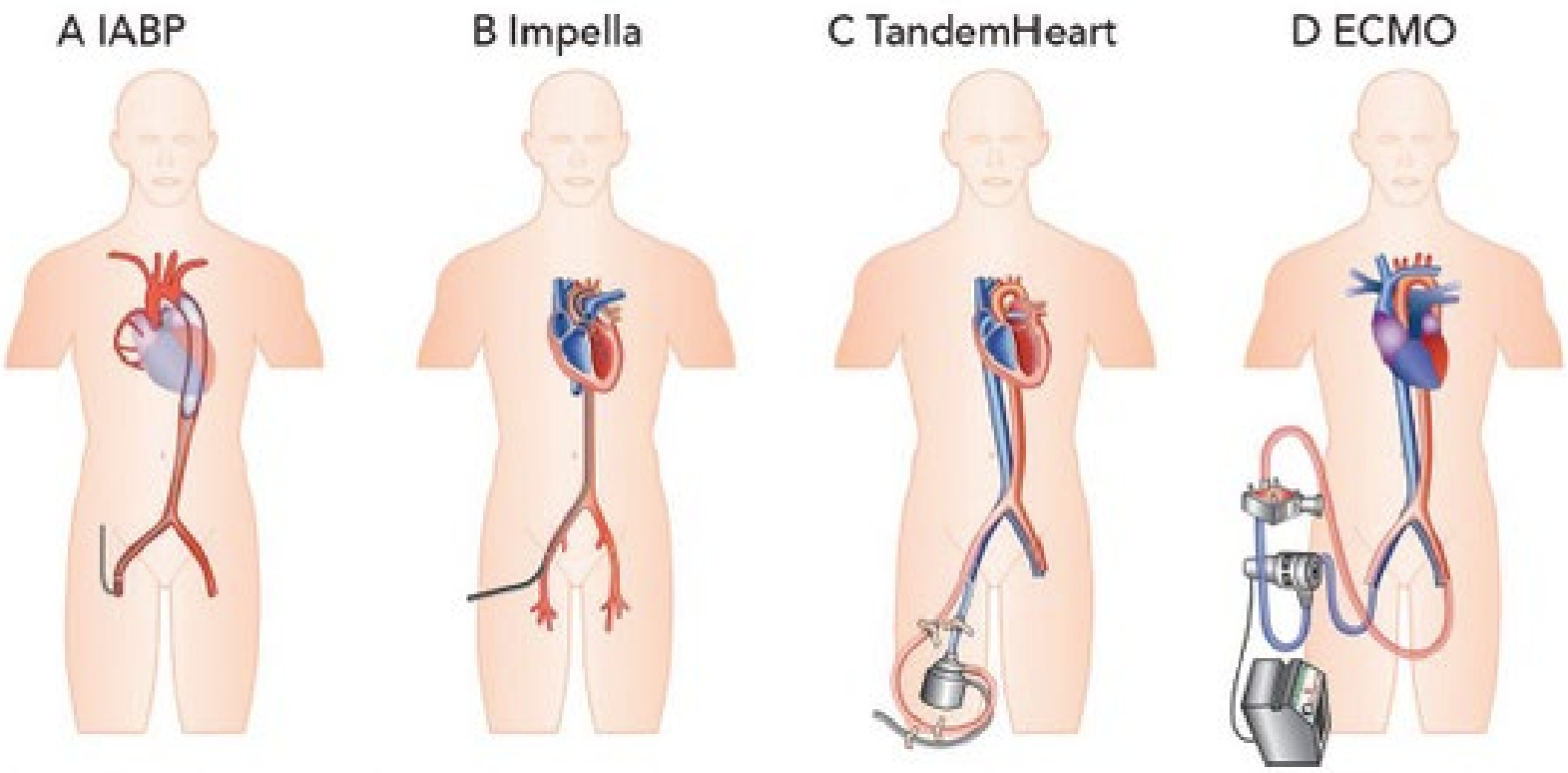
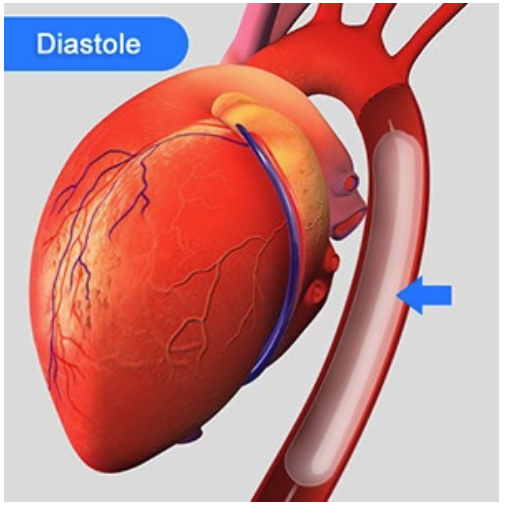
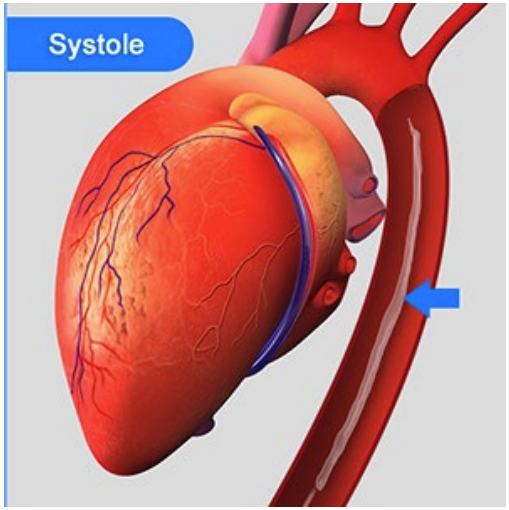
Mechanical Circulatory Support (MCS)



IABP

- *Active inflation augments diastolic blood flow*
  - Increases MAP -> Increased CBF
- *Active deflation reduces afterload*
  - Decreased LVEDP/Work
- *Support dependent on volume of blood displacement (0.3 – 0.5L)*
- *Requires stable rhythm*
- *Enhances inherent LV function*





J Am Coll Cardiol Intv 2015;8:229-44

IABP

- ***Registry and Retrospective Analyses are in-conclusive***

- ***BCIS-1 Trial -> HRPCI***
- ***CRISP-AMI -> AMI without Shock***
- ***IABP-SHOCK II -> AMI with Shock***

- ***Meta-Analyses***

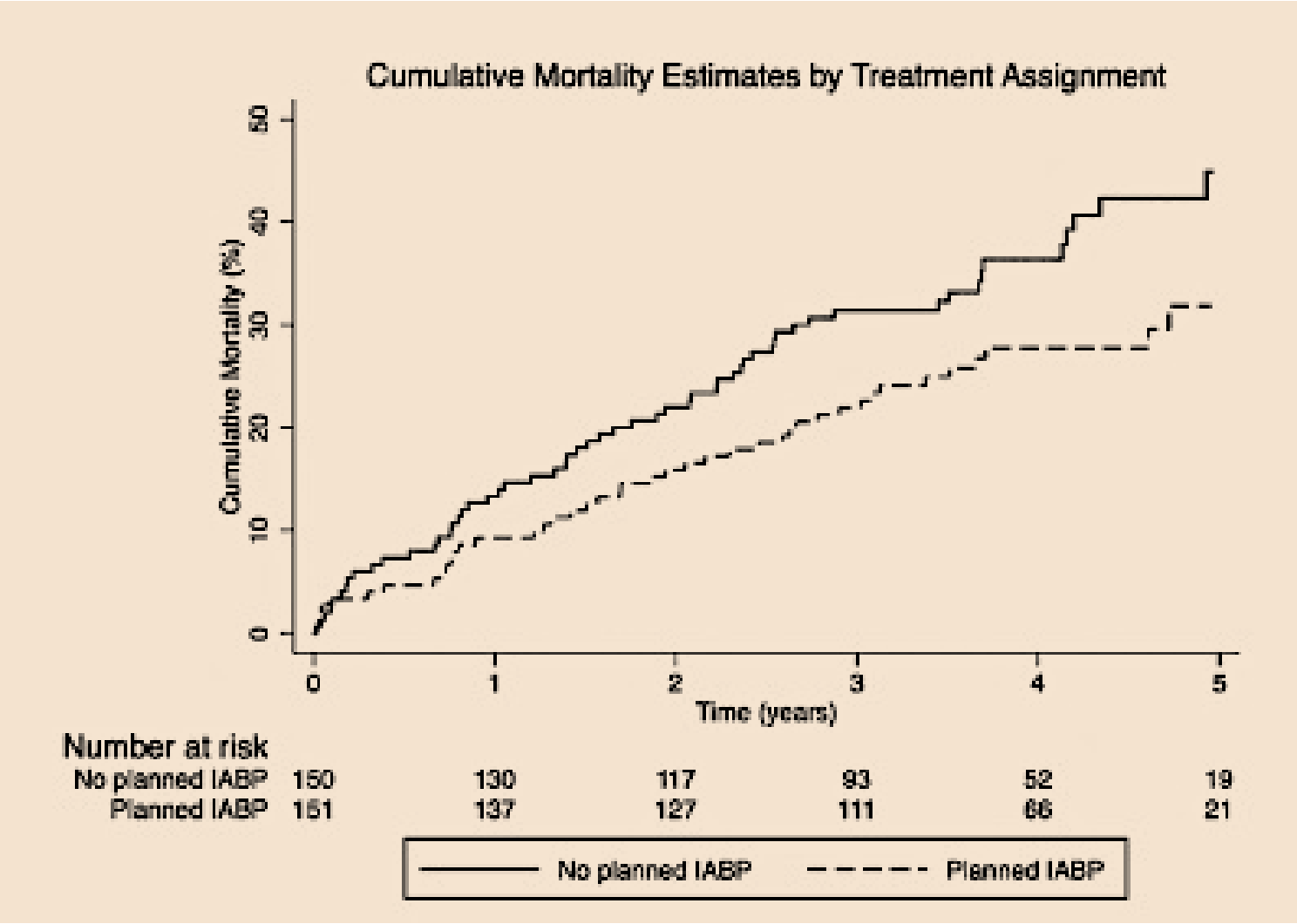
J Am Coll Cardiol Intv 2015;8:229-44

IABP

- *BCIS-1, 2010*
  - 301 pt, Prospective, Open-label, MCT, RCT in UK
  - Elective IABP before HR PCI vs. Standby Use
  - 1°: MACCE at 28d -> **15.2% v. 16%**
  - No difference in 2° of 6m mortality or bleeding
  - 18 patients cross-over (12%)
  - 5yr all-cause mortality from BCIS shows a significant reduction in IABP group

J Am Coll Cardiol Intv 2015;8:229-44
Circulation 2013 (12): 207-12

IABP



Circulation 2013 (127): 207-12

IABP

- ***CRISP-AMI, 2011***
  - **337pt Prospective, Open-label, MC (30) RCT**
  - **Anterior MI patients without CS**
  - **IABP prior to 1° PCI + 12hr v. Provisional IABP**
  - **1° : LV infarct size at 3-5d -> 42.1% v. 37.5%**
  - **15 patient crossover (8%)**
  - **No significant difference in all-cause mortality, vascular complications, bleeding at 30d or 6m**

JAMA 2011;306(12):1329-37

IABP

- ***IABP-SHOCK II, 2013***
  - **600 pt, Prospective, Open-label, MCT, RCT**
  - **AMI with CS**
    - **No CI, PCWP measured; Hemodynamic definition**
    - **90% in both arms on catecholamines**
  - **1°: 30d All-cause mortality -> 39.7% v. 41.3%**

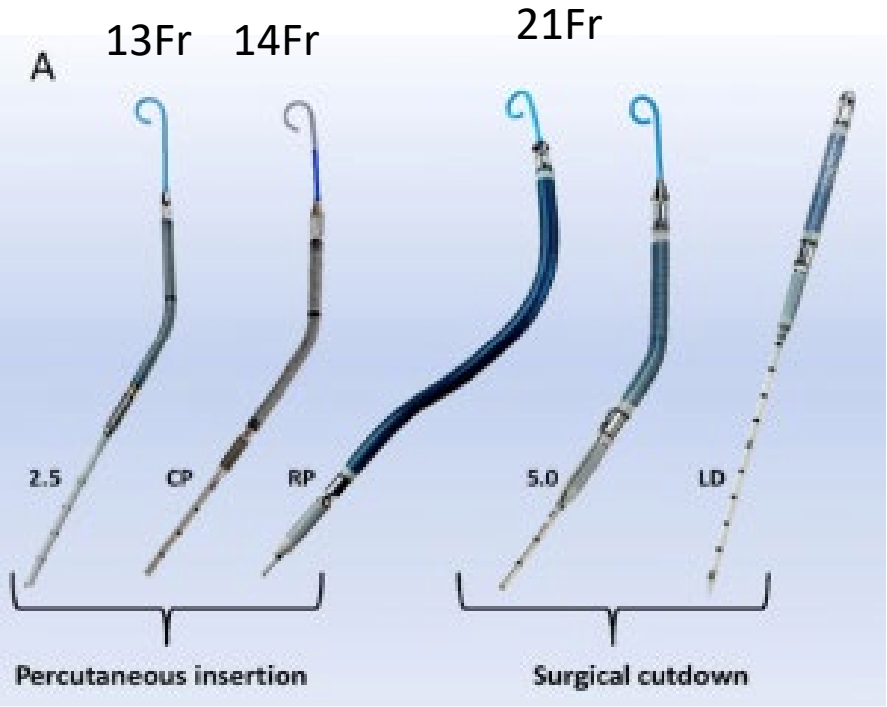
J Am Coll Cardiol Intv 2015;8:229-44

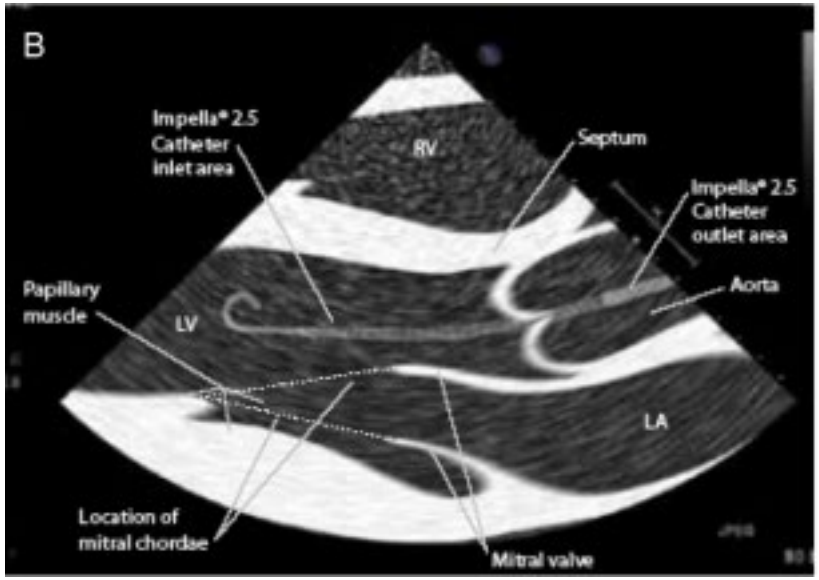
IABP

- ***Window of opportunity?***
- ***Too little support?***
- ***Co-morbid SIRs, multi-organ dysfunction, microvascular dysfunction overcome benefit?***
- ***Potentially un-studied long-term benefits?***
- ***Class IIa for CS complicating AMI***

J Am Coll Cardiol Intv 2015;8:229-44

Impella





J Am Coll Cardiol Intv 2015;8:229-44
International Journal of Cardiology 201 (2015): 684-91

Impella

- ***Key Physiologic Mechanisms:***
  - **LV unloading with reduced LVEDP/LVEDV/wall tension and reduced MVO_2**
  - **Improved MAP/CO/Cardiac Power/coronary perfusion**
  - **Reduction in PCWP -> Unloading of LV/RV**
  - ***Load but not rhythm dependent***
  - ***V-A gradient impacts flow***

J Am Coll Cardiol Intv 2015;8:229-44
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Impella

- ***Protect II, Prospective, MC RCT, 2012***
  - **IABP v. Impella 2.5 in non-emergent HR-PCI**
  - **452 Patients / Target 654**
    - **Trial terminated early for futility**
  - **30d MAE at DC/30d -> No difference (35.1% v. 40.1%)**
  - **90d significant reduction in MAE in PP analysis in Impella group (40% v. 51%)**

Circulation 2012;126:1717-27

Impella

Table 4. Combined In- and Out-of-Hospital Hierarchical Outcomes for the Per Protocol Population

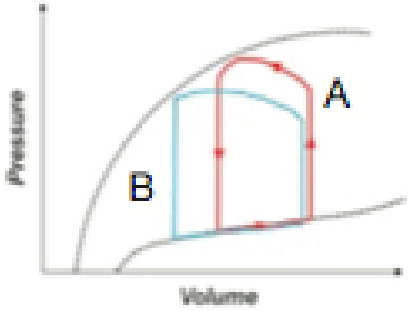
	30 Days			90 Days		
	IABP (n=211)	Impella 2.5 (n=216)	*P*	IABP (n=210)	Impella 2.5 (n=215)	*P*
Composite of major adverse events	42.2	34.3	0.092	51.0	40.0	0.023
Death	6.2	6.9	0.744	9.0	11.6	0.383
Stroke/TIA	1.9	0.0	0.042	2.4	0.9	0.240
Myocardial infarction	10.9	13.4	0.425	14.8	11.6	0.340
Repeat revascularization	4.3	1.4	0.072	8.1	3.7	0.055
Need for cardiac or vascular operation*	1.4	0.9	0.634	1.9	1.4	0.680
Acute renal dysfunction	4.7	4.2	0.774	4.8	4.2	0.774
Cardiopulmonary resuscitation/ventricular arrhythmia†	3.3	2.3	0.531	4.3	2.3	0.258
Aortic valve damage/increase in aortic insufficiency	0.0	0.0	. . .	0.0	0.0	. . .
Severe hypotension requiring treatment	9.0	4.6	0.072	5.7	3.7	0.332
Angiographic Failure	0.5	0.5	0.987	0.0	0.5	0.322

Comparison of IABP with Impella

Effect on Cardiac Work

Balloon Pump

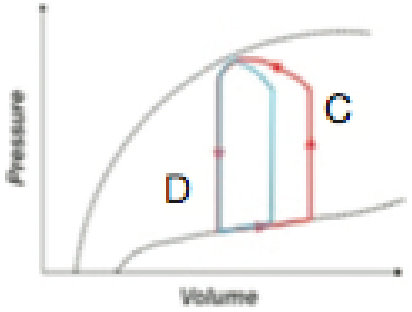
- Reduces systolic aortic pressure
- Increases Stroke volume



Stroke Volume increase offsets pressure reduction

Impella

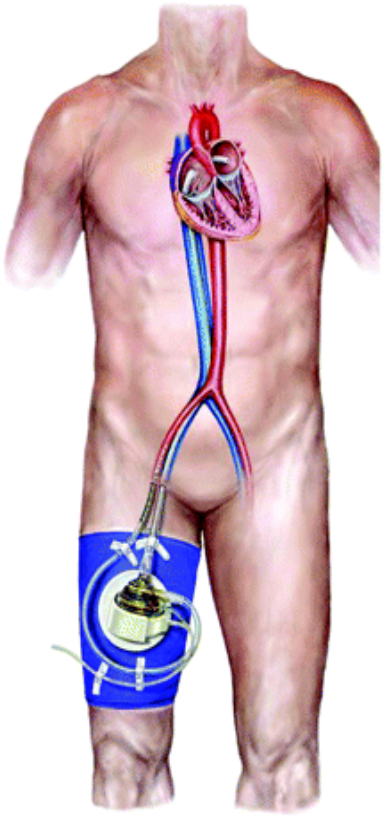
- Unloads left ventricle
- Reduces diastolic volume

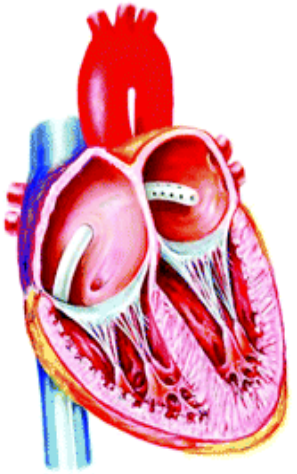


Volume reduction reduces PV loop area and cardiac work

Tandem Heart

- *4-5L support*
- *Parallel circuit*
- *Femoral Vein/Trans-septal (21Fr)/Femoral Artery access (17Fr)*
- *Limb ischemia, hemolysis, longer implant times, complex management, TSP*
- *No mortality benefit when compared with IABP in 2 small RCTs in AMI w/CS*





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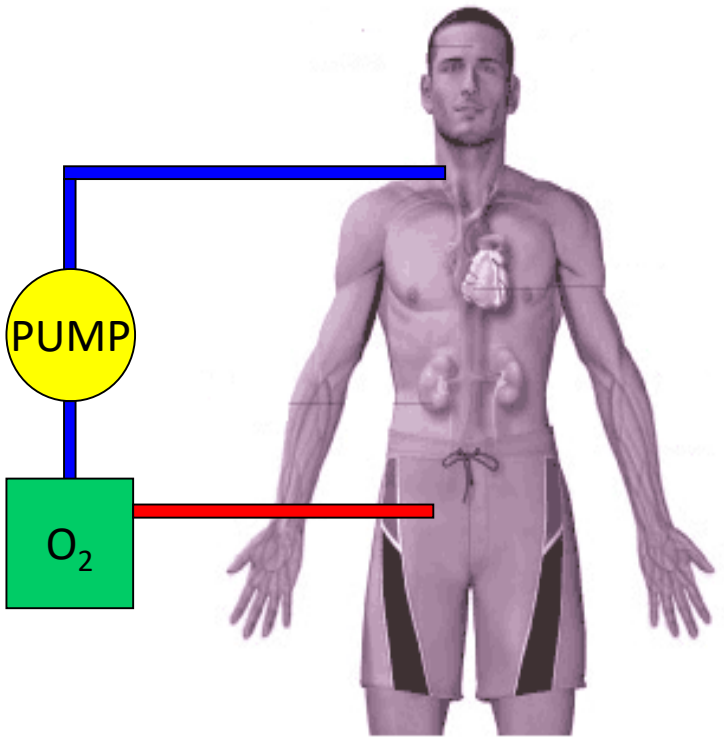
ECMO

- *Parallel CPB circuit providing hemodynamic/ventilatory support*
- *>20Fr Venous/Arterial cannulas*
- *Increased LV afterload*
- *Hemolysis/AC/Limb ischemia/CNS events*



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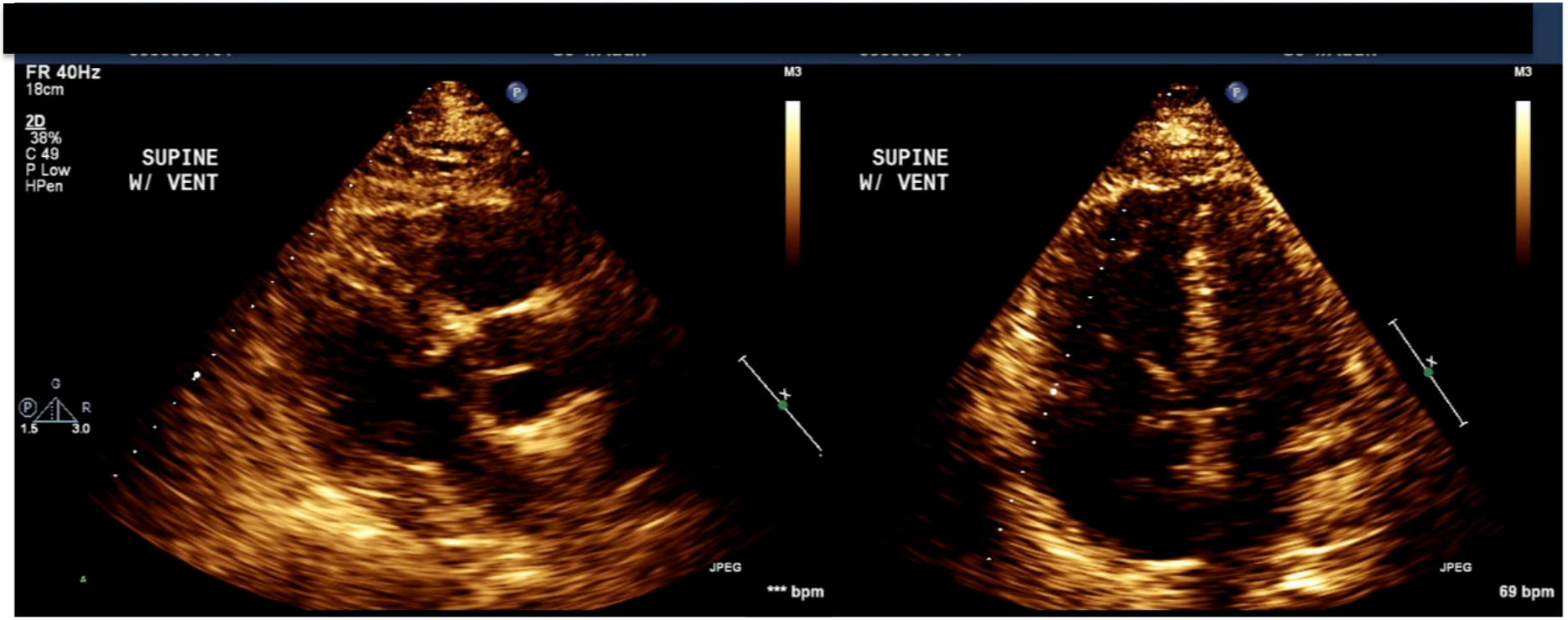
Case 1.

- *73M, HTN, HLP, Prostate Ca*
- *Presented to OSH with CP, iSTE*
- *LHC performed, unable to engage RCA*
- *LV gram showed normal LVEF*
- *Patient with progressive hypotension after PE ruled out*
- *Transferred to our institution*

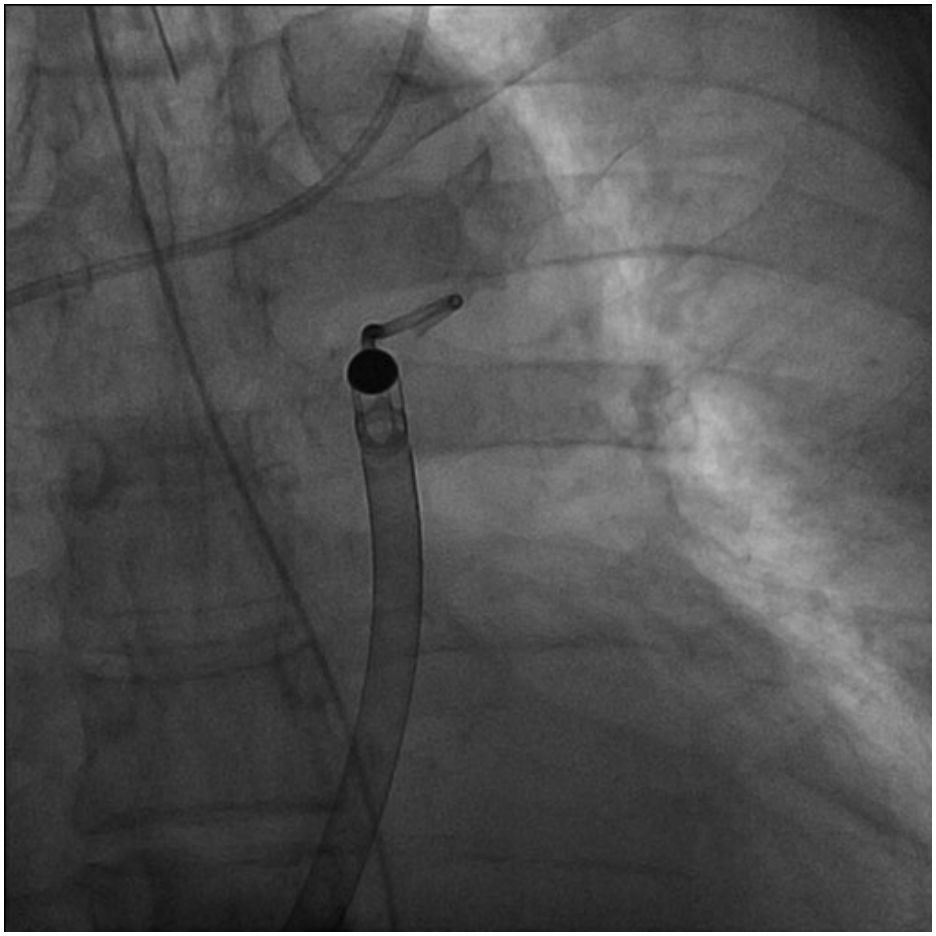
Case 1.

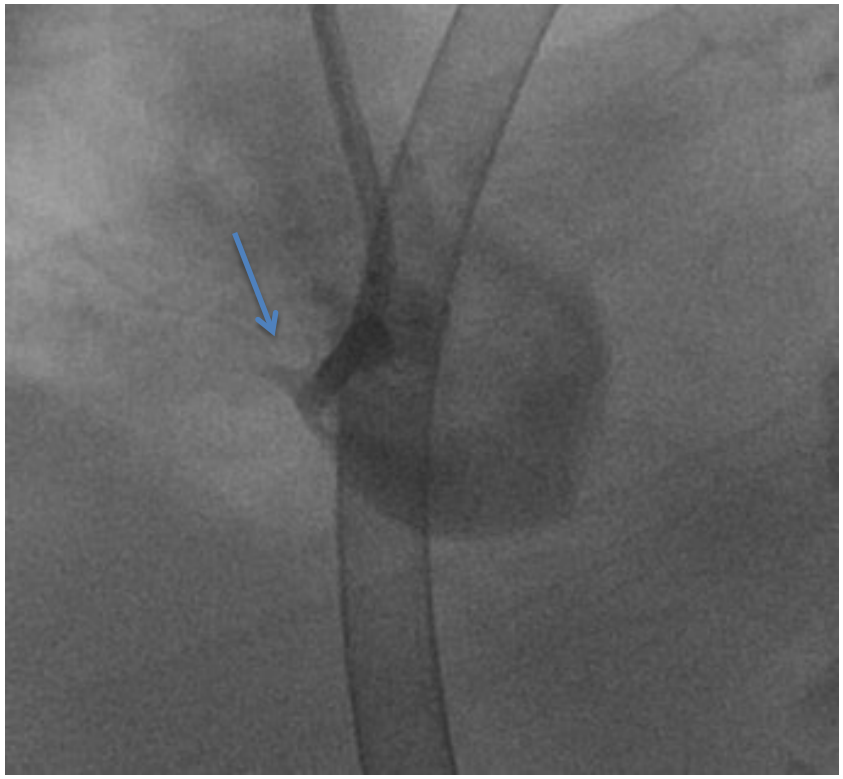

FR 40Hz
18cm
2D
38%
C 49
P Low
HPen
SUPINE
W/ VENT
M3
JPEG
*** bpm
SUPINE
W/ VENT
M3
JPEG
69 bpm

Case 1.

- ***Options?***

Case 1.





Case 1.

- ***Hemodynamic improvement***
- ***Pressors weaned***
- ***Progressive AKI -> Anuria***
- ***LFTs rose to 100,000s***
- ***Ultimately expired after developing recurrent arrhythmias requiring shocks***

Case 2.

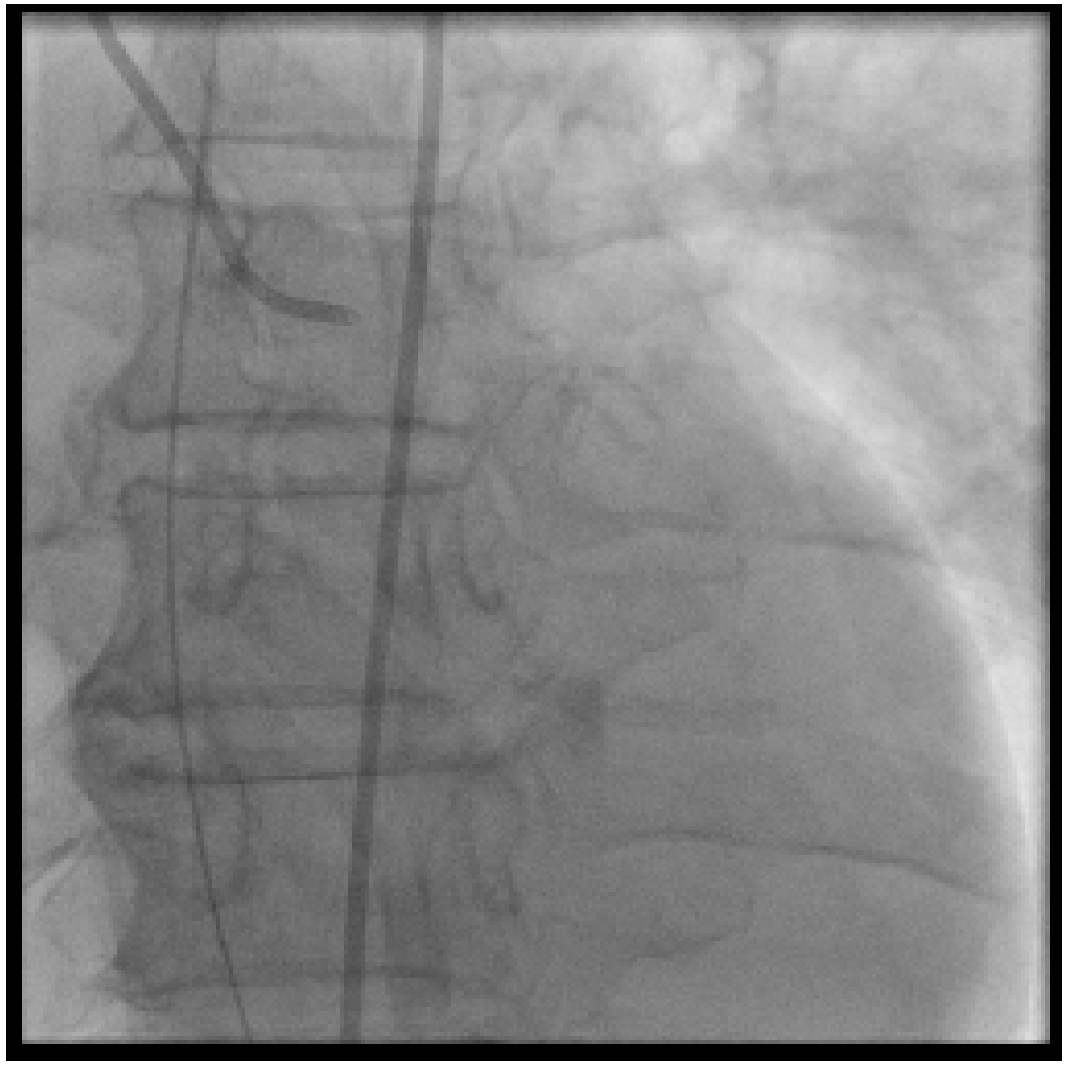
- *57M, IDDM, long-standing T use, poor medical care, works on a farm*
- *Transferred to our institution with diagnosis of Legionella Pneumonia*
- *Trop rose from 4 to 40, EKG with new elevation in V1-V3, LVEF of 25%, new hemodynamic instability*
- *Cr 2.97*

Case 2.

- ***Arrived to CCL:***
  - **Intubated, 100% on FIO_2 of 100%**
  - **Dopamine 5mcg/kg; Levophed 0.04mcg/kg**
  - **Ao 66/49 (57)**

- ***RHC:***
  - **RA 13 RV 37/13 PA 36/26 W 24 Fick CO/CI 3.43/1.85**
  - **PA sat 62% SVR 1026dynes (800-1200)**

Case 2.



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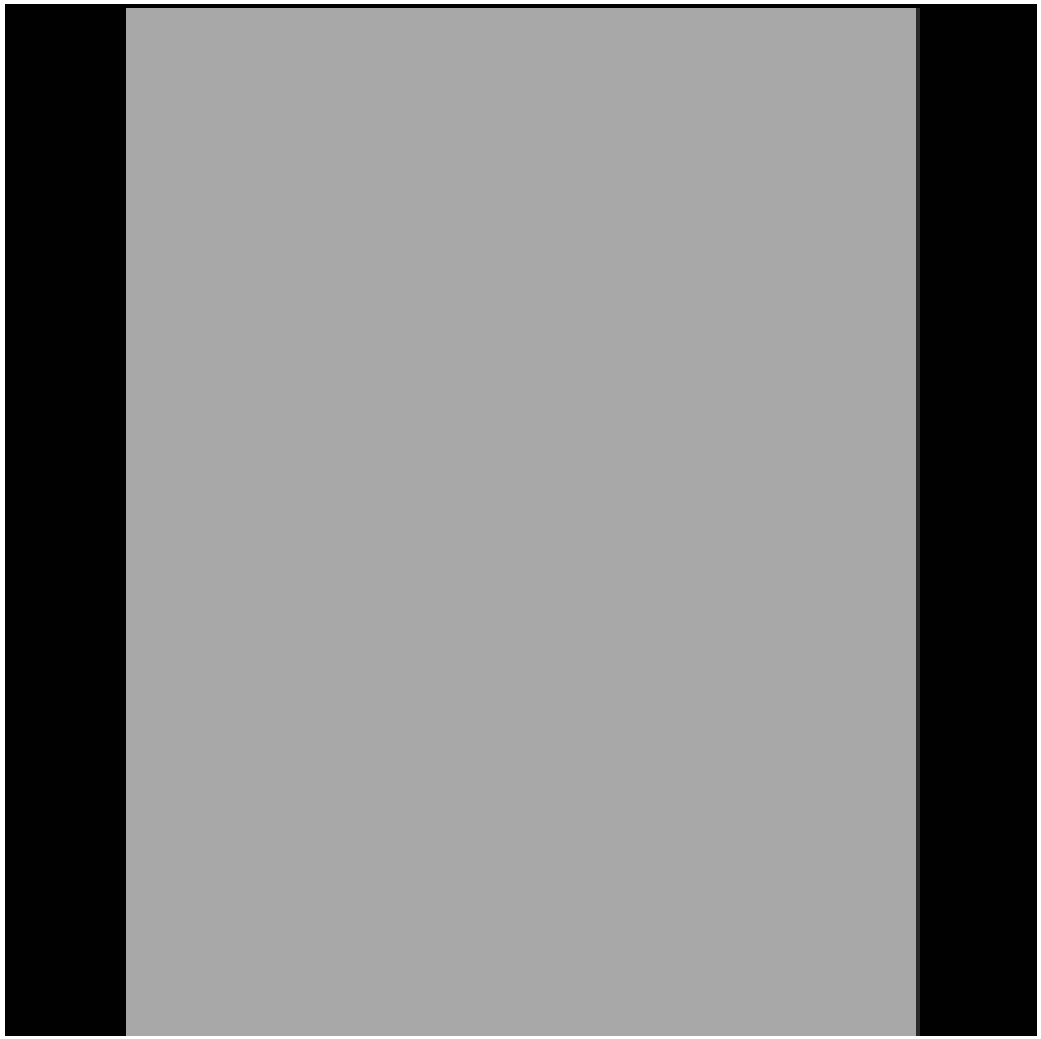
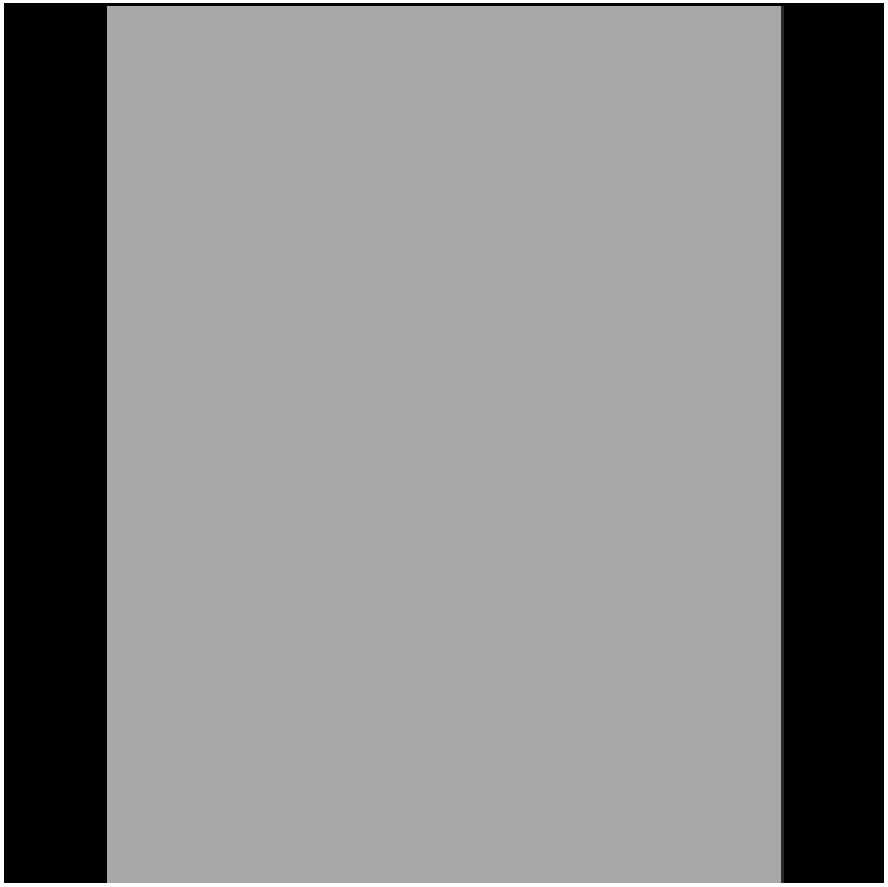
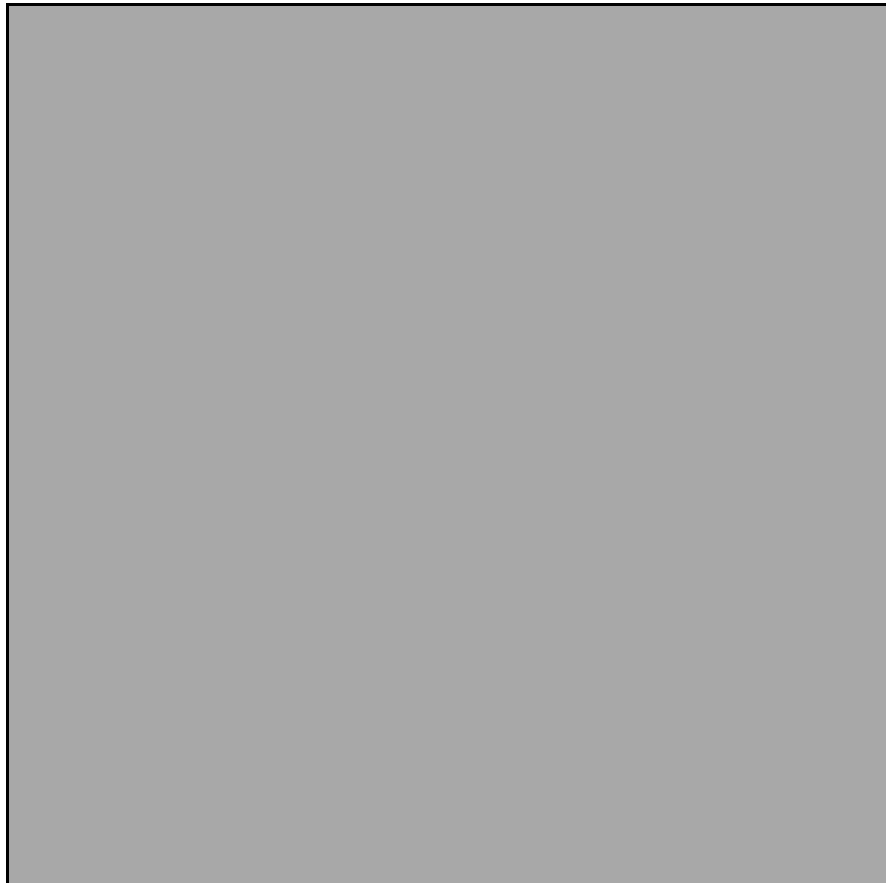


Case 2.

- *Options?*
- *Discussed Axillary Impella with CT Surgery*
- *Declined due to concerns of hemolysis*

Case 2.





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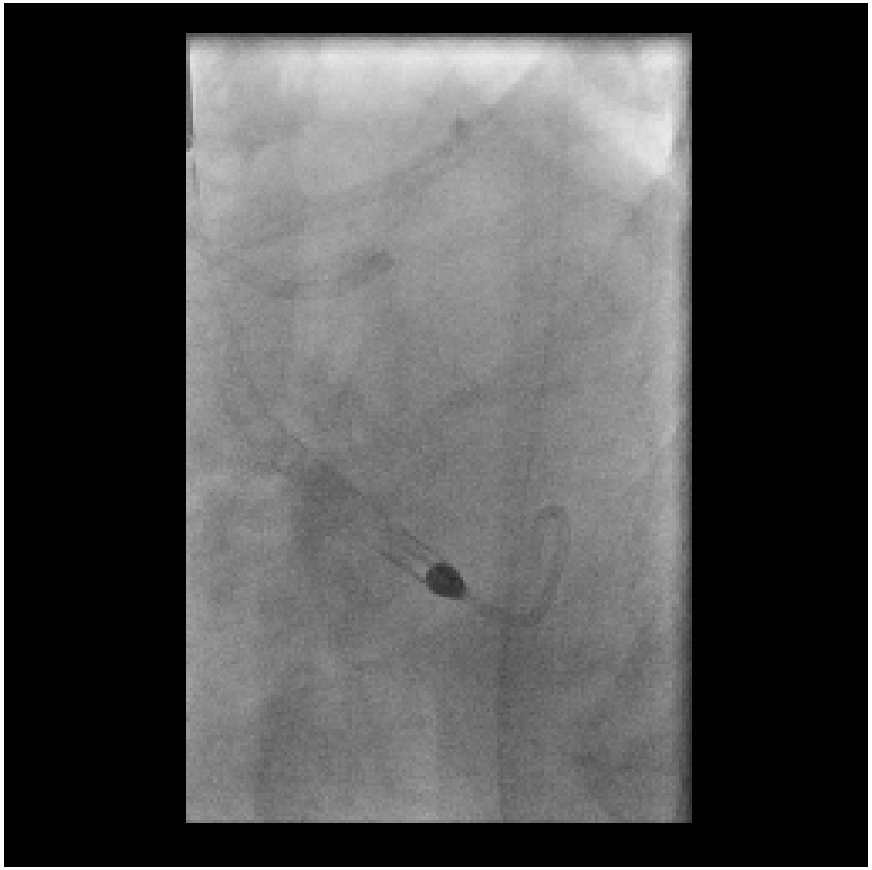

Case 2.

- ***Weaned off pressors***
- ***Progressive AKI -> CVVH -> HD***
- ***Discharged to Rehab facility Day 26***

Expert Consensus Document | May 2015

2015 SCAI/ACC/HFSA/STS Clinical Expert Consensus Statement on the Use of Percutaneous Mechanical Circulatory Support Devices in Cardiovascular Care

Endorsed by the American Heart Assocation, the Cardiological Society of India, and Sociedad Latino Americana de Cardiologia Intervencion; Affirmation of Value by the Canadian Association of Interventional Cardiology-Association Canadienne de Cardiologie d'intervention*

JACC 2015; 65(19)

Conclusions

- *Numerous clinical scenarios to consider MCS*
- *IABP may not be adequate if profound LV dysfunction*
- *ECMO/Tandem Heart may have a role with concurrent oxygenation issues*
- *Limb ischemia, bleeding, hemolysis, vascular complications remain limiting factors*

JACC 2015; 65(19)