Mechanical Circulatory Support in Cath Lab – Which and When?

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Outlines

- Clinical case
- Populations requiring percutaneous MCS
- Percutaneous mechanical circulatory support
  - Available devices
  - Evidence
  - Practical approach to pMCS

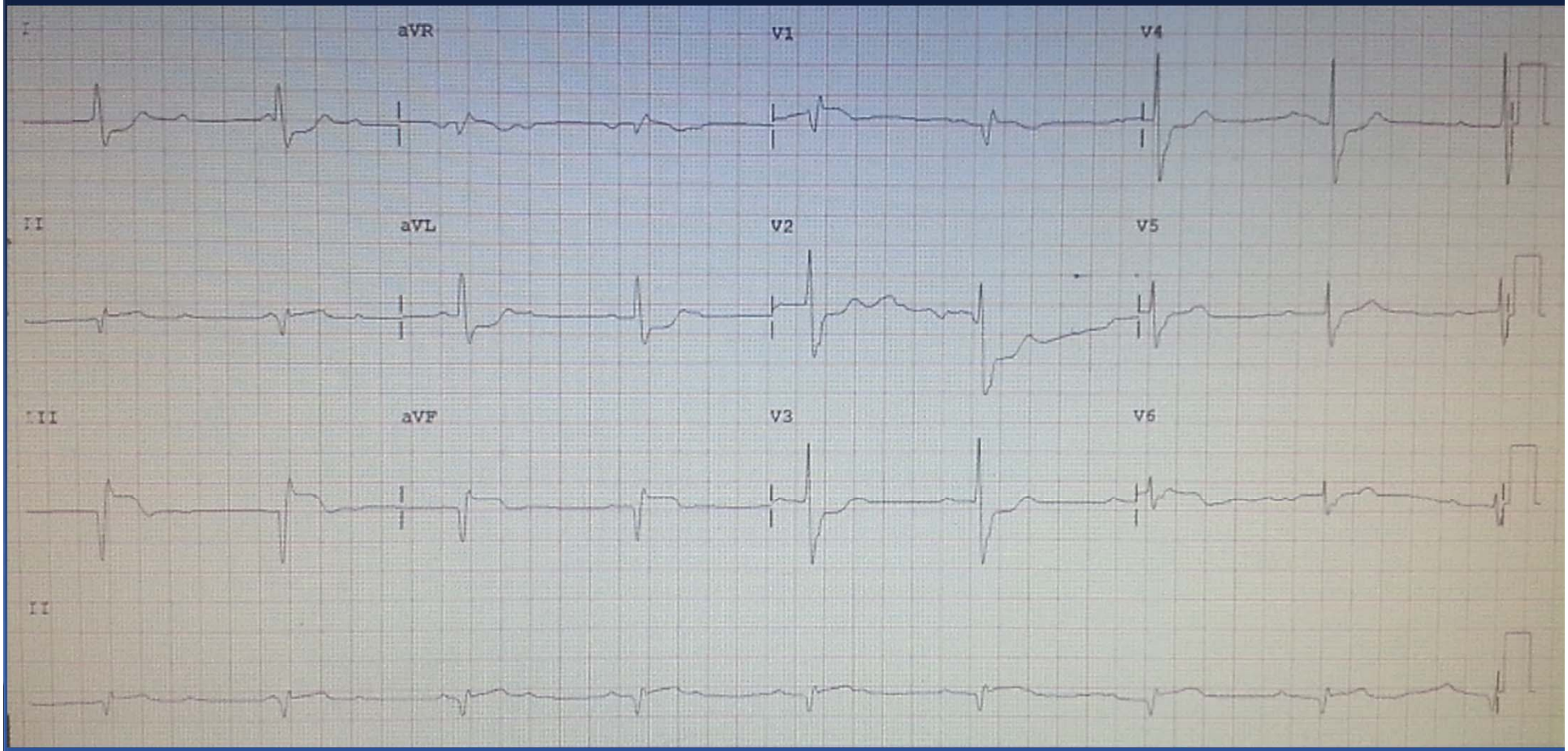
Case # 1

64 / M

- CC
  - Chest pain (onset; 5 days ago)
- Medical history
  - DM/HTN/Hyperlipidemia (-/-/-)
  - Current smoking (+; 2-3packs/day x 30 years)
  - Alcohol(+; beer 5-10 bottles /day x 30 years)

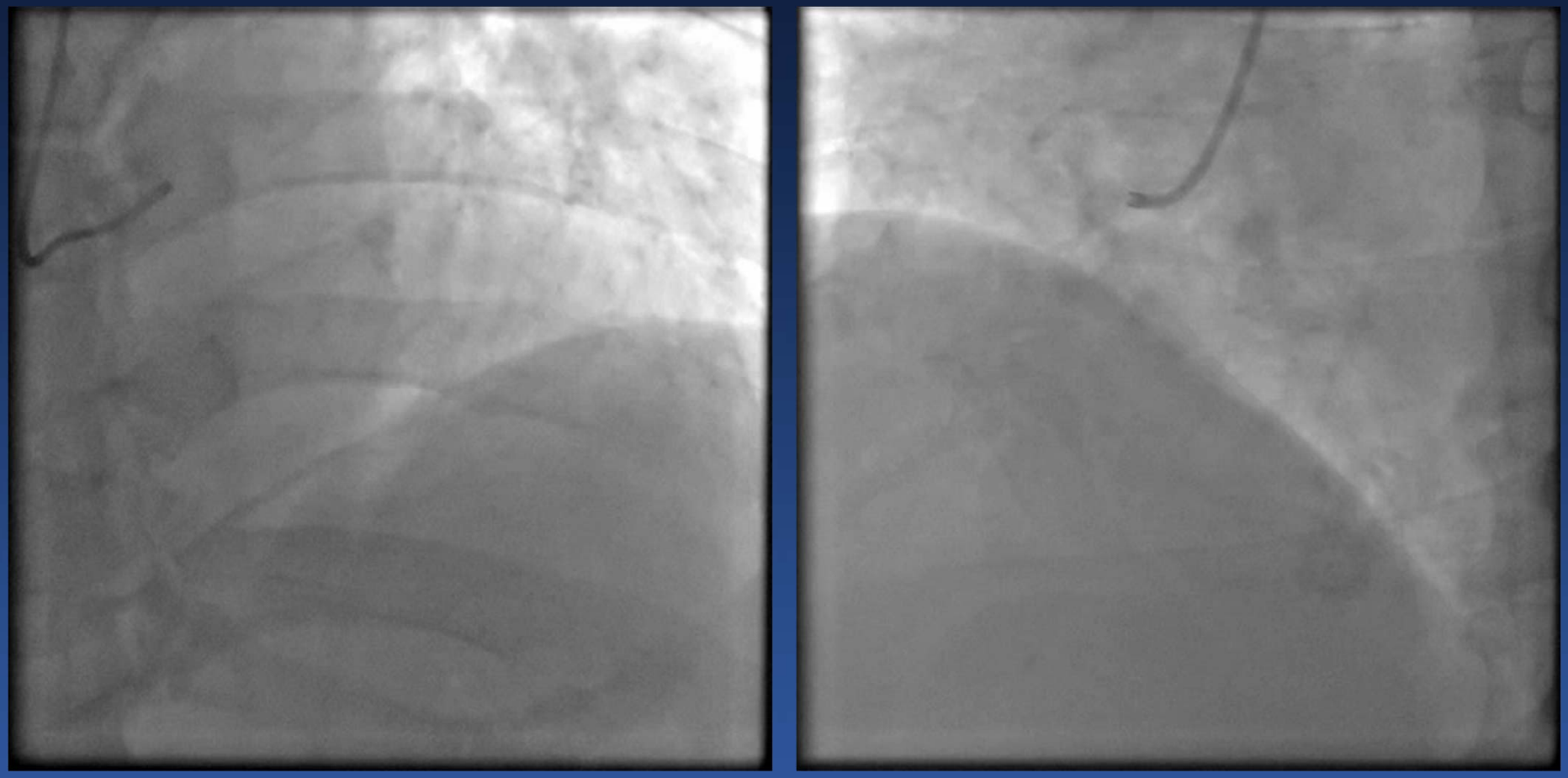
Case # 1

- Initial ECG



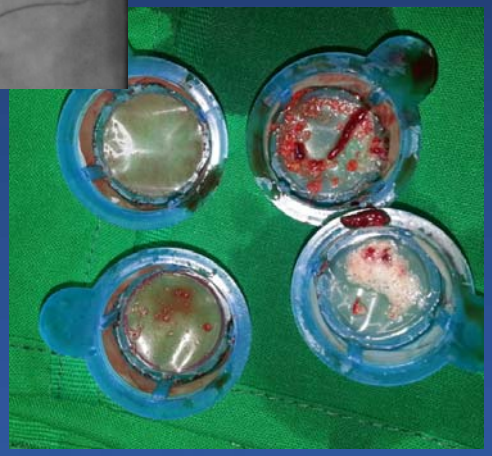
Case # 1

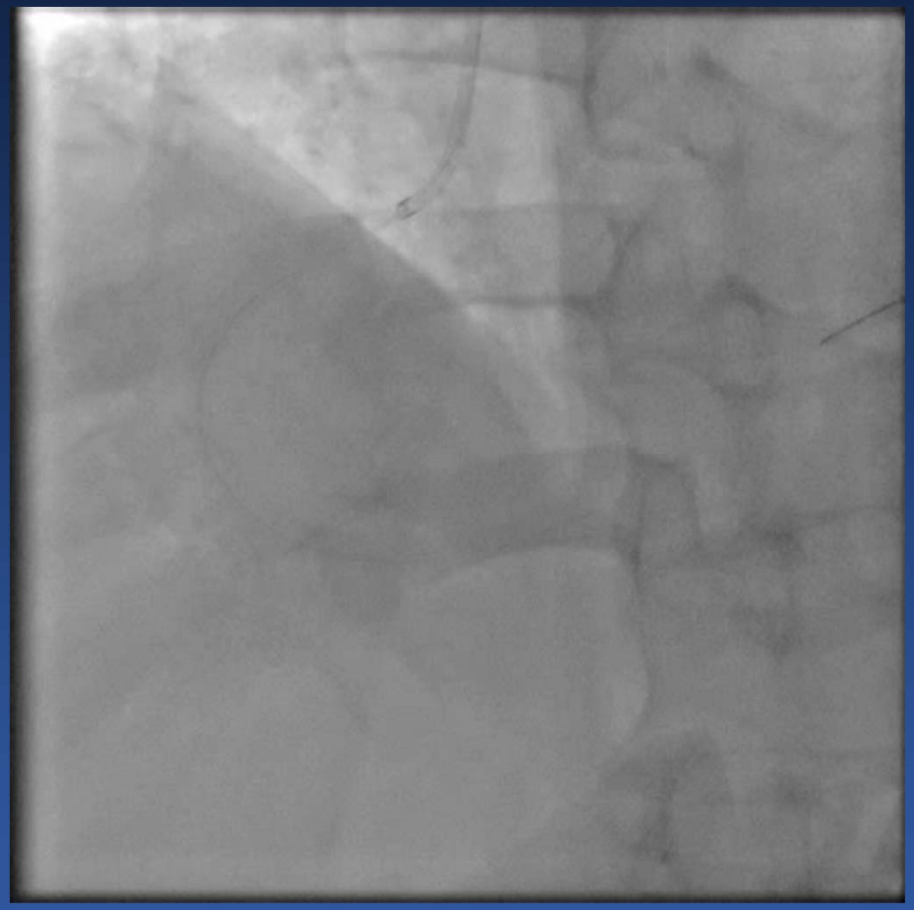
- Coronary angiogram



Case # 1

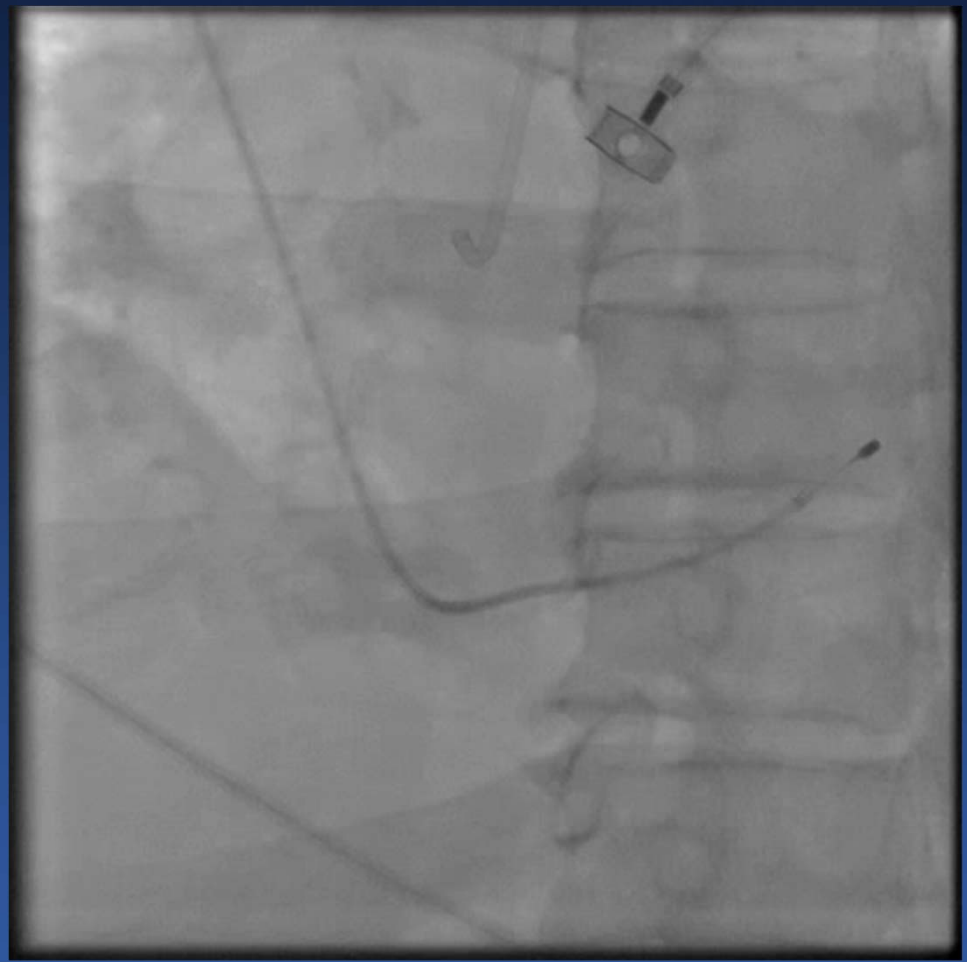
- PCI; Repeated Thrombectomy using aspiration catheter
  Abciximab IC & IV
  4.0*34mm stenting at pmRCA, Thrombectomy





Case # 1

- Post-PCI day #3 - chest pain
- ECG -STE in inferior leads, complete AV block
- CAG : Stent thrombosis



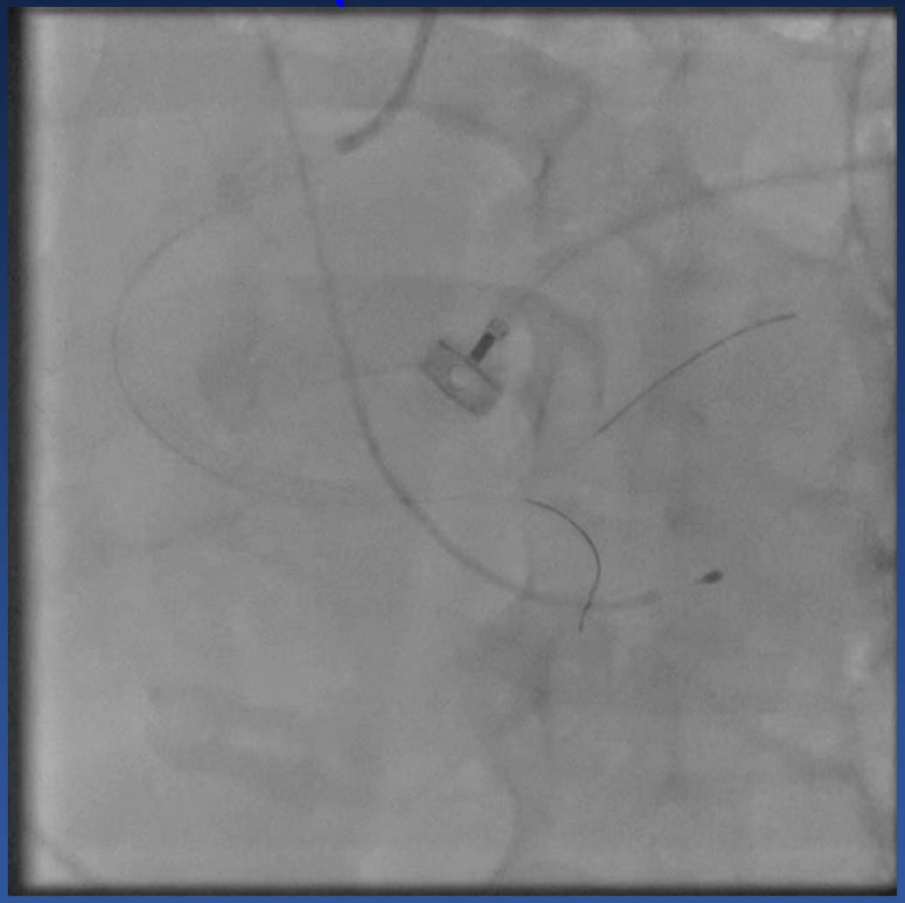
Case # 1

- PCI; Thrombectomy using aspiration catheter

  Abciximab IC & IV

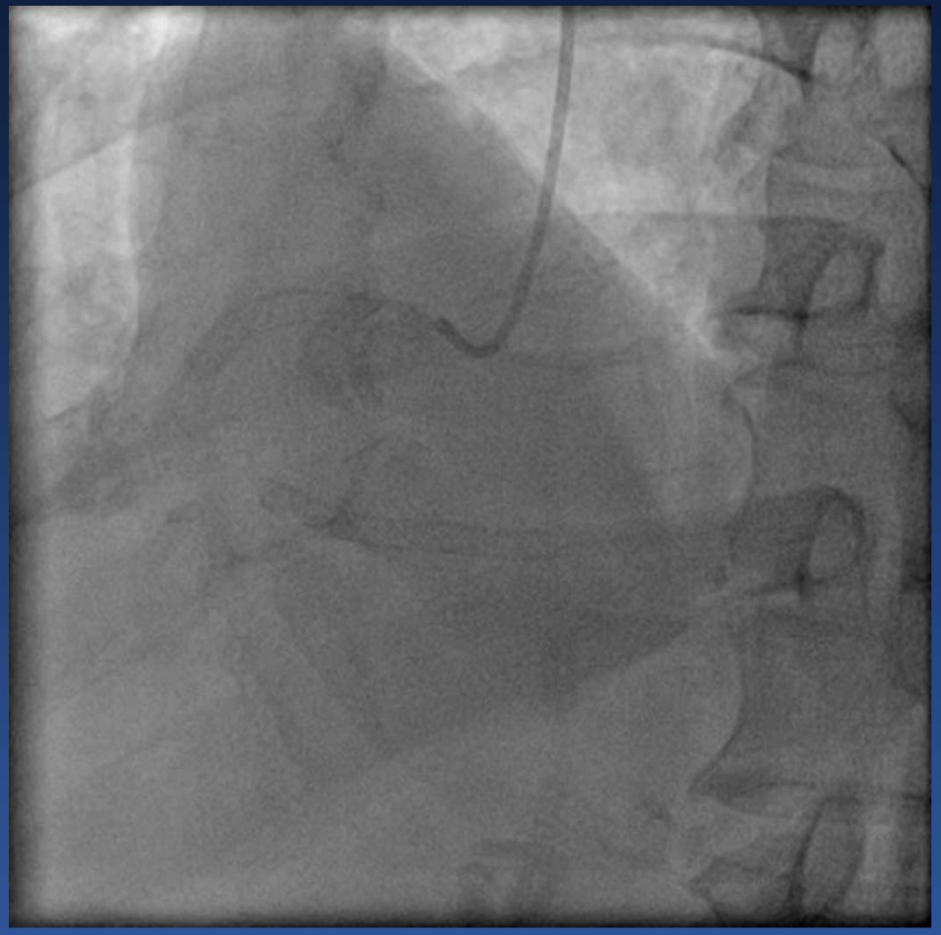
  POBA & 3.5*38mm stenting at mdRCA

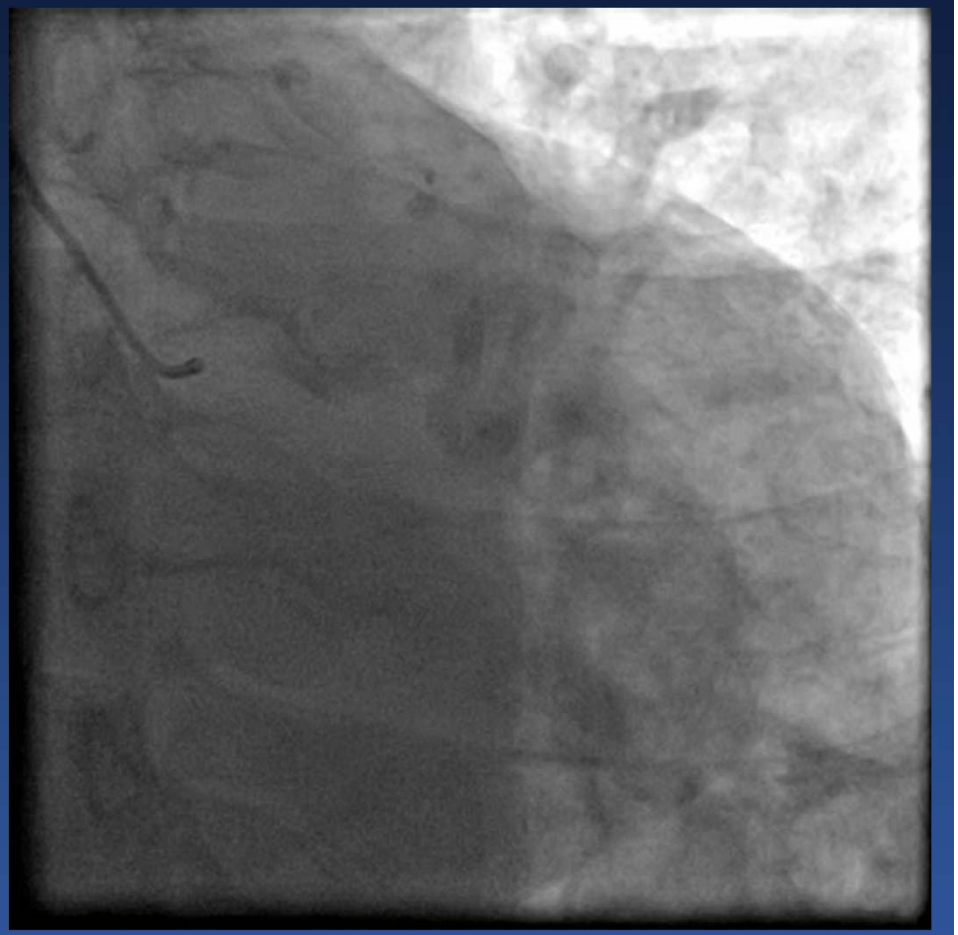
  IABP (Intra-aortic balloon pump)



Case # 1

- 1-yr follow-up CAG





Case # 2

- 55 / F
- Chief complaint

  Collapse (30 minutes ago)

- Brief medical history

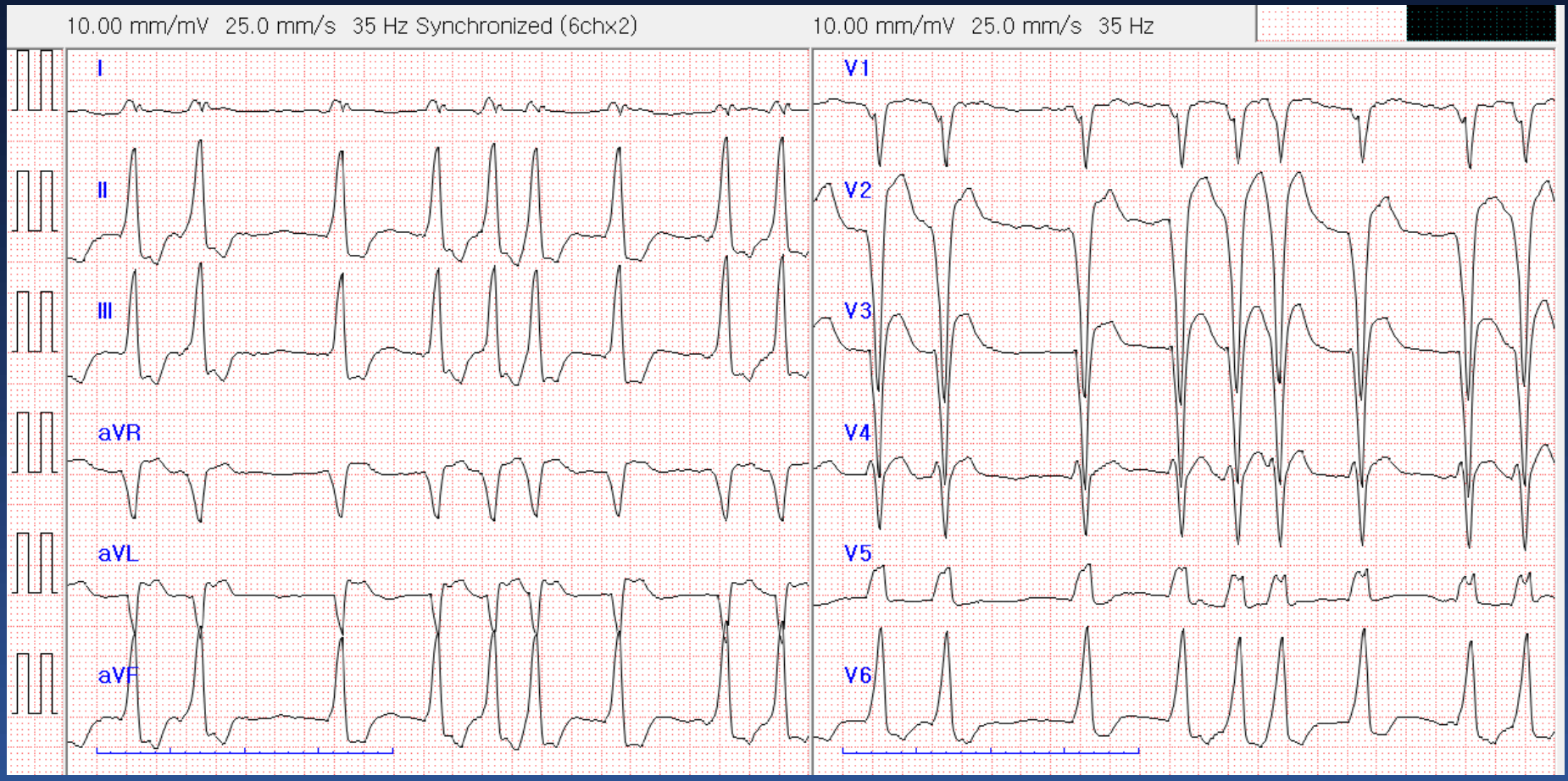
  Collapsed after running

  15 minutes of bystander CPR out-hospital

  Recurrent events of in-hospital CPR

  VA-ECMO was inserted 30 minutes after arrival

Case # 2


10.00 mm/mV 25.0 mm/s 35 Hz Synchronized (6chx2)
10.00 mm/mV 25.0 mm/s 35 Hz
I
II
III
aVR
aVL
aVF
V1
V2
V3
V4
V5
V6

Case # 2

- Coronary angiogram

Case # 2

- **PCI procedure : Thrombectomy using aspiration catheter**

Case # 2

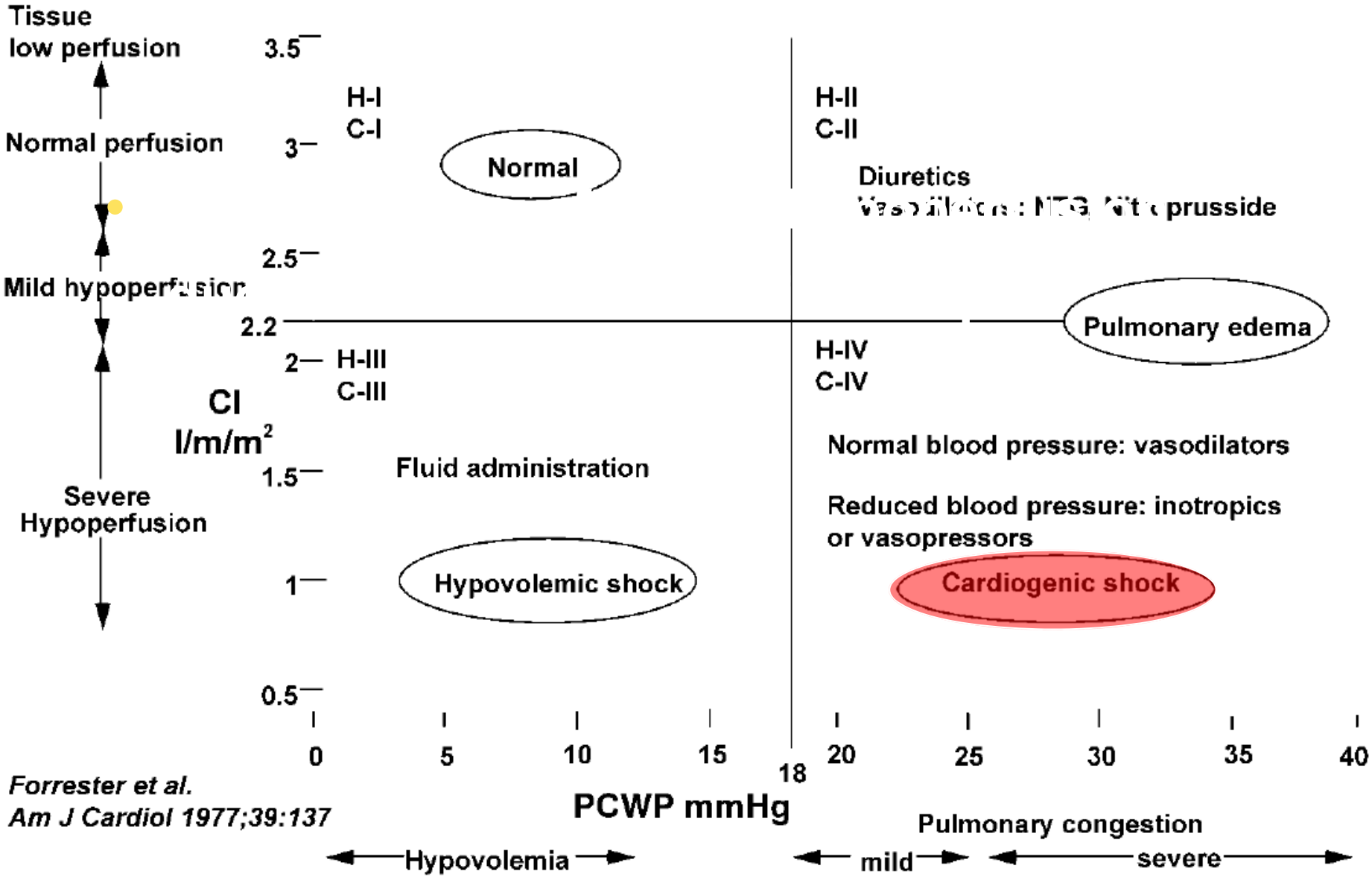
- PCI procedure : 3.5*18mm stenting at LM-pLAD

Populations requiring pMCS in the Cath Lab

1. Cardiogenic shock
2. Cardiac arrest
3. High-risk PCI

Atkinson TM, et al. JACC Cardiovasc Interv. 2016;9:871-83.

Cardiogenic shock
Forrester classification



Forrester et al.
Am J Cardiol 1977;39:137

Populations requiring pMCS - Cardiogenic shock

Table 1. Pragmatic and Clinical Trial Definitions of CS

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·min^{-1}·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 hypoperfusion Clinical hypoperfusion: Cold extremities, oliguria, mental confusion, dizziness, narrow pulse pressure Laboratory hypoperfusion: Metabolic acidosis, elevated serum lactate, elevated serum creatinine

CI indicates cardiac index; CS, cardiogenic shock; ESC, European Society of Cardiology; HF, heart failure; IABP-SHOCK II, Intraaortic Balloon Pump in Cardiogenic Shock II; LV, left ventricular; MI, myocardial infarction; PCWP, pulmonary capillary wedge pressure; SBP, systolic blood pressure; and SHOCK, Should We Emergently Revascularize Occluded Coronaries for Cardiogenic Shock.

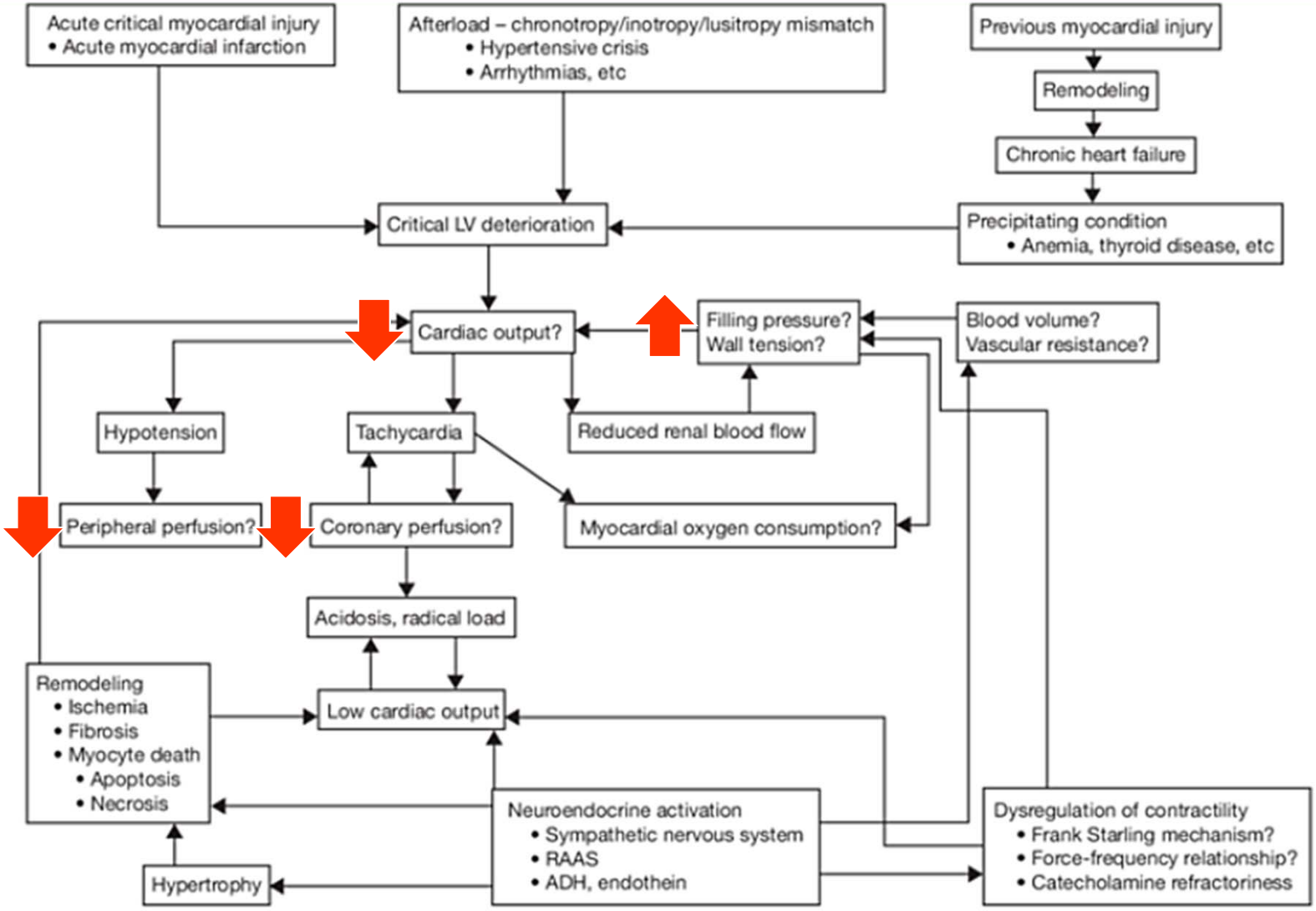
*In setting of MI complicated by predominantly LV dysfunction.

†In setting of acute MI.

1) **Sustained hypotension (decreased cardiac output)**
2) **Elevated LV filling pressure (Increased PCWP)**
3) **Signs of impaired organ perfusion**

van Diepen S, Circulation. 2017;136:e232-e268.

Pathophysiology of Acute Heart Failure



Nieminen et al. Eur Heart J. 2005;26:384-416

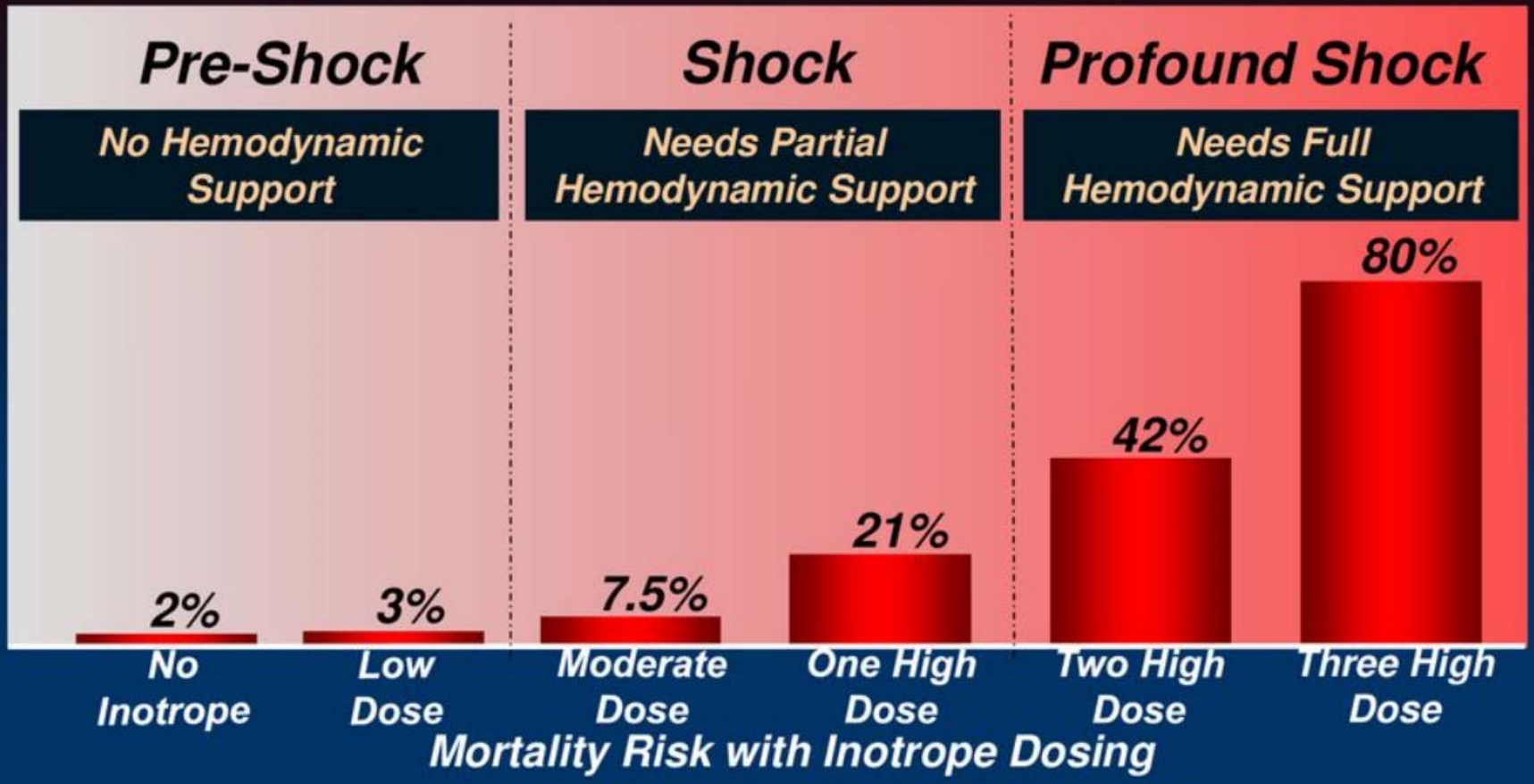
Spectrum of cardiogenic shock

TABLE 2 Spectrum of Cardiogenic Shock

Pre/Early Shock	Shock	Severe shock
Clinical	Clinical	Clinical
SBP <100 mm Hg	SBP <90 mm Hg	SBP <90 mm Hg
HR 70–100 beats/min	HR >100 beats/min	HR >120 beats/min
Normal lactate	Lactate >2	Lactate >4
Normal mentation	AMS	Obtunded
Cool extremities	Cool extremities	Cool extremities
Hemodynamic	Hemodynamic	Hemodynamic
CI 2–2.2	CI 1.5–2.0	CI <1.5
PCWP <20	PCWP >20	PCWP >30
LVEDP <20	LVEDP >20	LVEDP >30
CPO >1 W	CPO <1 W	CPO <0.6 W
Vasoactive medications	Vasoactive medications	Vasoactive medications
0 or 1 low dose	1 moderate to high dose	2 or more

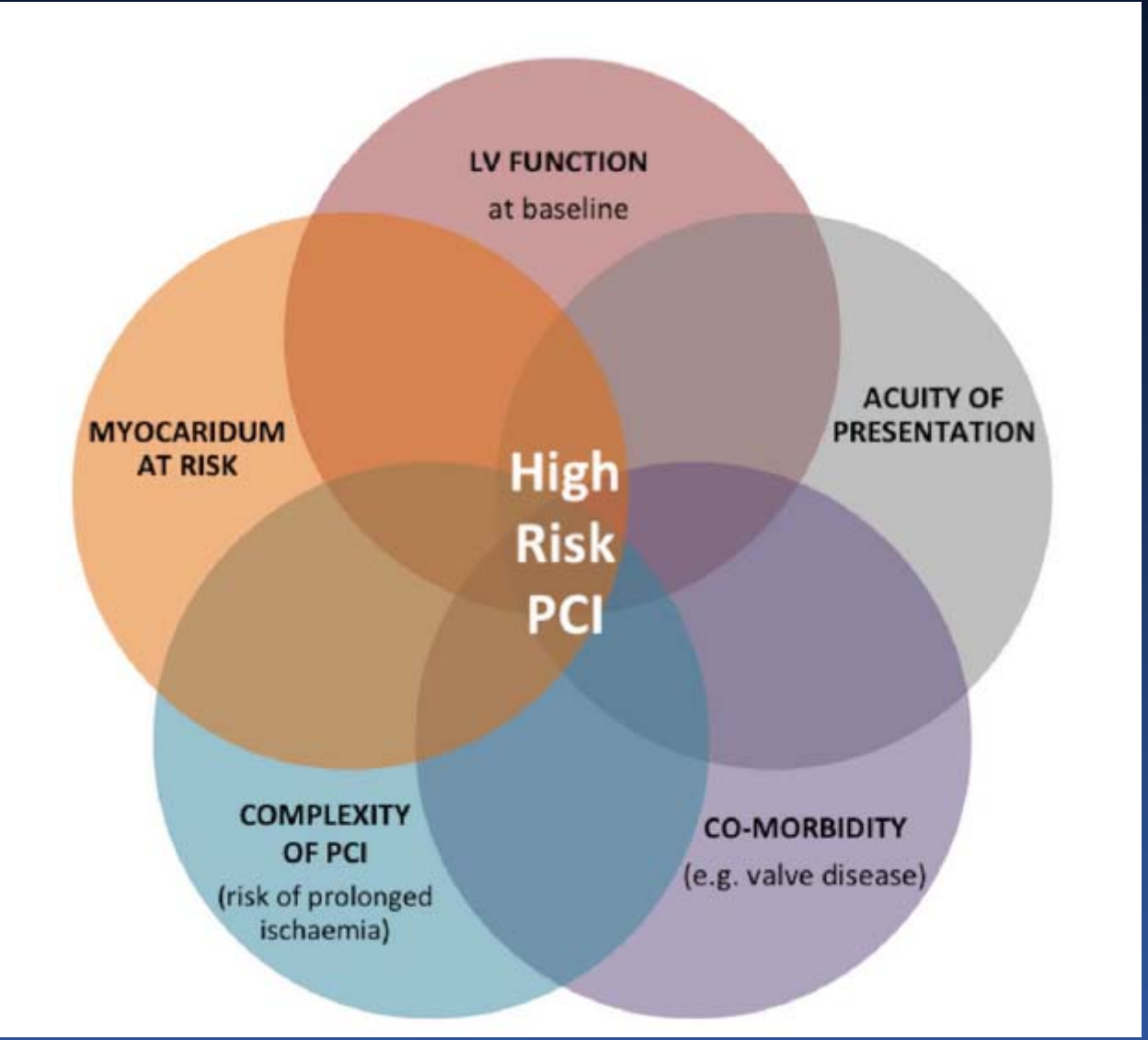
Atkinson TM, et al. JACC Cardiovasc Interv. 2016;9:871-83.

Cardiogenic Shock is a Spectrum



Adapted from Samuels LE et al, J Card Surg. 1999 Jul-Aug; 14(4):288-93

Populations requiring pMCS
- High-risk PCI



Briceno N, et al. Heart 2016;102:1494–1507.

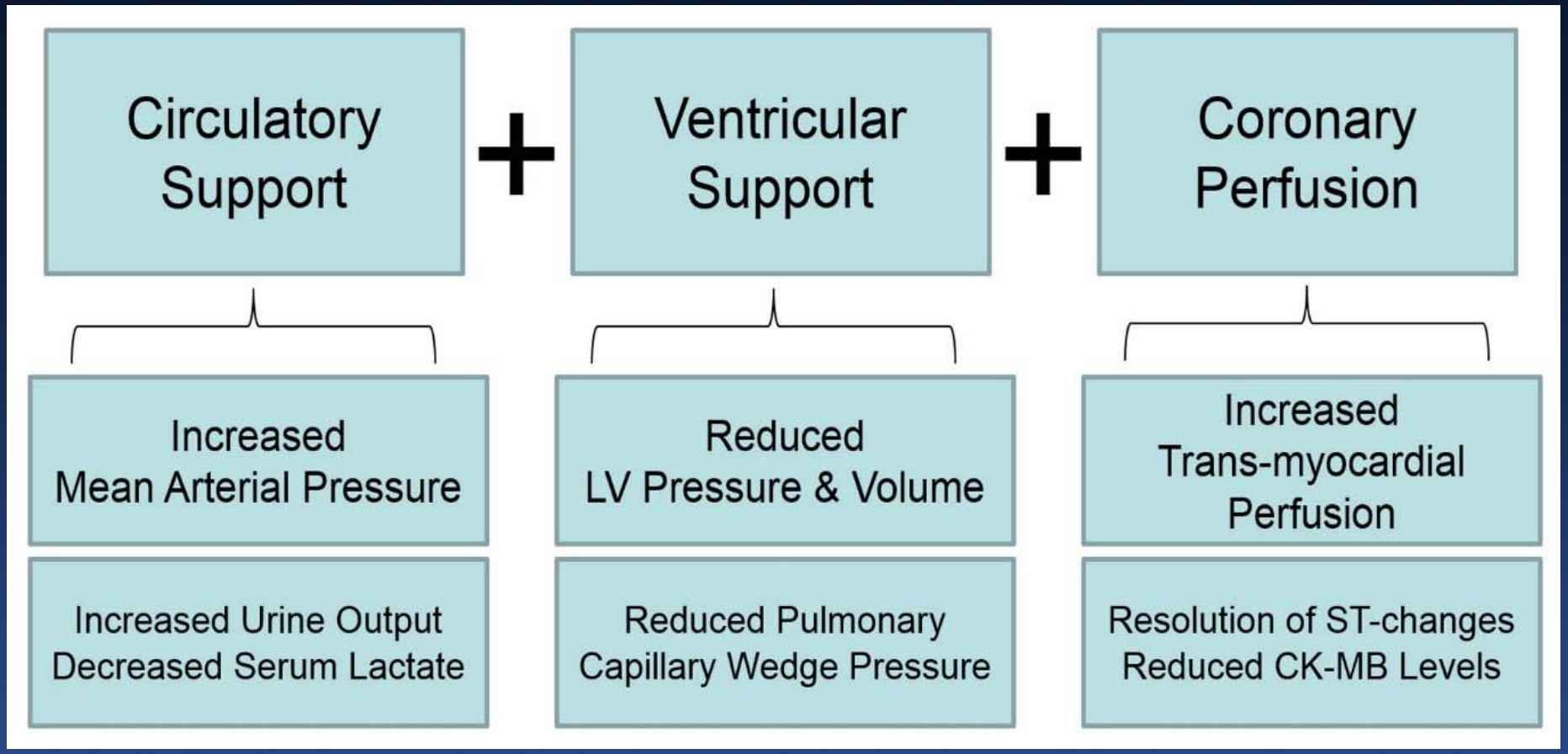
Populations requiring pMCS
- High-risk PCI

TABLE 3 High-Risk PCI

Clinical
LVEF <35%
Electrical instability
Congestive heart failure
Comorbidities
Severe aortic stenosis
Severe mitral regurgitation
Chronic obstructive pulmonary disease
Chronic kidney disease
Diabetes
Cerebrovascular disease
Peripheral vascular disease
Age >75 yrs
Acute coronary syndrome
Coronary anatomy
Last patent vessel
UPLMN
3 vessel disease, SYNTAX score >33
Target vessel providing collaterals to a territory, which supplies >40% of the myocardium
Distal left main bifurcation

Myat A, et al. JACC Cardiovasc Interv. 2015;8:229-244.

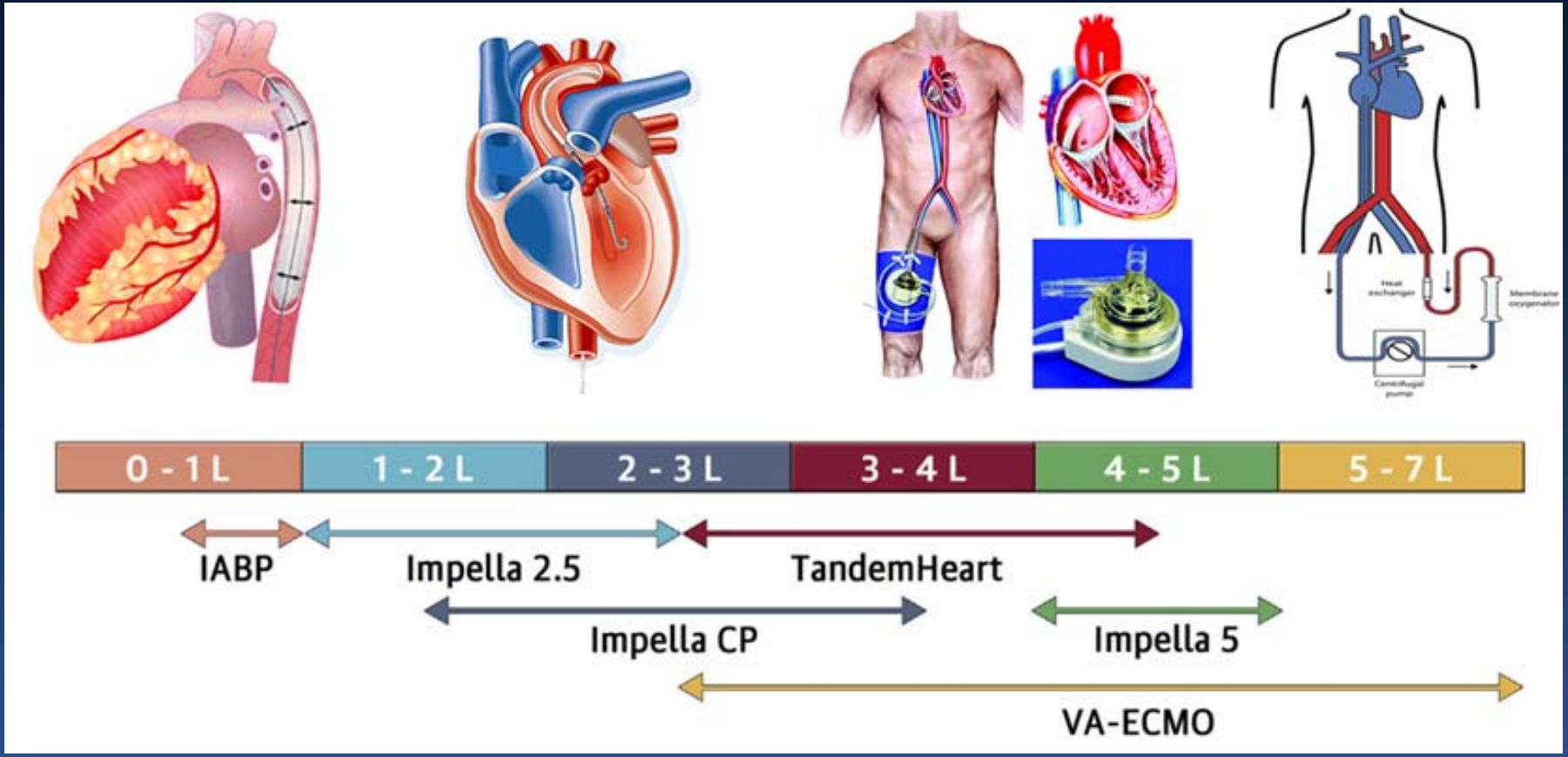
Ideal goal of cardiac support



- Safe, Simple Use
- Systemic Hemodynamic Support
- Myocardial Protection

Kapur. NK et al

Available pMCS devices



Atkinson TM, et al. JACC Cardiovasc Interv. 2016;9:871-83.

There Is No Ideal Device

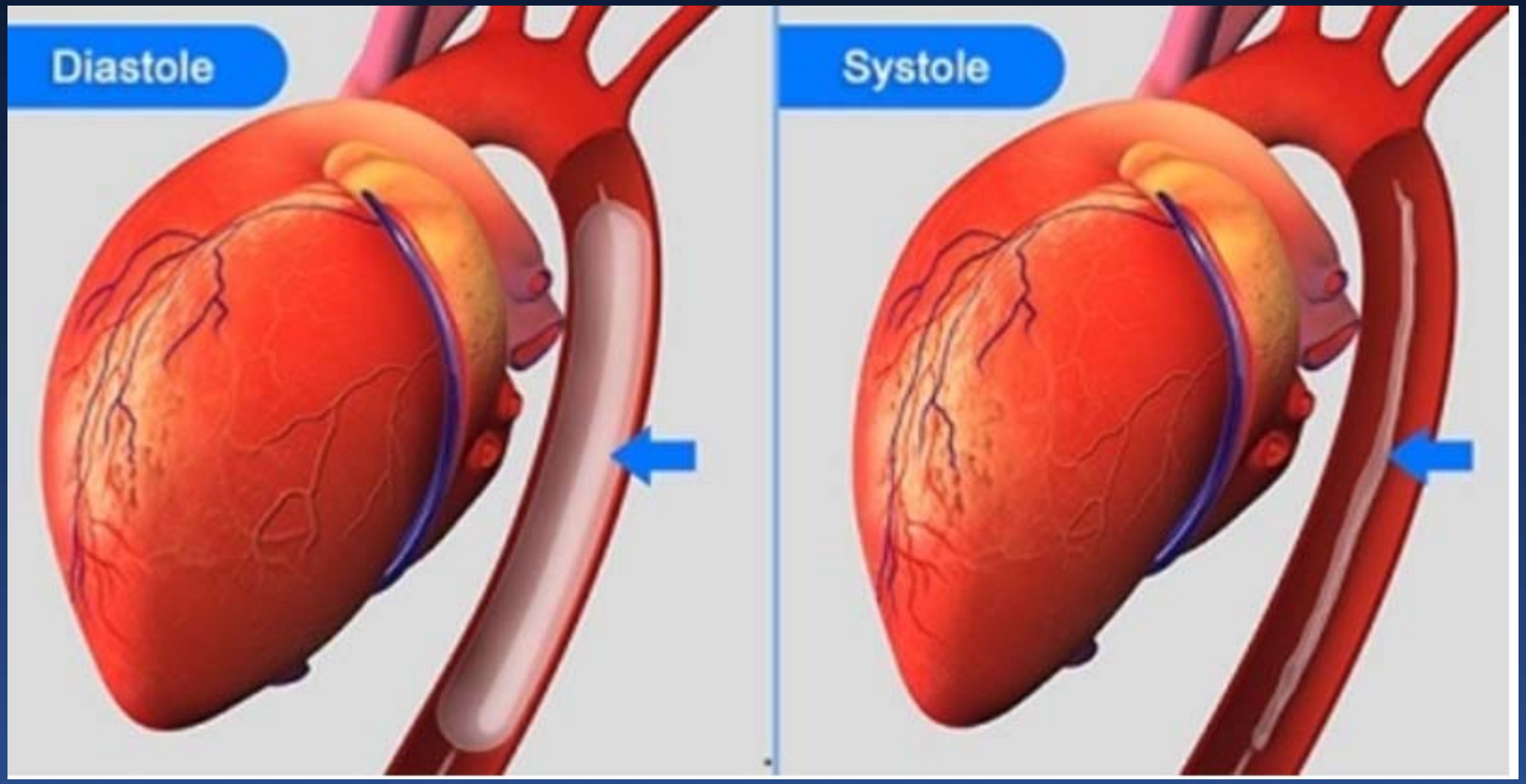
Table 2 Summary of the overall goals of mechanical circulatory support, and how each device impacts on these, as a guide for device selection

	A: Myocardial protection		B: Organ perfusion	C: Ease of use
	Supply	Demand		
Inotropes/ vasopressors	?	−−	(−)	++
IABP	+	(+)	(+)	++
Impella	+	++	+	+
TandemHeart	?	++	+	−
VA-ECMO	?	−	+	−

+, desired effects; −, undesired effects; ?, missing/equivocal data. IABP, intra-aortic balloon pump; VA-ECMO, veno-arterial extracorporeal membrane oxygenation.

Briceno N, et al. Heart 2016;102:1494–1507.

Intra-Aortic Balloon Pump (IABP)



IABP


augmented
DP
unassisted SP
assisted SP
↑ coronary perfusion
↑ O_2 supply
↓ afterload
↓ O_2 demand
AoEDP
assisted
AoEDP

IABP

PROs:

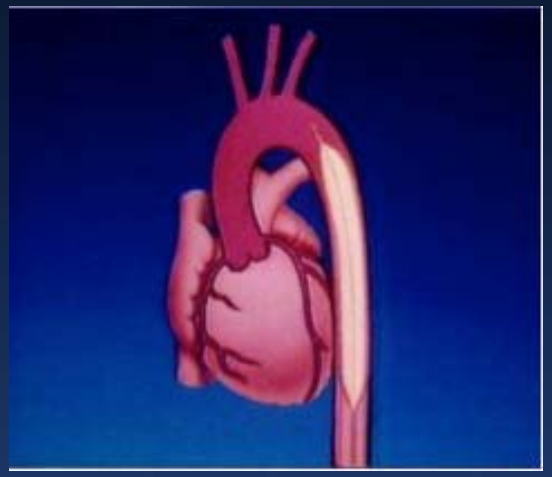
- Well known technology
- Increases coronary perfusion
- Mild increase in cardiac output
- Ease of use
- Cost

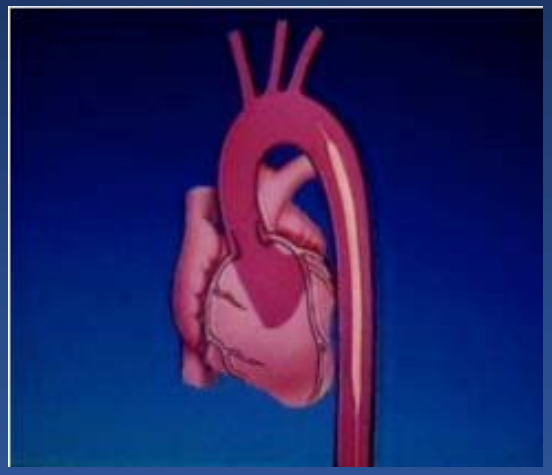
CONs:

- Requires a minimum of cardiac function
- Requires a stable rhythm
- Modest unloading
- Negative randomized studies

CIx:

- Aortic regurgitation
- Aortic aneurysm, Aortic dissection
- Peripheral artery disease





Evidence : IABP

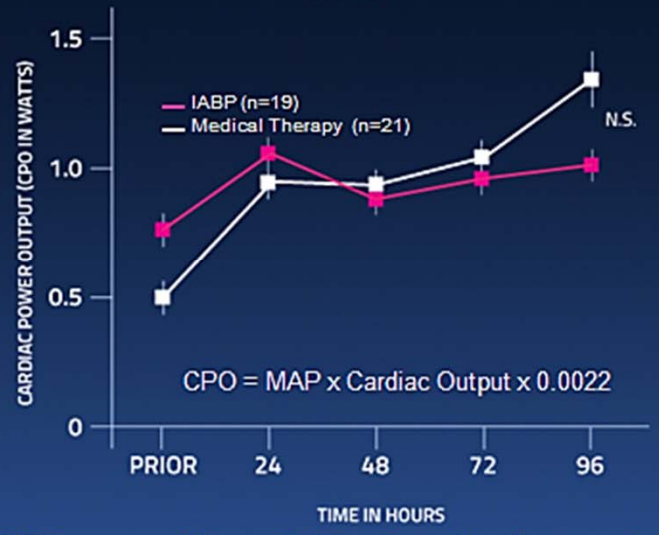
Acute MI with Fibrinolysis

- **Waksman *et al*. (Eur Heart J, 1993)**
  - n=45, observational (case/control 1:1)
  - Improved survival
    - Hospital : 46% vs 19%, 12 m : 38% vs 10%, $p < 0.001$
- **TACTICS (J Thromb Thrombolysis, 2005)**
  - n=57, randomized 1:1
  - Improved survival only Killip III/IV – 6 m : 39% vs 80%, p=0.05
- **Barron *et al*. (Am Heart J, 2001)**
  - National Registry of MI
  - Shock with AMI
  - n=23,180 (1:2 IABP vs. no MCS)
  - IABP associated with reduced in hospital mortality following fibrolytics (49% vs. 67%)
  - No difference with PCI

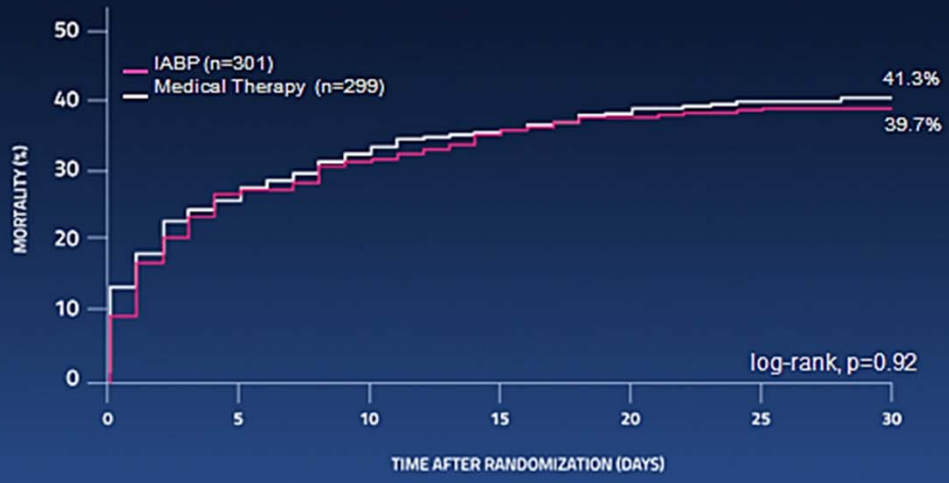
Evidence : IABP
Cardiogenic Shock

IABP in AMI Cardiogenic Shock: No Hemodynamic or Survival Benefit

IABP SHOCK I
Randomized Controlled Trial[1]
N = 40



IABP-SHOCK II
Randomized Controlled Trial[2]
N = 600



IABP Increased hazard risk of stroke, downgraded to Class III (harm), Level of Evidence A, ESC STEMI Guidelines 2014

Promdzomsly R. et al. Crit Care Med. 2010;38:152-60
Thiele H. NEJM. 2012; 367:1287-96

Evidence : IABP
High risk PCI

Circ Cardiovasc Qual Outcomes. 2012

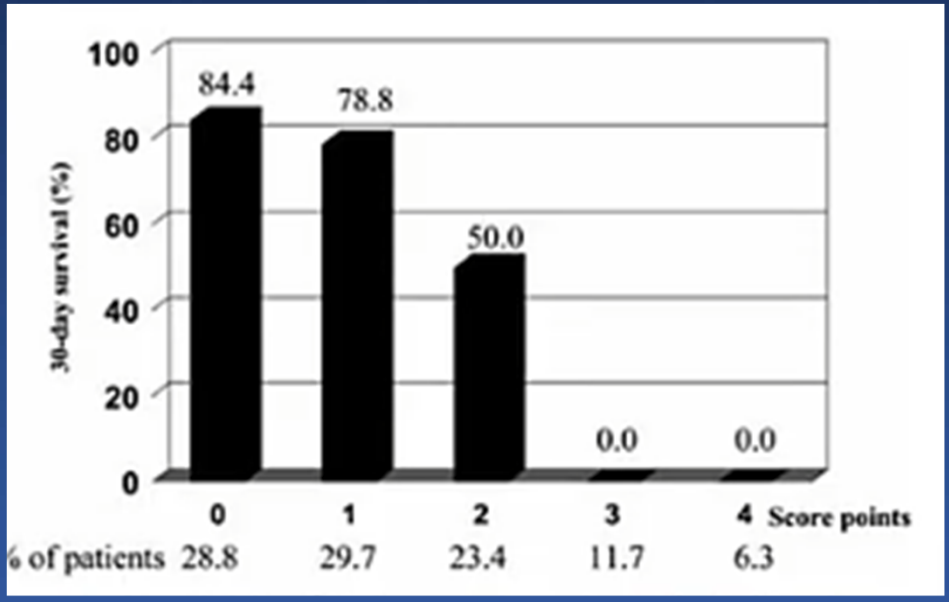
NCDR (82)	High risk including STEMI and CS	UPLMN, CS, severely depressed EF (<30%), or STEMI	181,599	No difference in mortality	No difference in mortality	
BCIS-1 (4)	HR-PCI	EF <30%, severe CAD: jeopardy score >8, no shock or STEMI	301	No difference in survival	No difference in survival	Increase minor bleeding in IABP arm Decreased periprocedural complications in IABP (decreased hypotension) Elective IABP at 5 yrs associated with RRR 34% for all-cause mortality

JAMA 2010

Adopted from Atkinson TM, et al. JACC Cardiovasc Interv. 2016;9:871-83.

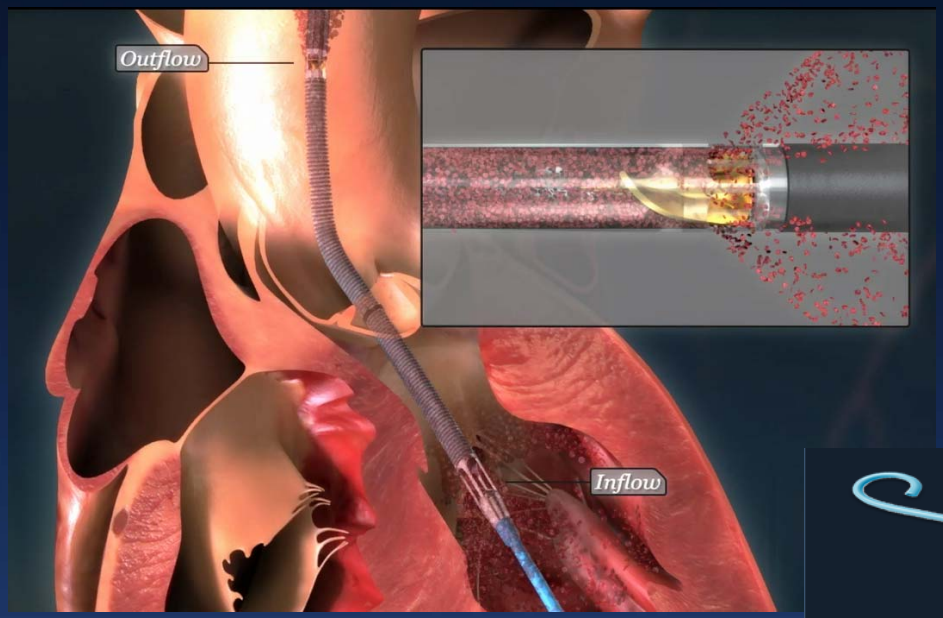
Predictors for 30-day mortality during IABP

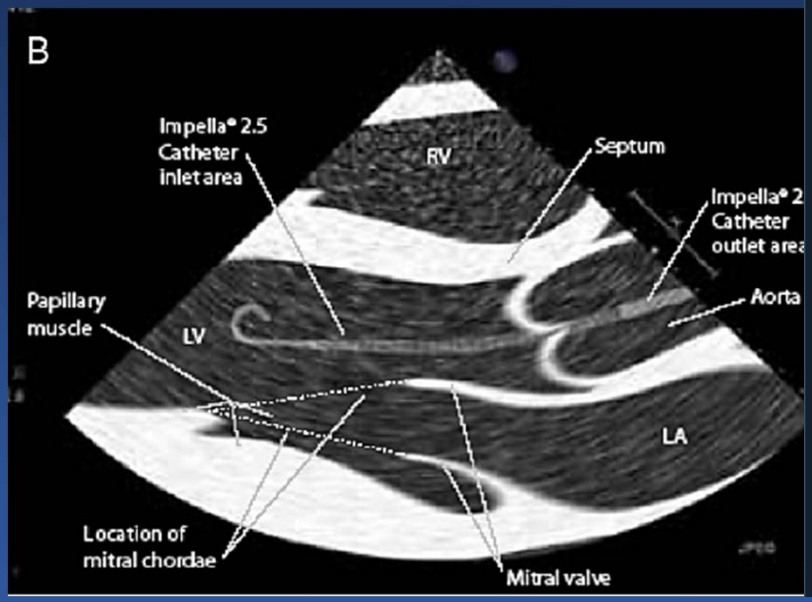
Parameter	Exp (B)	95% CI of Exp (B)	*p* value
MAP at 6 h ≤ 60 mmHg	3.73	1.96 – 7.07	< 0.001
CVP at 6 h ≥ 14 mmHg	3.63	1.81 – 7.28	< 0.001
Adrenaline at 6 h ≥ 0.04 mg/kg BW/min	2.60	1.36 – 4.97	0.01
Lactate at 6 h ≥ 6 mmol/l	2.50	1.32 – 4.75	0.01

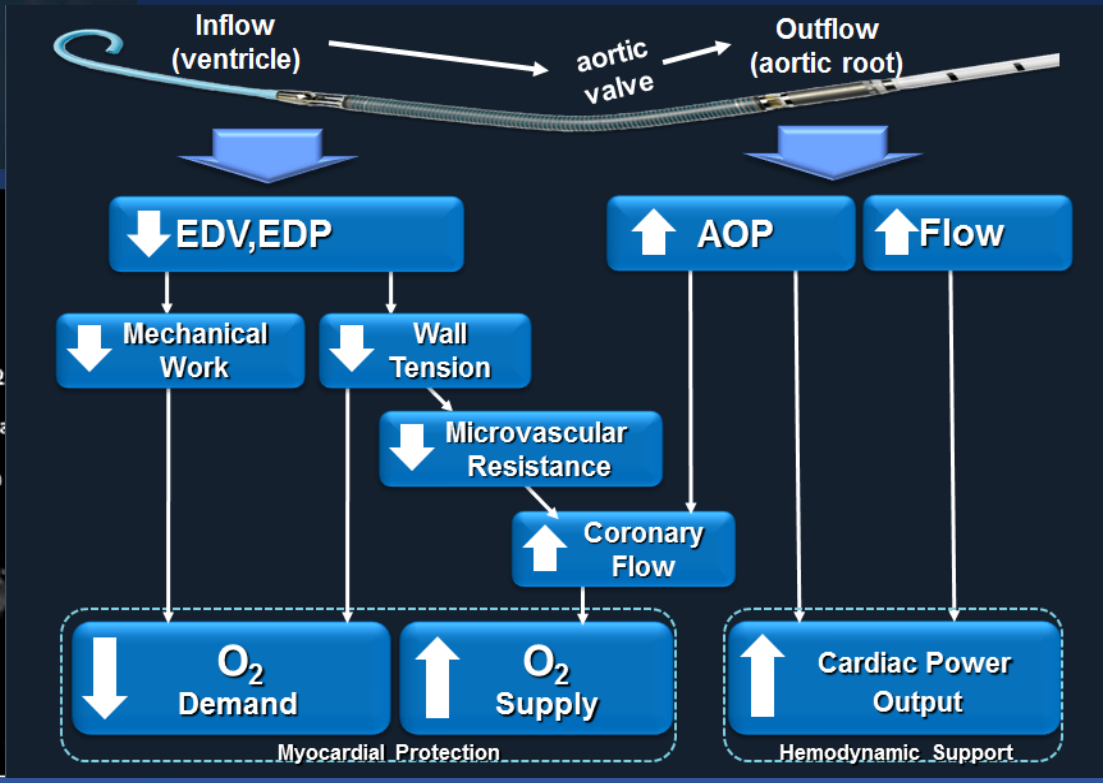


Thorac Cardiovasc Surg. 2007 Apr;55(3):163-7.

Impella

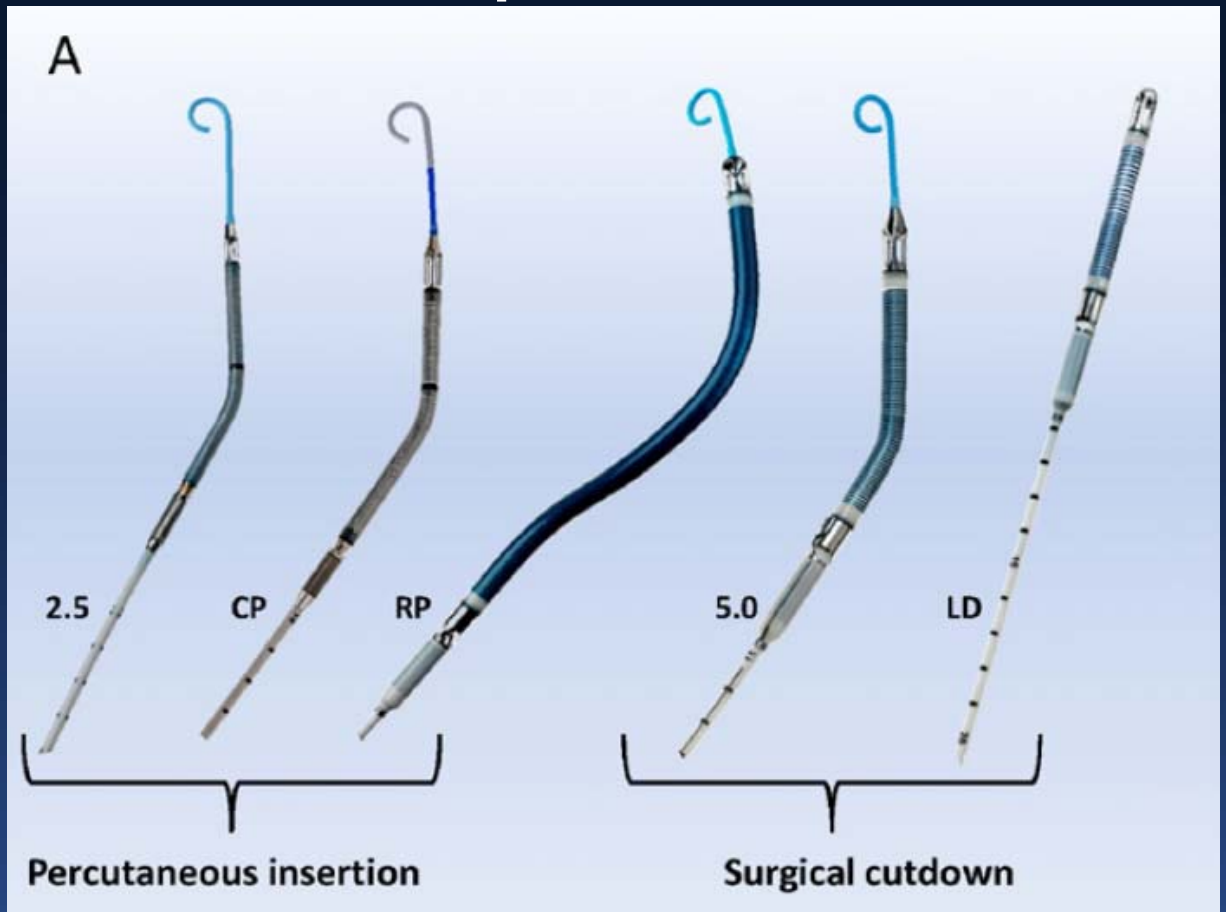






F. Burzotta et al. / International Journal of Cardiology 201 (2015) 684–691

Impella - Platform Technology



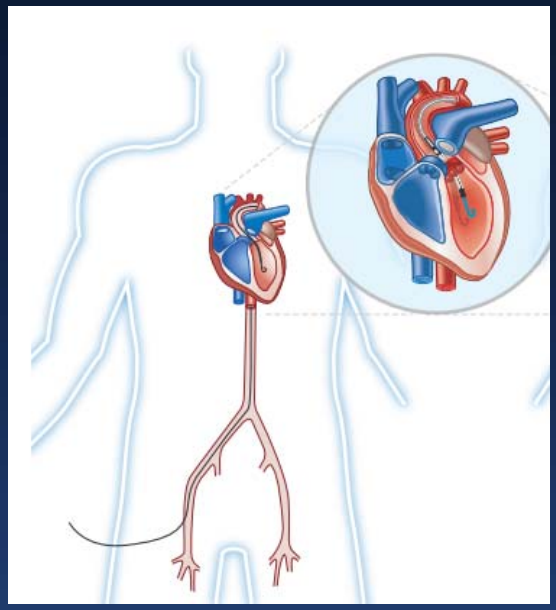


Table 1
Pump characteristics.

	Impella 2.5	Impella CP	Impella 5.0/LD	Impella RP
Access	Percutaneous, femoral	Percutaneous, femoral	Surgical, axillary/fem or ascend aorta	Percutaneous, femoral vein
Output (max)	2.5 L/min	4.0 L/min	5.0 L/min	4.6 L/min
Guiding catheter size	9 F	9 F	9 F	11 F
Motor size	12 F	14 F	21 F	22 F
Introducer size	13 F peel away	14 F peel away	Dacron graft 10 mm recommended	23 F peel away
RPM (max)	51,000	46,000	33,000	33,000
EU approval	5 days CE Mark	5 days CE Mark	10 days CE Mark	14 days CE Mark

Impella

PROs:

- Relatively easy to implant and manage
- Easy to wean
- Better data for PCI support

CONs:

- Cost
- Easy dislodgement
- Hemolysis
- Inappropriate support
  - Decrease native output
- Vascular complication

CIx:

- LV thrombus
- Severe AS, Mechanical AV
- PAD

Evidence : Impella
Cardiogenic shock

IMPRESS (Ouweneel et al. JACC 2017)

- Severe cardiogenic shock in AMI
- IABP vs. Impella CP
- n=48, prospective, explorative randomized 1:1
- No difference in 30-day or 6-month mortality
  - 30-day mortality ~50% on both groups

Evidence : Impella
Cardiogenic shock

Received: 14 October 2017 | Accepted: 30 October 2017
DOI: 10.1002/ccd.27427

ORIGINAL STUDIES

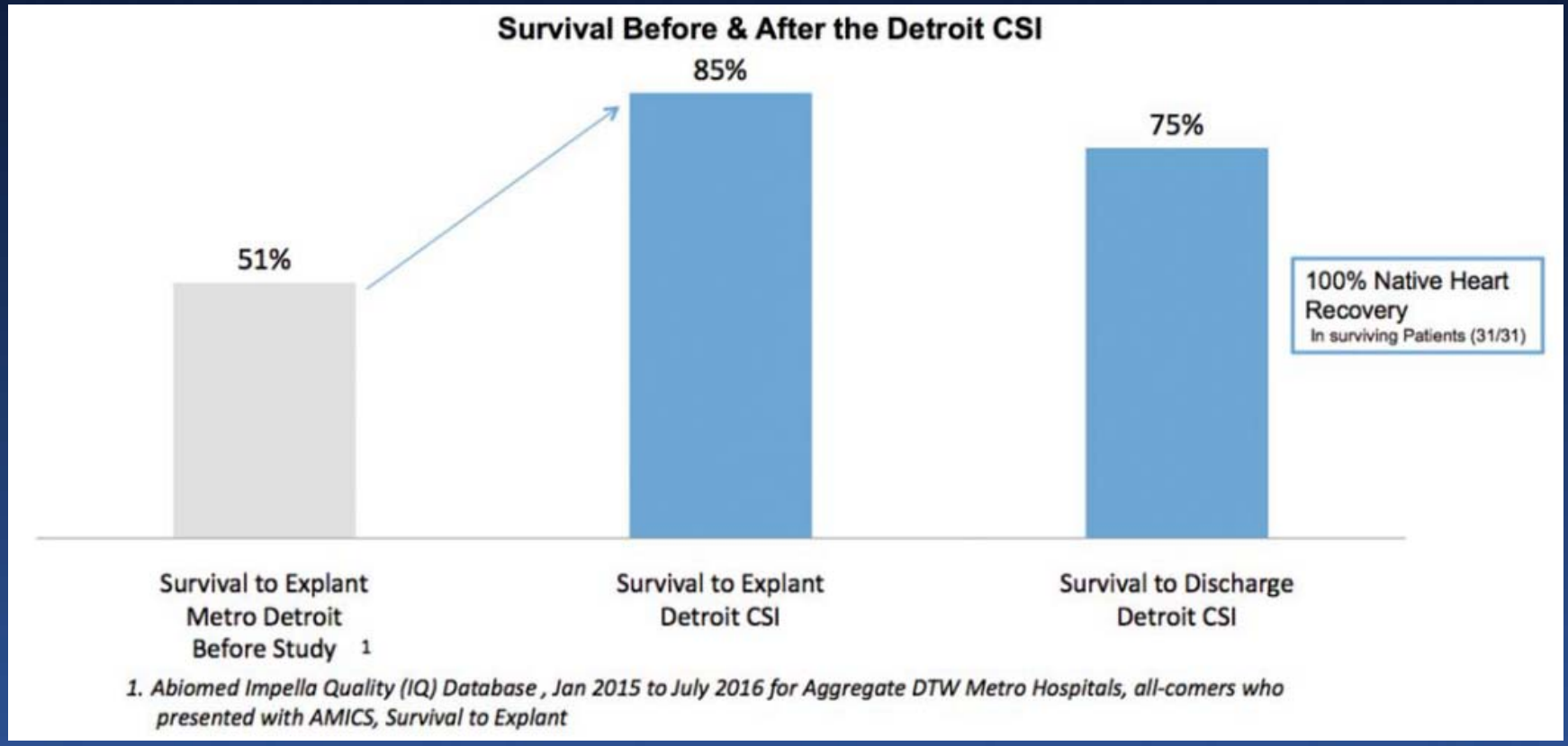
WILEY

Feasibility of early mechanical circulatory support in acute myocardial infarction complicated by cardiogenic shock: The Detroit cardiogenic shock initiative

- EARLY MCS (Impella CP)
- Early PAC
- Minimize Inotropes/ Pressors

Basir MB, et al. Catheter Cardiovasc Interv. 2018;91:454-461.

Evidence : Impella
Cardiogenic shock



Basir MB, et al. Catheter Cardiovasc Interv. 2018;91:454-461.

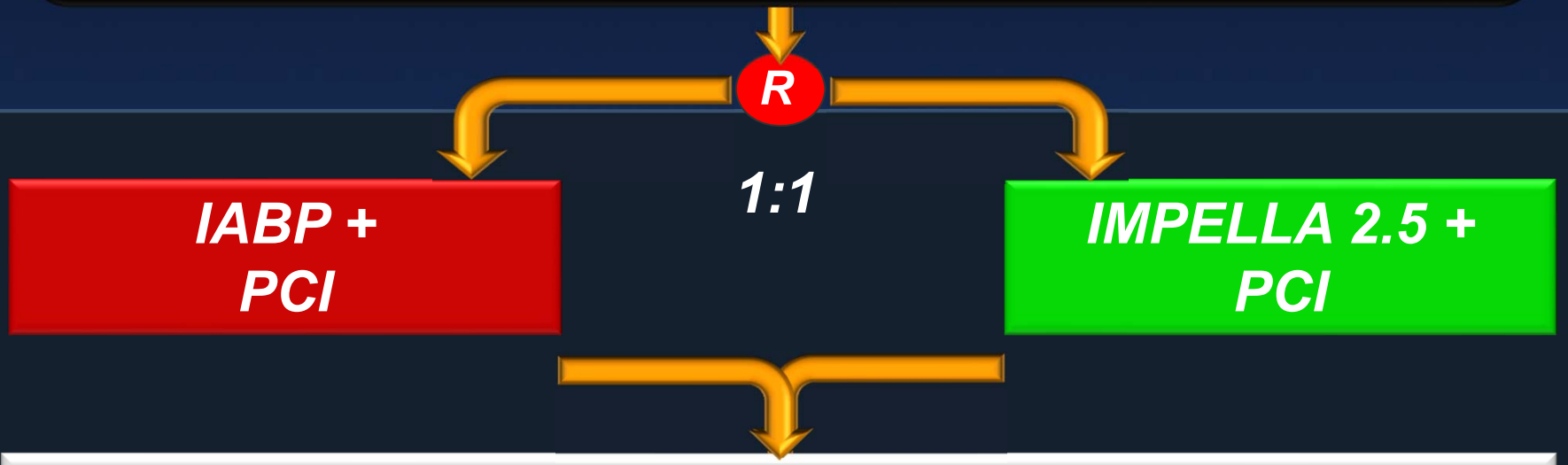
Evidence : Impella
High risk PCI

PROTECT II (O' Neill et al. Circulation 2012)

- High risk PCI, IABP vs. Impella 2.5
- N=452, prospective, randomized 1:1
- Use of Impella improved hemodynamics
- No significant difference in MAE at 30 days
- Trend towards decreased MAE with Impella at 90 days (Significant in on-treatment analysis p=0.048)

PROTECT II Trial Design

Patients Requiring Prophylactic Hemodynamic Support During Non-Emergent High Risk PCI on Unprotected LM/Last Patent Conduit and LVEF≤35% OR 3 Vessel Disease and LVEF≤30%



Primary Endpoint = 30-day Composite MAE* rate

Follow-up of the Composite MAE* rate at 90 days

* **Major Adverse Events (MAE):**
Death, MI (>3xULN CK-MB or Troponin) , Stroke/TIA, Repeat Revasc, Cardiac or Vascular Operation of Vasc. Operation for limb ischemia, Acute Renal Dysfunction, Increase in Aortic insufficiency, Severe Hypotension, CPR/VT, Angio Failure

O'Neill WW, et al. Circulation. 2012;126:1717-27.

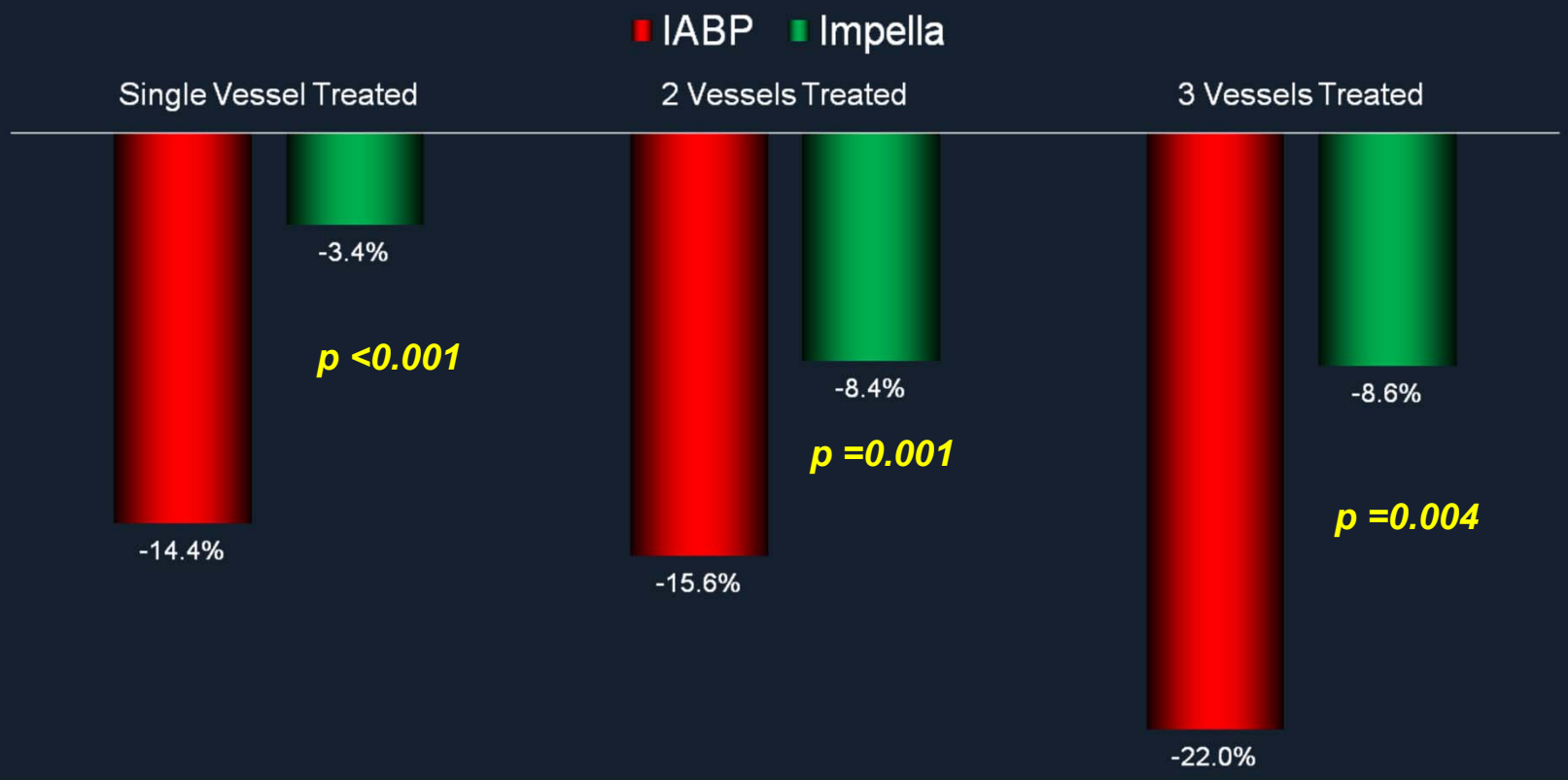
PROTECT II Study: Baseline Patient Characteristics

Patient Characteristics	IABP (N=211)	Impella (N=216)	*P value*
Age	67±11	68±11	0.553
Gender-Male	82.0%	80.9%	0.778
History of CHF	82.9%	91.2%	0.011
Current NYHA (Class III / IV)	54.9%	58.5%	0.485
Diabetes Mellitus	49.8%	53.5%	0.442
Renal insufficiency	29.5%	22.8%	0.114
Peripheral Vascular Disease	27.0%	25.0%	0.637
Implantable Cardiac Defib.	31.4%	35.8%	0.339
Prior CABG	29.4%	39.5%	0.028
LVEF	24.0±6.4	23.3±6.3	0.262
STS Mortality score	6±7	6±6	0.579
Not Surgical Candidate	63.5%	63.3%	0.957
SYNTAX score	29.5±13.7	30.3±13.2	0.620

O'Neill WW, et al. Circulation. 2012;126:1717-27.

PROTECT II

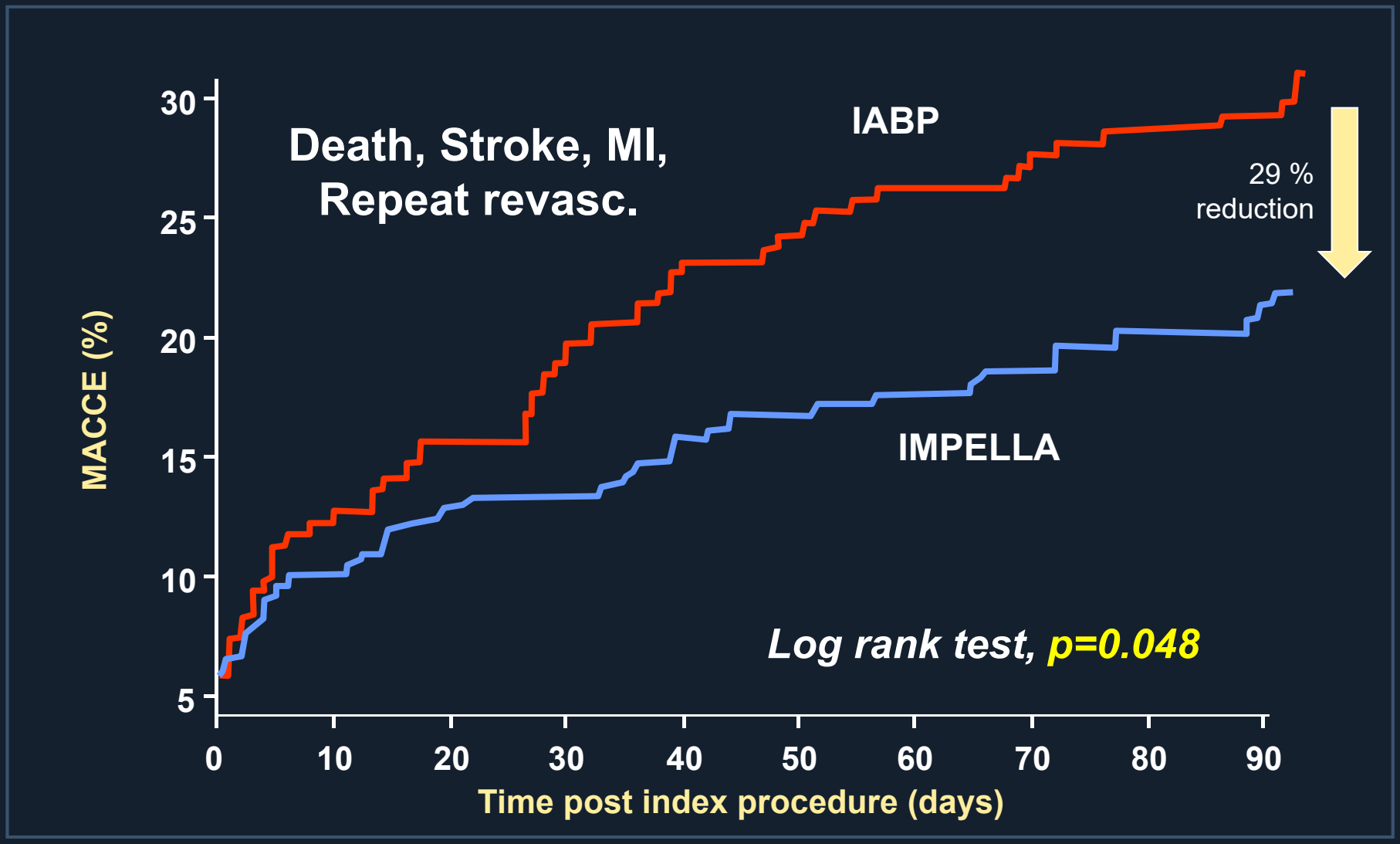
Reduction of Arterial Pressure During Procedure



O'Neill WW, et al. Circulation. 2012;126:1717-27.

PROTECT II MACCE**

Per Protocol Population, N=427



O'Neill WW, et al. Circulation. 2012;126:1717-27.

Impella (US indication)

THE IMPELLA VENTRICULAR SUPPORT SYSTEMS HAVE BEEN APPROVED FOR TWO SEPARATE INDICATIONS FOR USE

Impella 2.5® and Impella CP®

The Impella 2.5 and the Impella CP are temporary (<6 hours) ventricular support systems indicated for use during high-risk percutaneous coronary interventions (PCI) performed in elective or urgent, hemodynamically stable patients with severe coronary artery disease and depressed left ventricular ejection fraction, when a heart team, including a cardiac surgeon, has determined high-risk PCI is the appropriate therapeutic option. Use of the Impella 2.5 and the Impella CP in these patients may prevent hemodynamic instability which can result from repeat episodes of reversible myocardial ischemia that occur during planned temporary coronary occlusions and may reduce peri- and post-procedural adverse events.

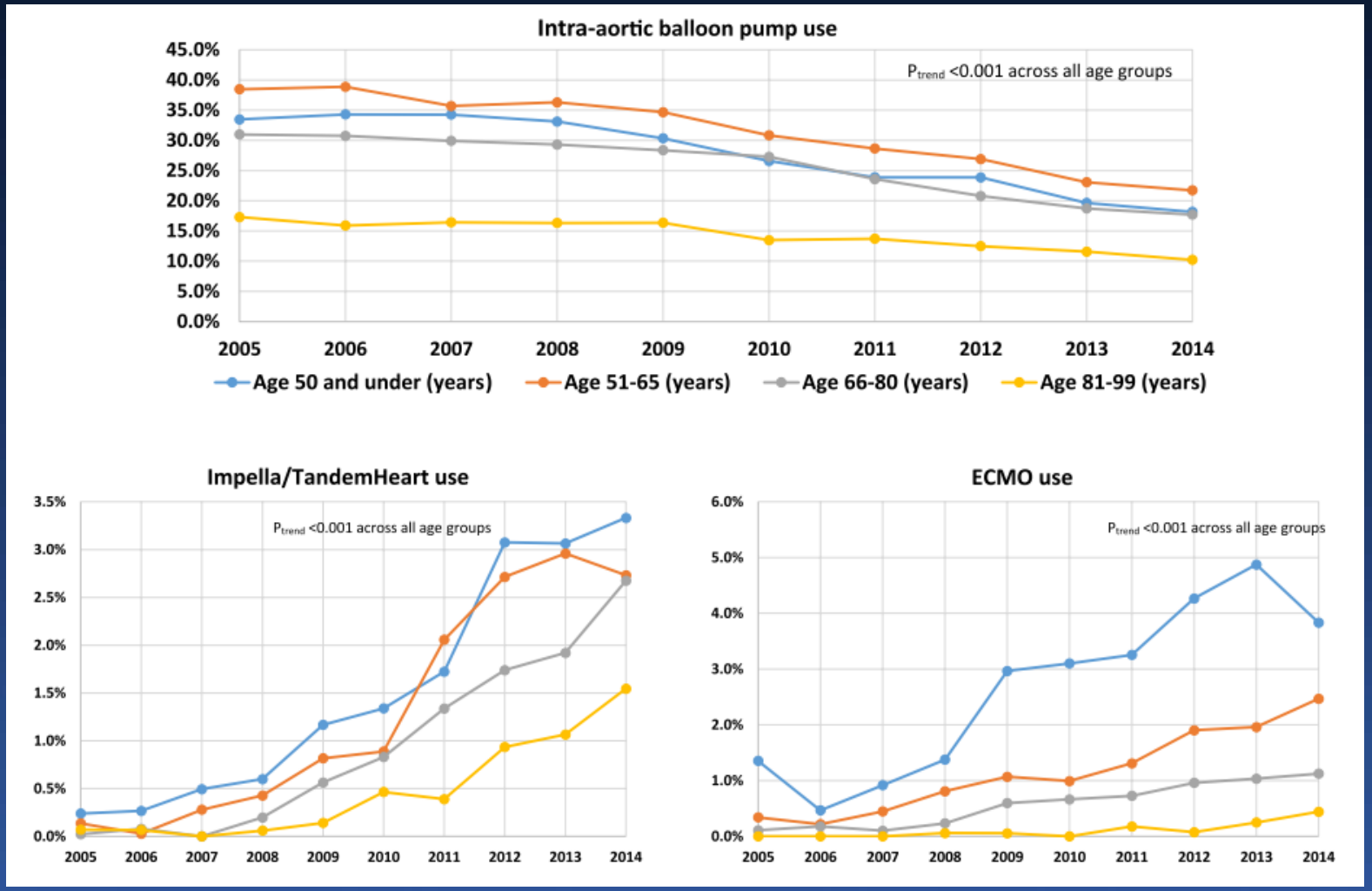
Impella 2.5, Impella CP, Impella 5.0®, and Impella LD®

The Impella 2.5, Impella CP, Impella 5.0, and Impella LD Catheters, in conjunction with the Automated Impella® Controller, are temporary ventricular support devices intended for short term use (≤ 4 days for the Impella 2.5 and Impella CP, and ≤ 6 days for the Impella 5.0 and Impella LD) and indicated for the treatment of ongoing cardiogenic shock that occurs:

- immediately (<48 hours) following acute myocardial infarction or open heart surgery, or
- in the setting of cardiomyopathy, including peripartum cardiomyopathy, or myocarditis

Trends in pMCS device in USA

US Registry: 144.254 patients with cardiogenic shock



Shah M, et al. Clin Res Cardiol. 2018;107:287-303.

PROTECT III

Procedural Characteristics vs. PROTECT II

	PROTECT III			PROTECT II	
	All N=898	Impella CP N=571	Impella 2.5 N=327	Impella 2.5 N=216	p-value PROTECT III All vs P II
# Vessels Treated	2.00±0.77	2.00±0.75	2.02±0.80	1.81±0.67	<0.001
3 Vessels Treated	29.9%	28.2%	32.7%	14.4%	<0.001
LAD	37.7%	37.6%	37.9%	34.2%	0.123
Left Main	15.7%	16.8%	13.5%	11.5%	0.011
LCx	27.7%	27.1%	28.9%	28.5%	0.716
RCA	15.7%	15.3%	16.4%	19.0%	0.058
Pre-PCI TIMI 0/1	14.7%	15.7%	12.5%	7.0%	<0.001
Atherectomy Use	43.3%	45.2%	40.0%	14.2%	<0.001
# Vessels w/ Atherectomy	2.01±0.75	2.03±0.74	1.96±0.77	1.44±0.62	<0.001
Contrast Volume (mL)	204.2±105.6	206.9±105.4	199.4±106.0	267.5±141.7	<0.001
Length of Support (hrs)	6.79±21.1	7.78±22.3	4.83±18.2	1.9±2.7	<0.001

tct2019

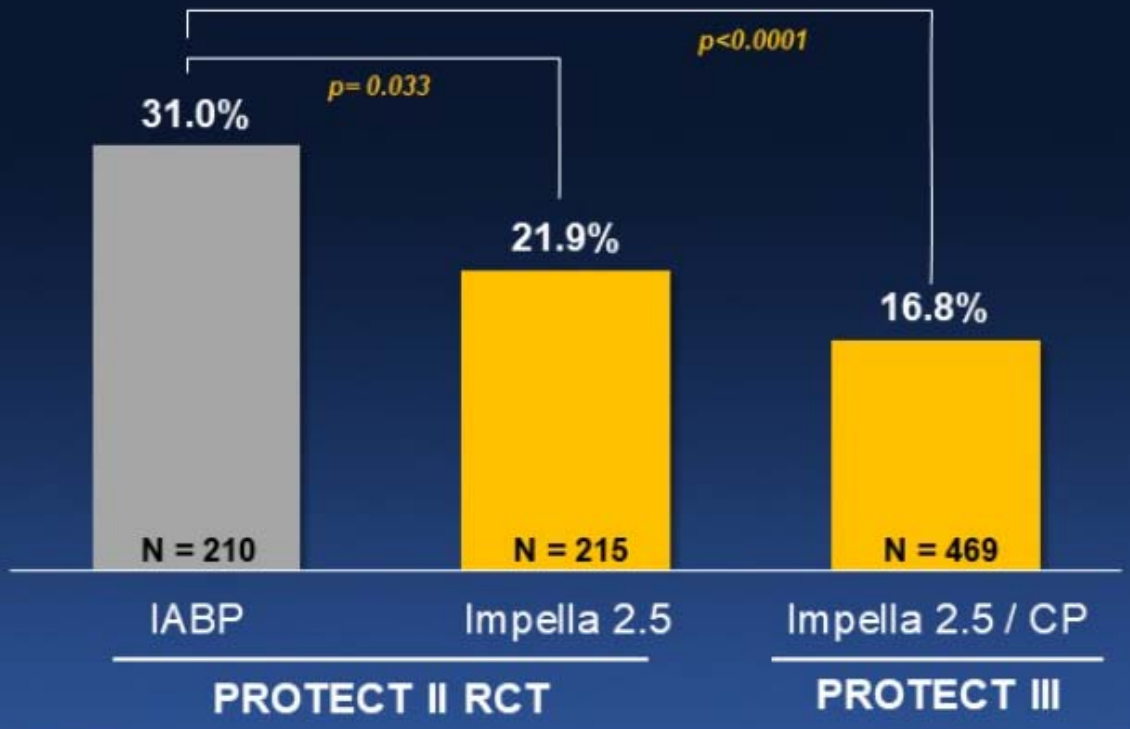
PROTECT III patients receive more complex procedures.

PROTECT III – Interim analysis

PROTECT III Outcomes Compared to Protect II

Composite Major Adverse Cardiac and Cerebrovascular Events (MACCE) at 90 Days

898 patients
45 sites in the US
March 2017 - July 2019



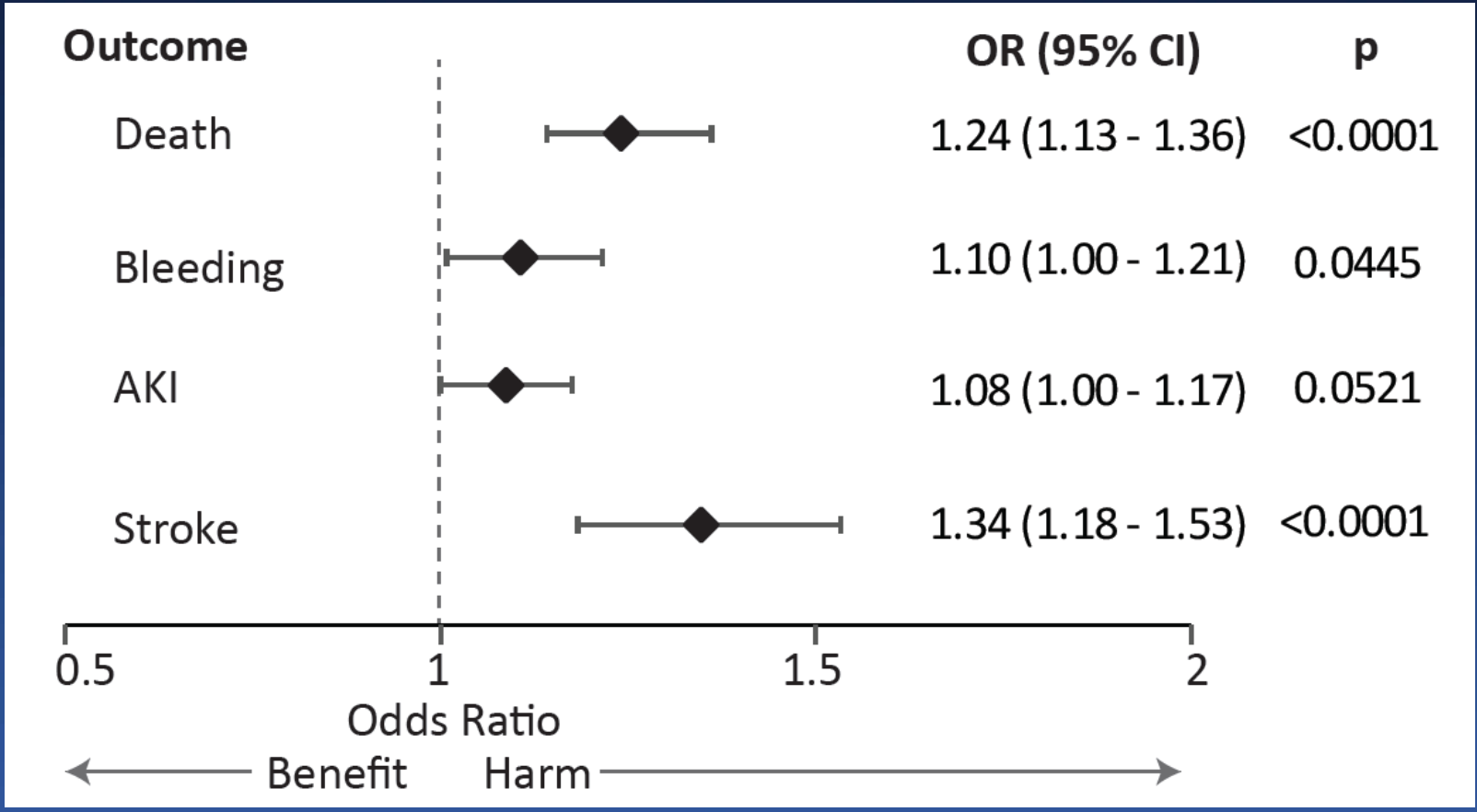
MACCE = Death, Stroke, MI, Repeat Revascularization

tct2019

N = number of patients with 90-day follow-up

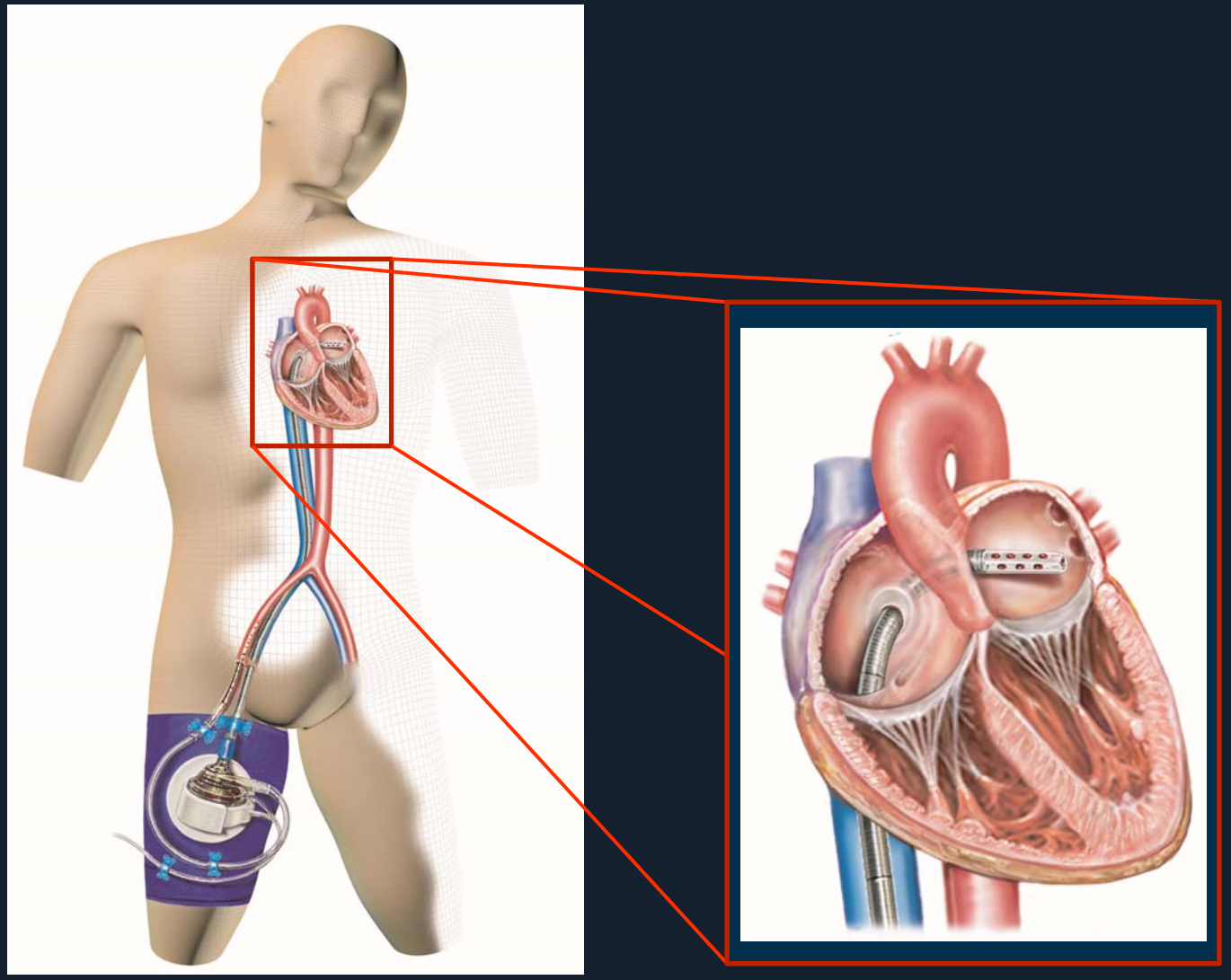
Real world data in USA

- Impella use – 31.9 % of MCS in 2016
- Pre-Impella era (2004-2007) vs. Impella era (2008-2016)
- Impella use was associated with higher rates of adverse events and costs.



Amin et al. Circulation. 2019 Nov 17. [Epub ahead of print]

TandemHeart



LA to FA bypass
Up to 5L/min

21 Fr venous,
15-19 Fr arterial

Transseptal puncture (Implantation time : 25-65 min)

Not widely used

↓ Preload
↓ MVO2
↓ Wall stress
LV unloading

Evidence : TandemHeart
Cardiogenic shock

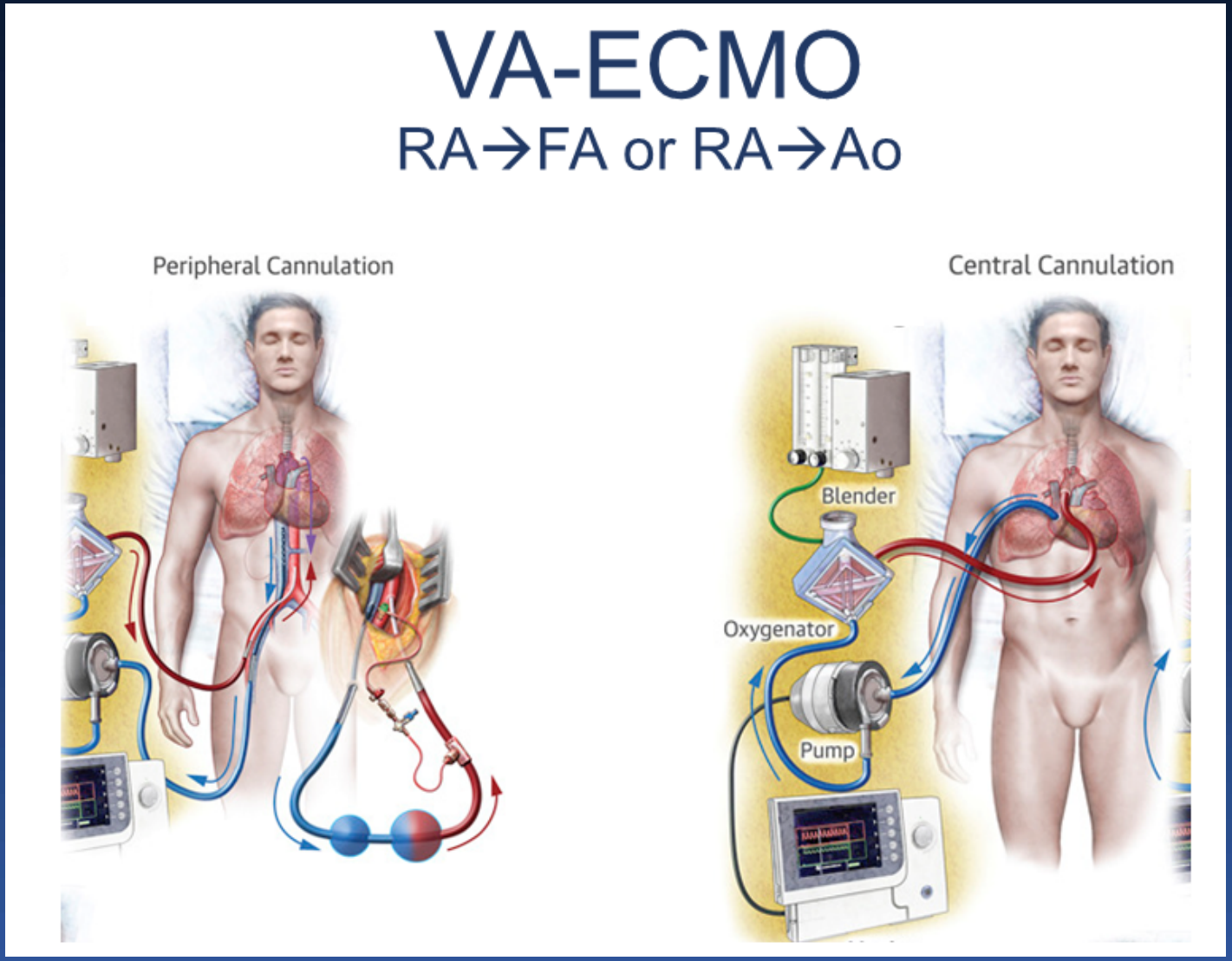
TandemHeart in AMI (Thiele H et al. Eur Heart J 2005)

- CS after AMI
- n=83, IABP vs. TandemHeart, randomized 1:1
- Improved CI, MAP, PWCP, metabolic variable
- Similar 30d mortality (~44%)

Texas Heart (Kur B et al. JACC 2011)

- Severe refractory CS (47.9% CPR)
- 80 Ischemic CMP, 37 nonischemic CMP
- Improvement in hemodynamics
- 30d mortality 40.2 % and 6m mortality 45.3 %

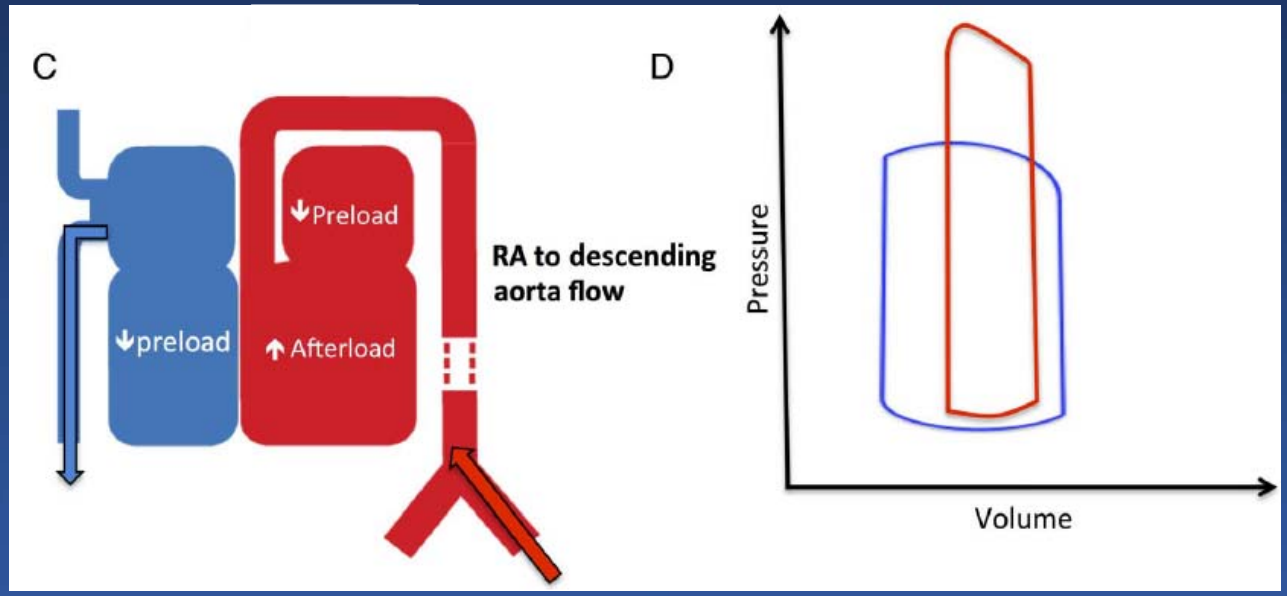
VA-ECMO


VA-ECMO
RA→FA or RA→Ao
Peripheral Cannulation
Central Cannulation
Blender
Oxygenator
Pump

Hemodynamics of Peripheral VA-ECMO

- Quick restoration of perfusion (3-7 L/min)
  - Full cardiac support with Oxygenation

- Increased in afterload is problematic when peripherally cannulated, if poor LV function
  - Increase in PCWP/Lung congestion
    > Consideration for unloading LV/LA
    (i.e. Septostomy, IABP, Impella)



Briceno N, et al. Heart 2016;102:1494–1507.

Evidence : VA-ECMO

Descriptive:

Cardiac Arrest and/or Shock

(Nichol et al. Resuscitation, 2006)

- Meta-analysis : 85 studies, n=1494
- Survival to discharge 47%

(Takyama et al. J Heart Lung Transpl. 2013)

- Single center; n=90 (23% with CPR)
- Survival to discharge: 49%

Descriptive:

E-CPR

(Thiagarajan et al. Ann Thorac Surg, 2009)

- ELSO Registry
- n=295 (75% AMI), 1992-2007
- Survival to discharge 27%

Descriptive:

Fulminant myocarditis

(Lorusso et al. Ann Thorac Surg,2016)

- Survival to discharge 72%
- Major complications 70%

Evidence : VA-ECMO

ECLS Registry Report

International Summary

July, 2019

For July reports, the current year is reported as a partial year only

Extracorporeal Life Support Organization
2800 Plymouth Road
Building 300, Room 303
Ann Arbor, MI 48109

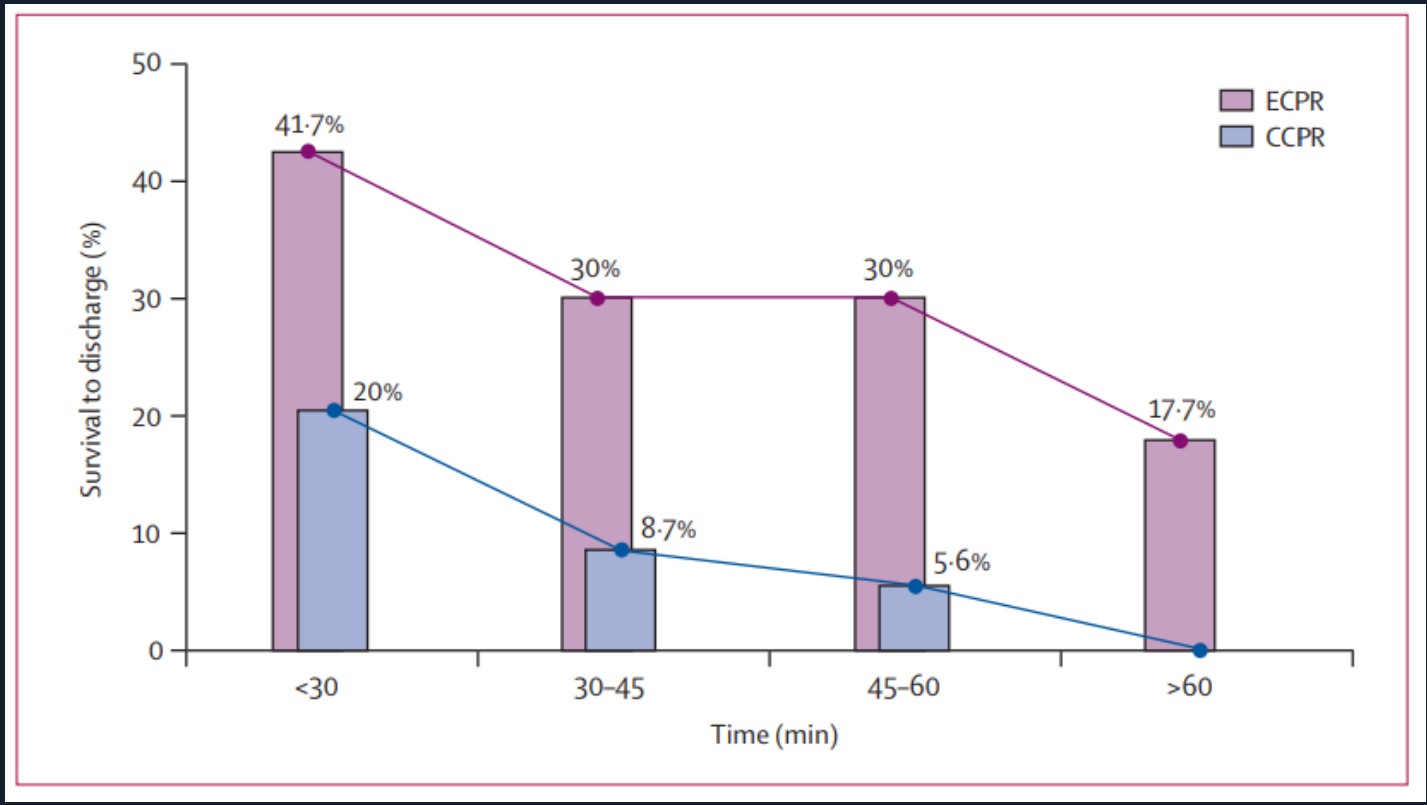
Overall Outcomes

	Total Runs	Survived ECLS		Survived to DC or Transfer	
Neonatal					
Pulmonary	31,923	28,050	87%	23,360	73%
Cardiac	8,498	5,874	69%	3,665	43%
ECPR	1,923	1,359	70%	812	42%
Pediatric					
Pulmonary	9,902	7,126	71%	5,879	59%
Cardiac	11,839	8,512	71%	6,251	52%
ECPR	4,608	2,760	59%	1,957	42%
Adult					
Pulmonary	21,874	15,159	69%	13,088	59%
Cardiac	22,193	13,177	59%	9,585	43%
ECPR	6,994	2,923	41%	2,074	29%
Total	119,754	84,940	70%	66,671	55%

Evidence : VA-ECMO

CPR with ECMO vs. Conventional CPR:
In-Hospital Cardiac Arrest

Survival to Discharge Based Upon Duration of CPR



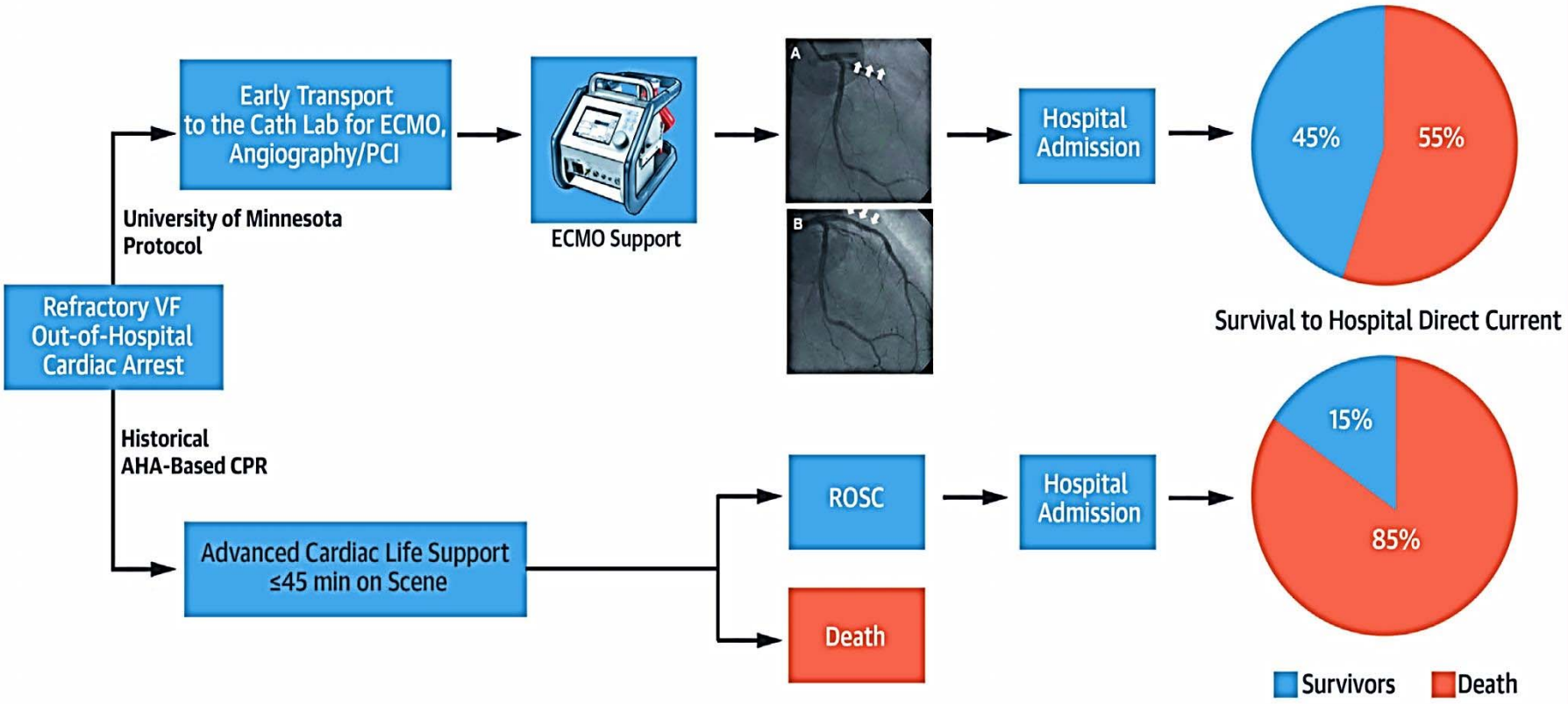
Chen YS, et al. Lancet 2008;372:554-61.

Chen et al. Lancet 2008;372:554–561.

Evidence : VA-ECMO

Out-Hospital Cardiac arrest

CENTRAL ILLUSTRATION Refractory Cardiac Arrest Due to VF/VT and the University of Minnesota ECLS/PCI Protocol



Yannopoulos, D. et al. J Am Coll Cardiol. 2017;70(9):1109-17.

Evidence: VA-ECMO+Impella (ECPELLA)

European Journal of Heart Failure (2017) **19**, 404–412
doi:10.1002/ejhf.668

RESEARCH ARTICLE

Concomitant implantation of Impella® on top of veno-arterial extracorporeal membrane oxygenation may improve survival of patients with cardiogenic shock

Table 3 Comparison of major outcomes between patients treated with veno-arterial extracorporeal membrane oxygenation (ECMO) and Impella and patients treated with veno-arterial ECMO only in the propensity score matching sample ($n = 63$)

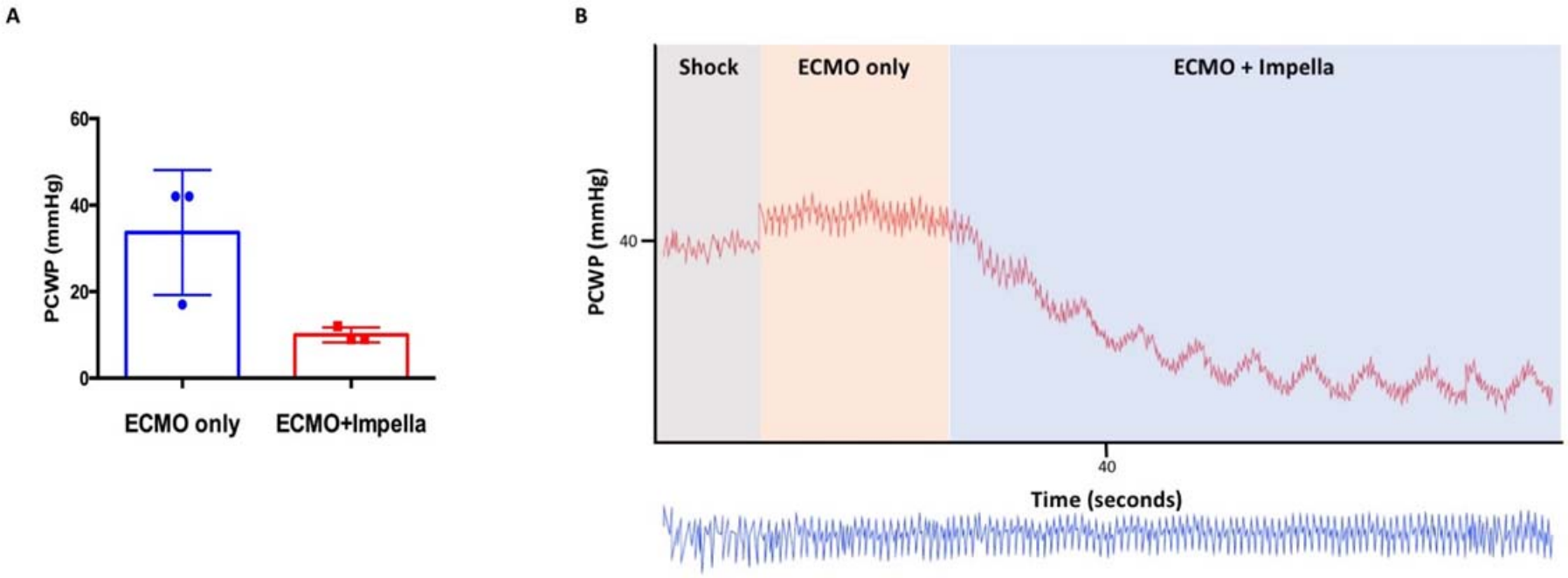
Parameter	Total ($n = 63$)	ECMO + Impella ($n = 21$)	ECMO ($n = 42$)	*P*-value
Hospital mortality, *n* (%)	41 (65)	10 (48)	31 (74)	0.04
Bridge to next therapy or recovery, *n* (%)	28 (44)	13 (62)	15 (36)	0.048
Weaning from MCS, *n* (%)	26 (41)	10 (48)	16 (28)	0.047
Bridge to recovery, *n* (%)	19 (30)	8 (38)	11 (26)	0.3
Bridge to VAD, *n* (%)	8 (13)	4 (19)	4 (9.5)	0.5
Bridge to cardiac transplantation, *n* (%)	0	0	0	
Duration of ECMO, h	120 (36–234)	148 (72–239)	73.5 (29–217)	0.2
Duration of MV, h	93 (29–228)	163 (90–228)	48 (17–265)	0.04
CVVH, *n* (%)	18 (29)	10 (48)	8 (19)	0.02
Haemolysis, *n* (%)	30 (48)	16 (76)	14 (33)	0.004
Major bleeding, *n* (%)	20 (32)	8 (38)	12 (29)	0.6
Minor bleeding, *n* (%)	14 (22)	4 (19)	10 (24)	0.8
LVEF at weaning, %	45.5 (30–55)	52.5 (47–55.5)	37.5 (25–50)	0.13

CVVH, continuous veno-venous haemofiltration; MCS, mechanical circulatory support; MV, mechanical ventilation; VAD, ventricular assist device.

Pappalardo F, et al. Eur J Heart Fail. 2017;19:404-412.

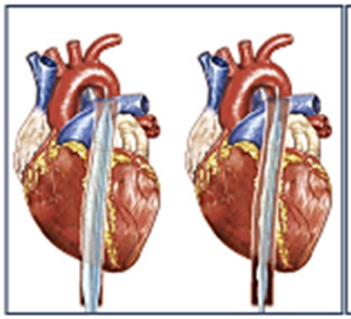
Evidence: VA-ECMO+Impella (ECPELLA)

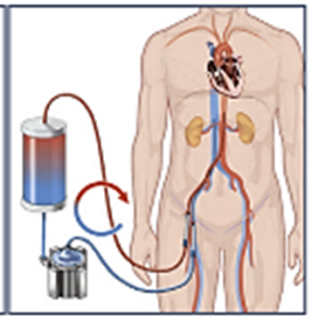
Rapid and Marked Reduction of PCWP with Impella added to ECMO



Schrage et al, JACC:HF, in press.

pMCS device available



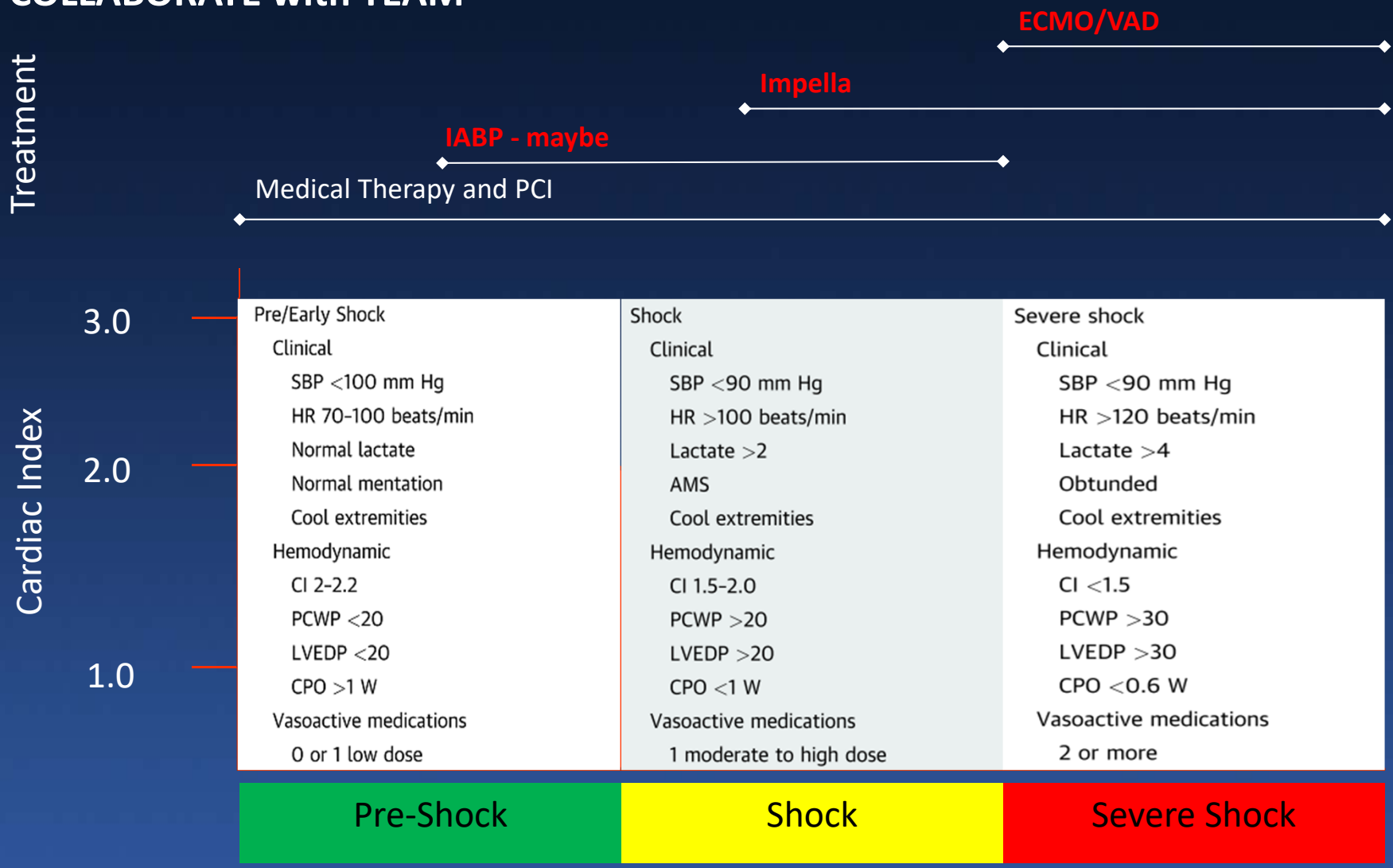



	IABP	IMPELLA	TANDEMHEART	VA-ECMO
Cardiac Flow	0.3-0.5 L/ min	1-5L/ min (Impella 2.5, Impella CP, Impella 5)	2.5-5 L/ min	3-7 L-min
Mechanism	Aorta	LV → AO	LA → AO	RA → AO
Maximum implant days	Weeks	7 days	14 days	Weeks
Sheath size	7-8 Fr	13-14 Fr Impella 5.0 - 21 Fr	15-17 Fr Arterial 21 Fr Venous	14-16 Fr Arterial 18-21 Fr Venous
Femoral Artery Size	>4 mm	Impella 2.5 & CP - 5-5.5 mm Impella 5 - 8 mm	8 mm	8 mm
Cardiac synchrony or stable rhythm	Yes	No	No	No
Afterload	↓	↓	↑	↑↑↑
MAP	↑	↑↑	↑↑	↑↑
Cardiac Flow	↑	↑↑	↑↑	↑↑
Cardiac Power	↑	↑↑	↑↑	↑↑
LVEDP	↓	↓↓	↓↓	↔
PCWP	↓	↓↓	↓↓	↔
LV Preload	---	↓↓	↓↓	↓
Coronary Perfusion	↑	↑	---	---
Myocardial oxygen demand	↓	↓↓	↔↓	↔

Atkinson TM, et al. JACC Cardiovasc Interv. 2016;9:871-83.

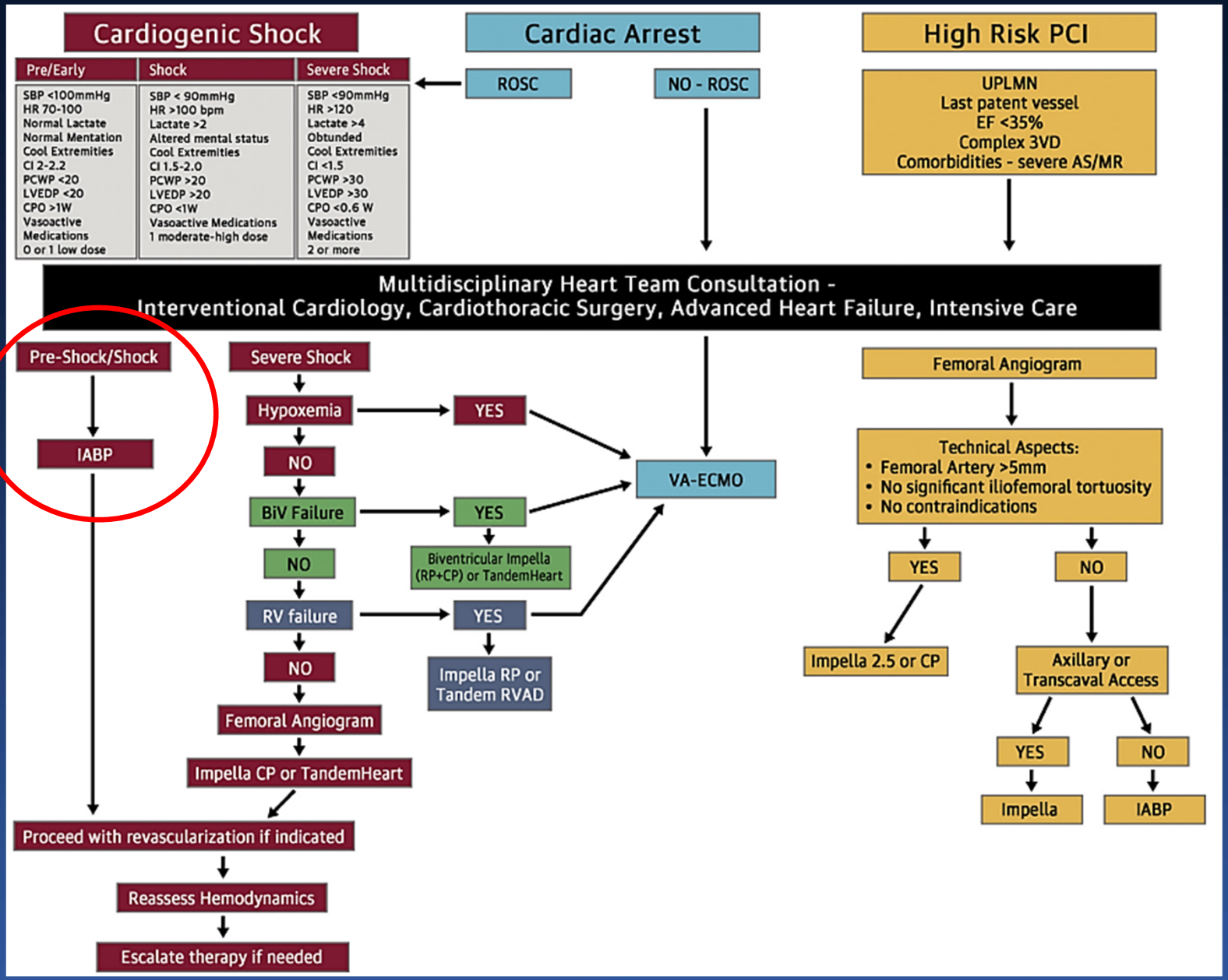
Practical approach to pMCS

Consider acidosis, lactate clr, oxygenation , RV function, RHC, ECHO
COLLABORATE with TEAM



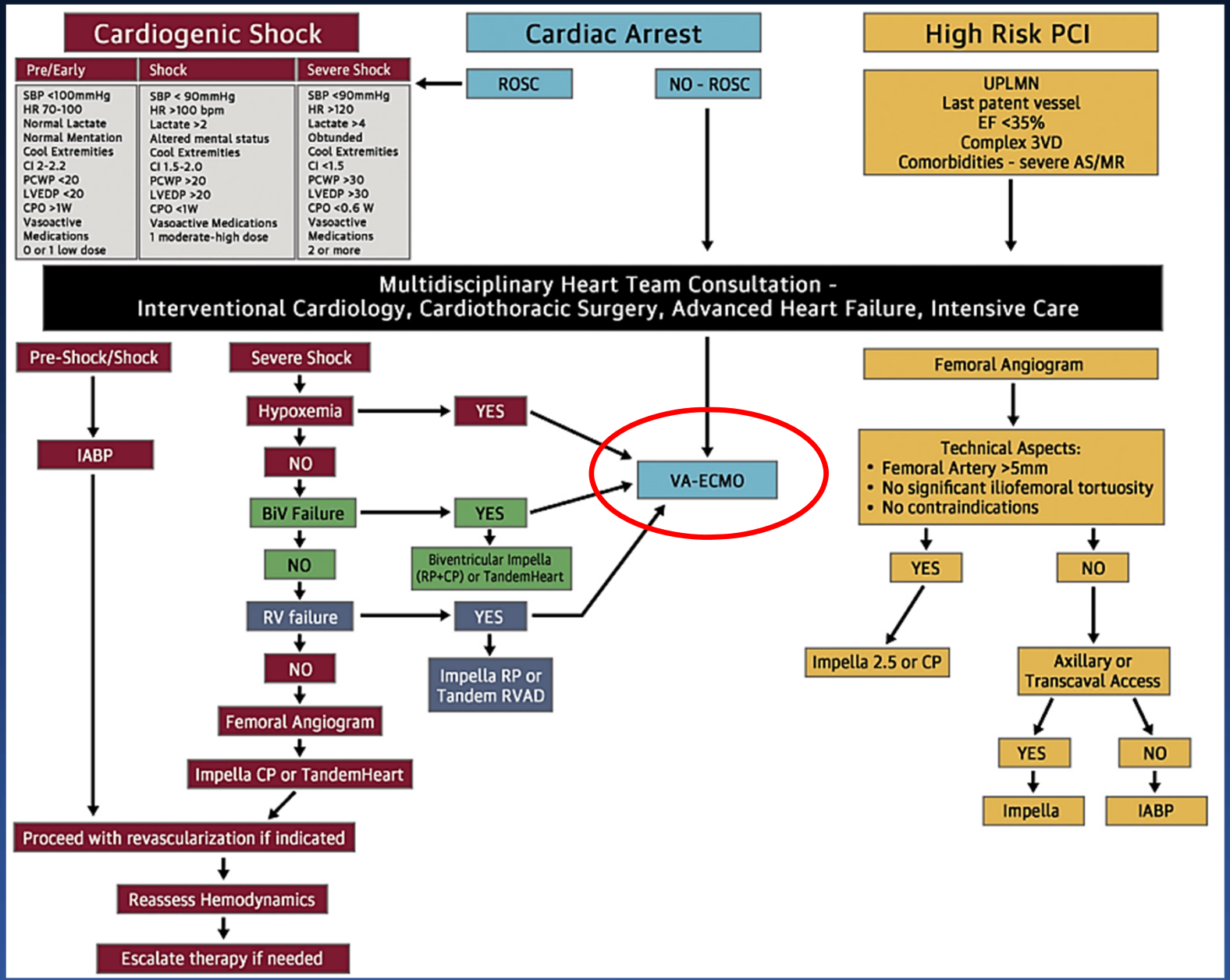
Modified from Atkinson TM, et al. JACC Cardiovasc Interv. 2016;9:871-83.

Practical approach to pMCS



Atkinson TM, et al. JACC Cardiovasc Interv. 2016;9:871-83.

Practical approach to pMCS



Atkinson TM, et al. JACC Cardiovasc Interv. 2016;9:871-83.

Practical approach to pMCS
High-Risk PCI

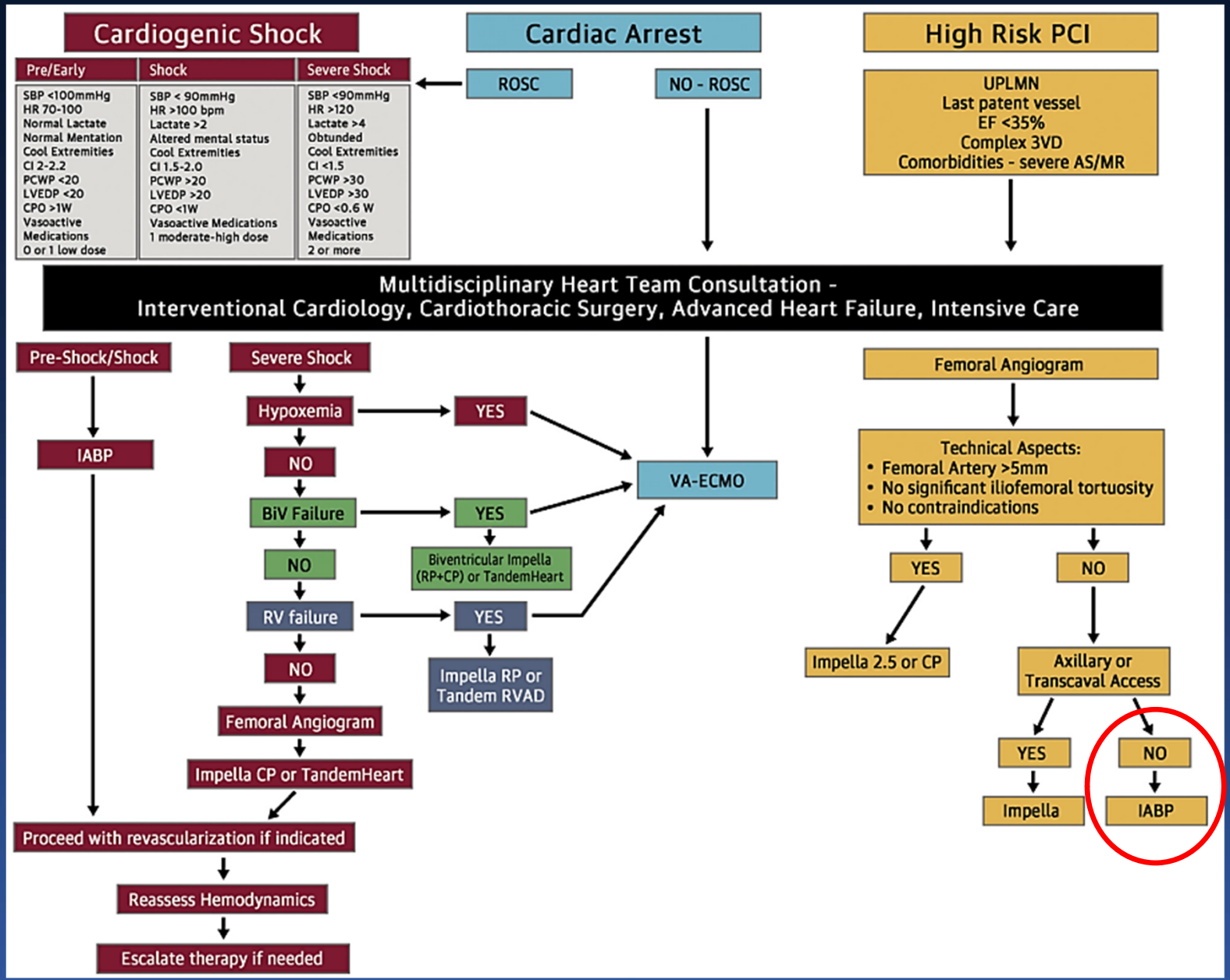
TABLE 3 High-Risk PCI

Clinical
LVEF <35%
Electrical instability
Congestive heart failure
Comorbidities
Severe aortic stenosis
Severe mitral regurgitation
Chronic obstructive pulmonary disease
Chronic kidney disease
Diabetes
Cerebrovascular disease
Peripheral vascular disease
Age >75 yrs
Acute coronary syndrome

Coronary anatomy
Last patent vessel
UPLMN
3 vessel disease, SYNTAX score >33
Target vessel providing collaterals to a territory, which supplies >40% of the myocardium
Distal left main bifurcation

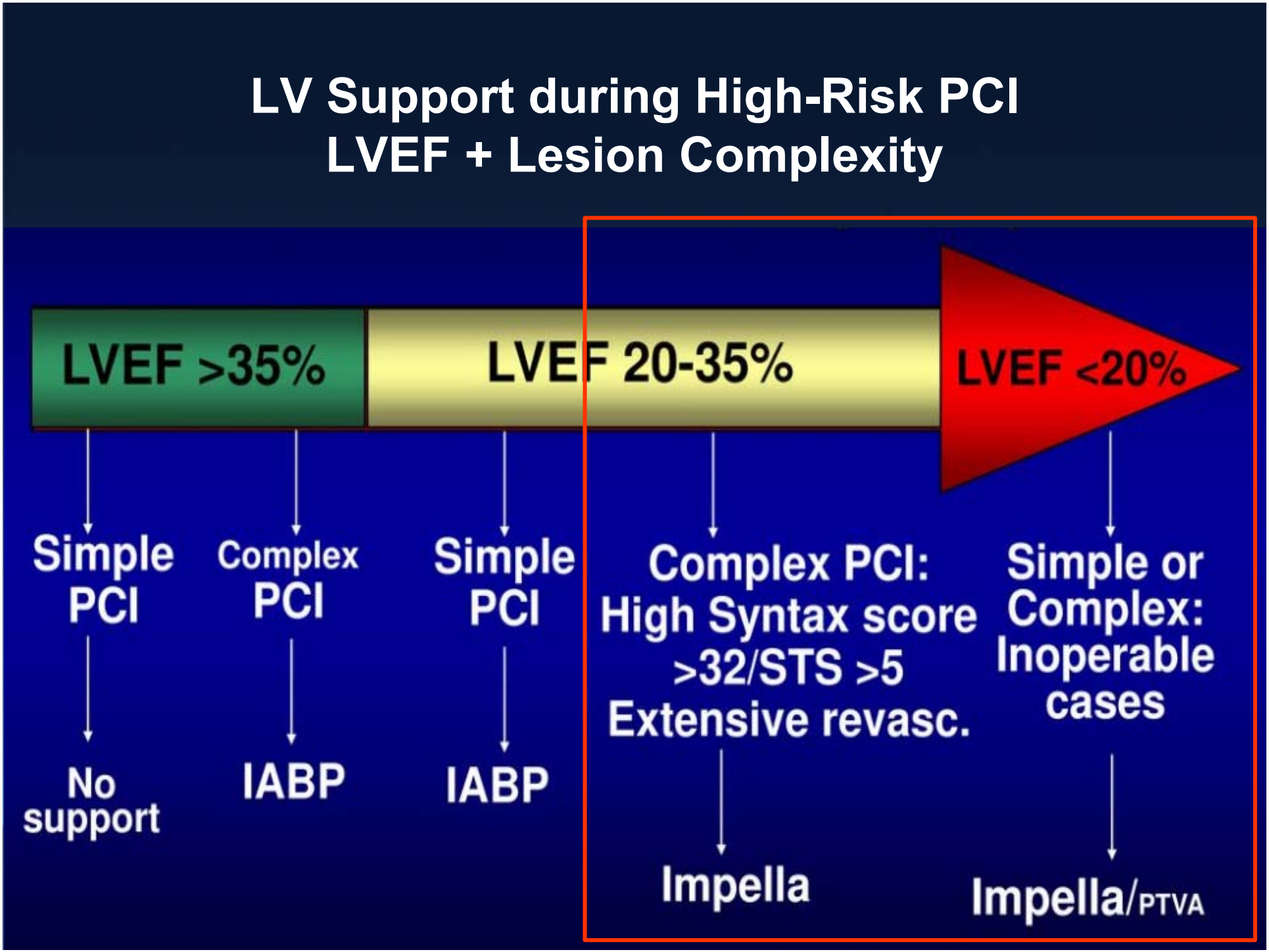
Myat A, et al. JACC Cardiovasc Interv. 2015;8:229-244.

Practical approach to pMCS

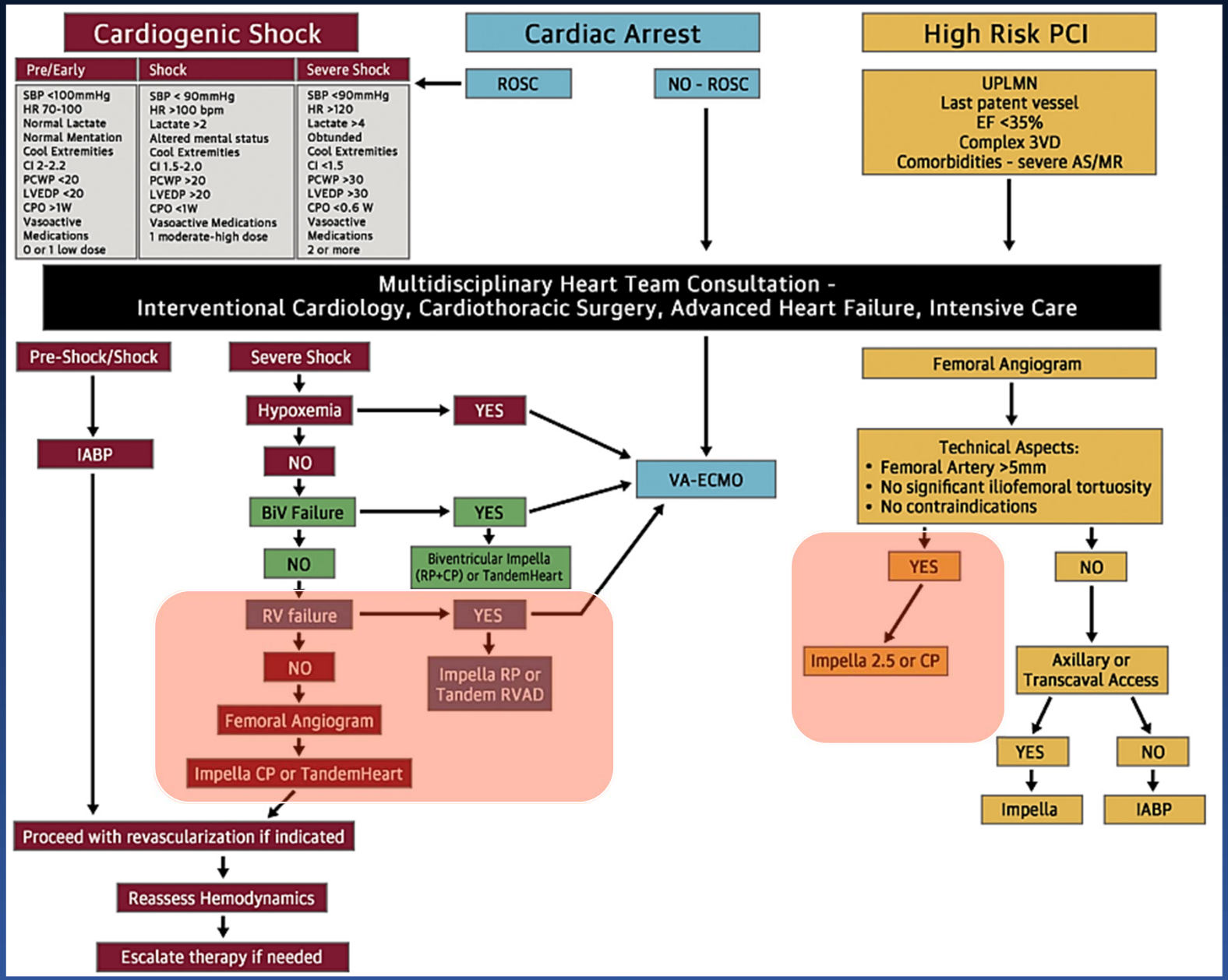


Atkinson TM, et al. JACC Cardiovasc Interv. 2016;9:871-83.

LV Support during High-Risk PCI
LVEF + Lesion Complexity



Lack of available options in Korea



Atkinson TM, et al. JACC Cardiovasc Interv. 2016;9:871-83.

Conclusion

Cardiogenic shock

- Terrible prognosis with limited therapeutic options

- Limited evidence for MCS
  - Methodological challenges
  - Small studies
  - No randomized prospective evidence of mortality benefit in all comers

- Careful patient selection is important

Conclusion

- In the setting of pre-shock with systemic hypoperfusion without a blood pressure <90 mmHg or high-risk PCI, it may be reasonable to use an IABP.
- In patients meeting criteria for severe cardiogenic shock and cardiac arrest, the use of VA-ECMO should be considered.
- The Impella showed beneficial effects on hemodynamics and improved survival benefits in high-risk PCI and cardiogenic shock registry, but real-world evidence was disappointing. Further research is needed.

- Thank you for listening