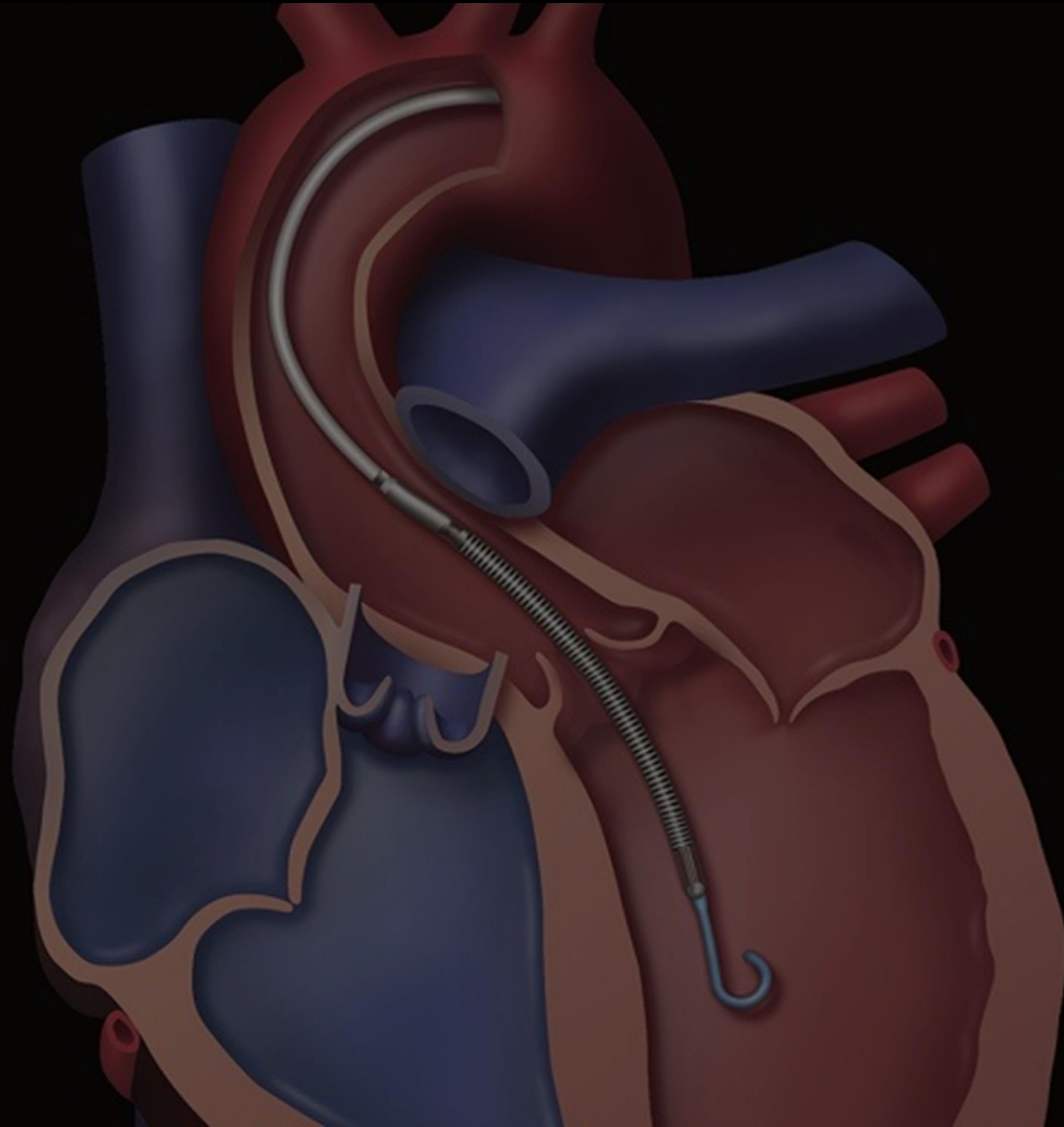
Use of Mechanical Circulatory Support Devices Among Patients With ACS Complicated by Cardiogenic Shock

Tai-Wei Chen, MD

Department of Cardiovascular Surgery

Taipei Veterans General Hospital



Outline

- ✓Cardiogenic shock
- ✓Mechanical circulatory support device
- ✓IABP, Intra-arterial balloon pump
- ✓Impella heart pump
- ✓ECMO pump

Cardiogenic shock

TABLE 1 Hemodynamic Criteria for Cardiogenic Shock

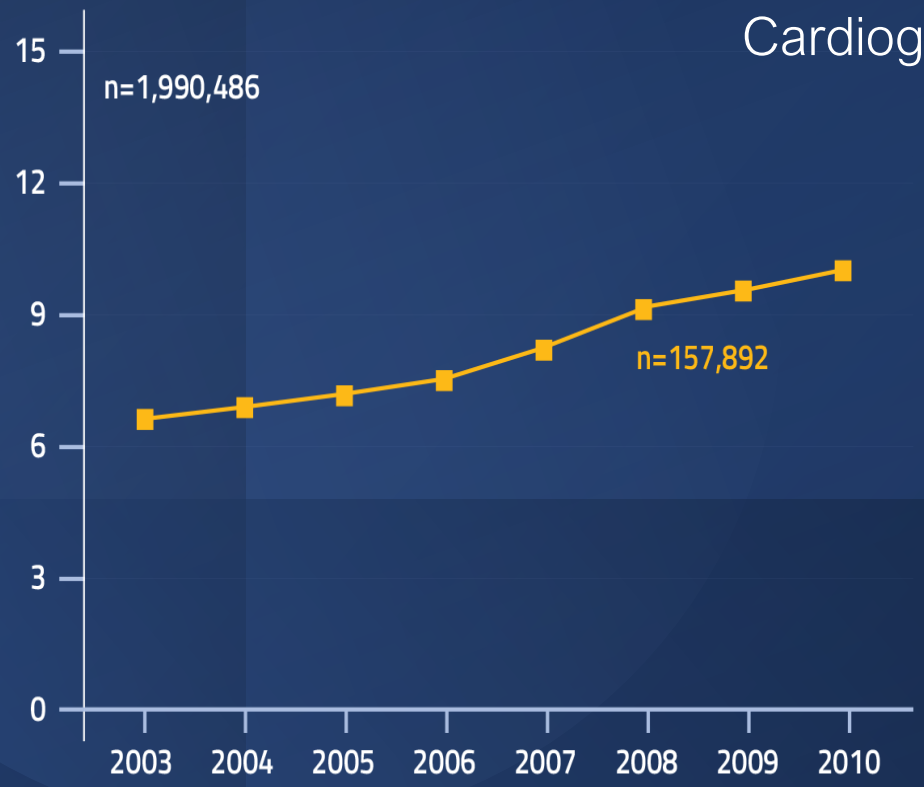
Clinical
SBP <90 mm Hg for 30 min
Supportive measures needed to maintain SBP >90 mm Hg
End-organ hypoperfusion
Cool extremities
UOP <30 ml/h
HR >60 beats/min
Hemodynamic
Cardiac index <2.2 ml/min/m^2
PCWP >15 mm Hg

The SHOCK trial defined cardiogenic shock according the clinical and hemodynamic criteria listed (11).

HR = heart rate; PCWP = pulmonary capillary wedge pressure; SBP = systolic blood pressure; UOP = urine output.

Atkinson, et al. J Am Coll Cardiol Intv. 2016;9:871–83.

Incidence of cardiogenic shock growing

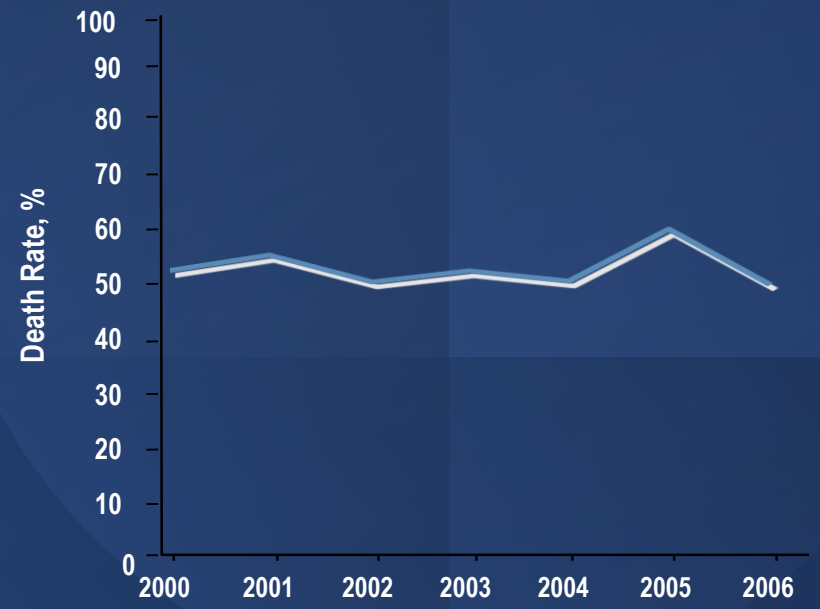


Cardiogenic Shock in STEMI Increasing [1]

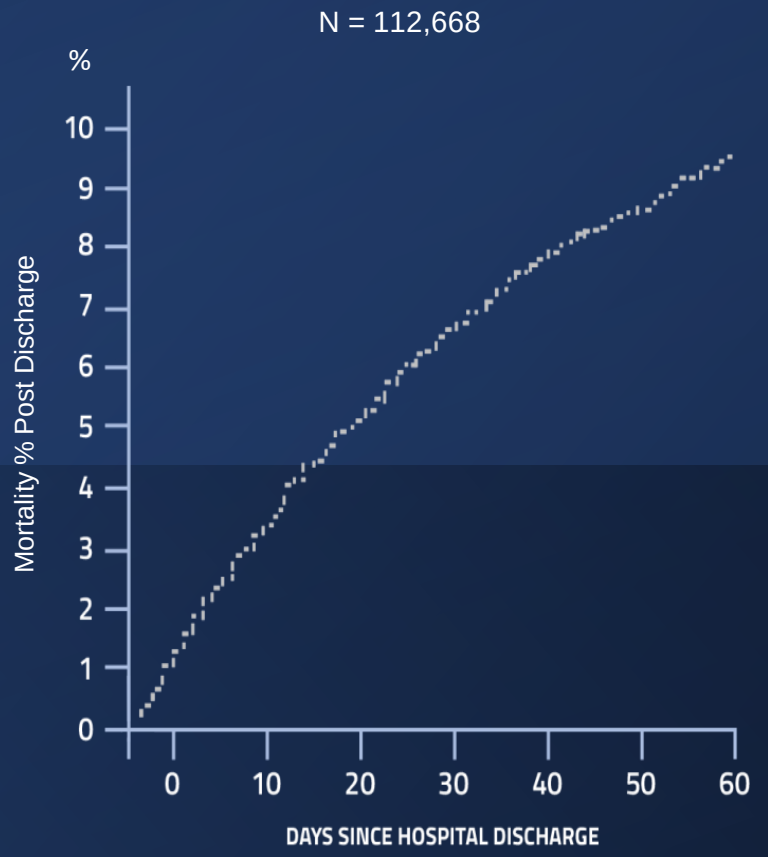
Dhaval Kolte, et al. J Am Heart Assoc 2014 .

Cardiogenic shock remains leading cause of death

High In-Hospital Mortality During AMI Cardiogenic Shock[1]

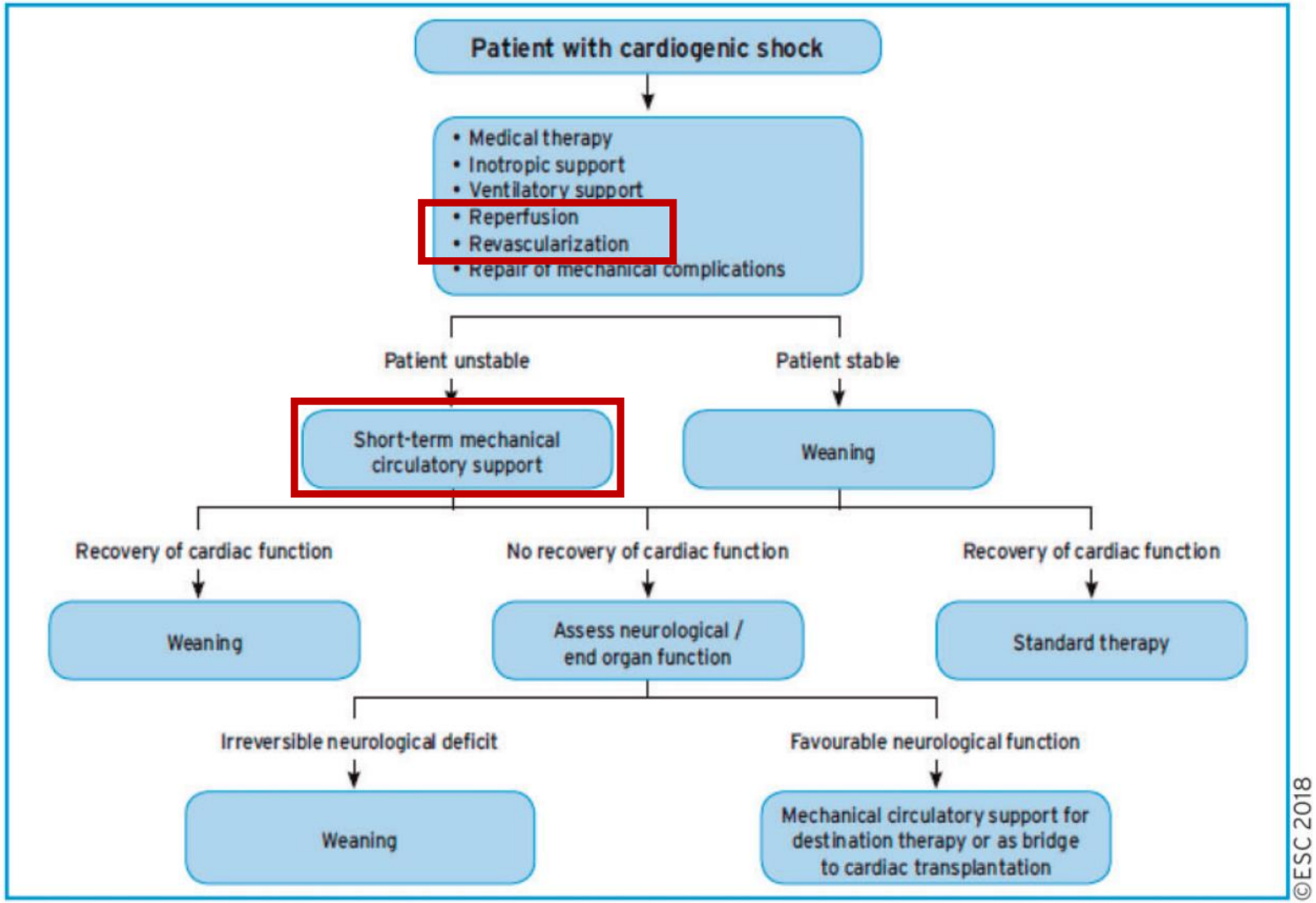


… and Ongoing Hazard Post Discharge after AMI Cardiogenic Shock[2]



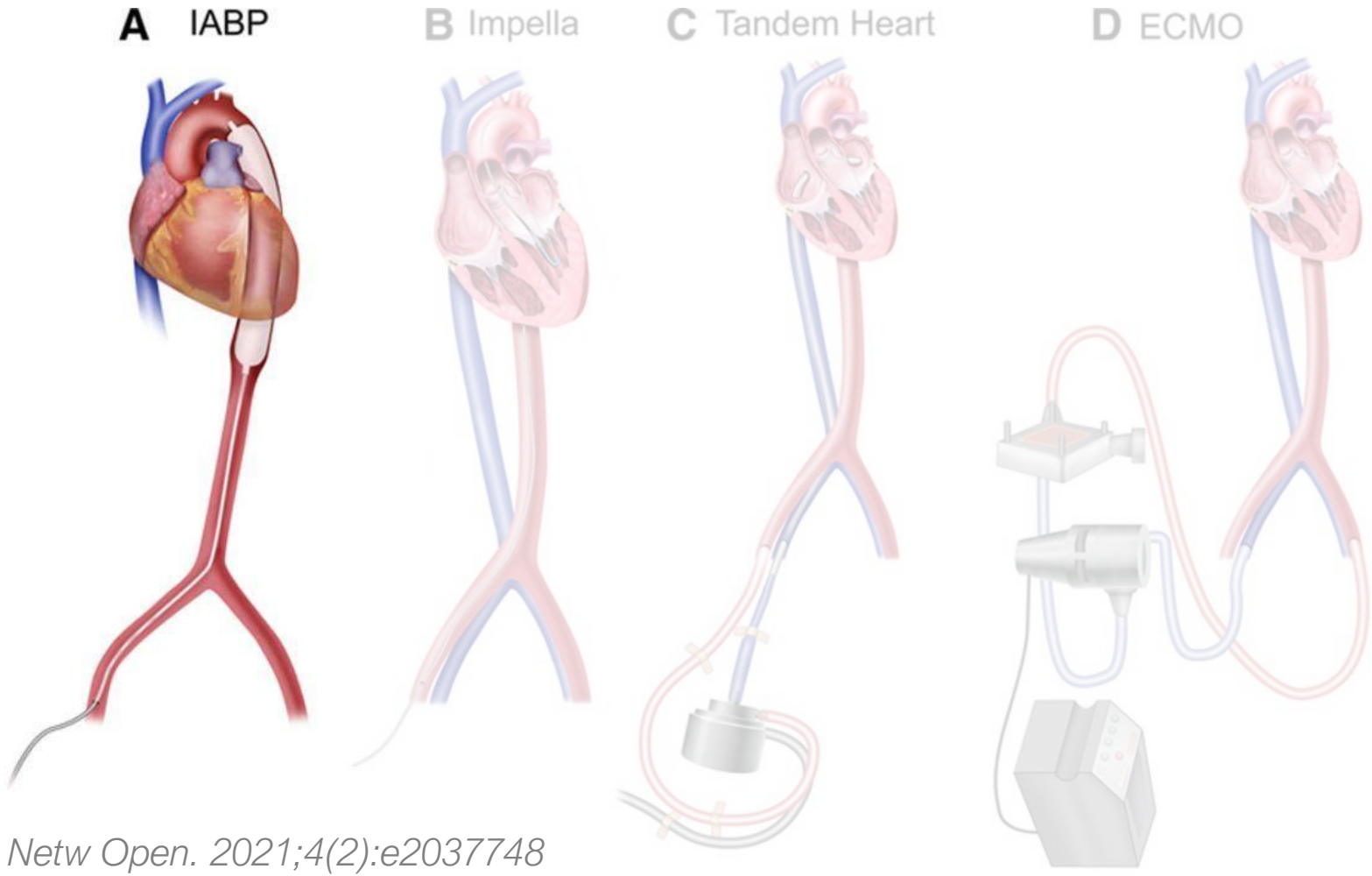
R. U Shah, et al. J Am Coll Cardiol. 2016 Feb 23;67(7):739-47.

Algorithm for the management of Cardiogenic shock



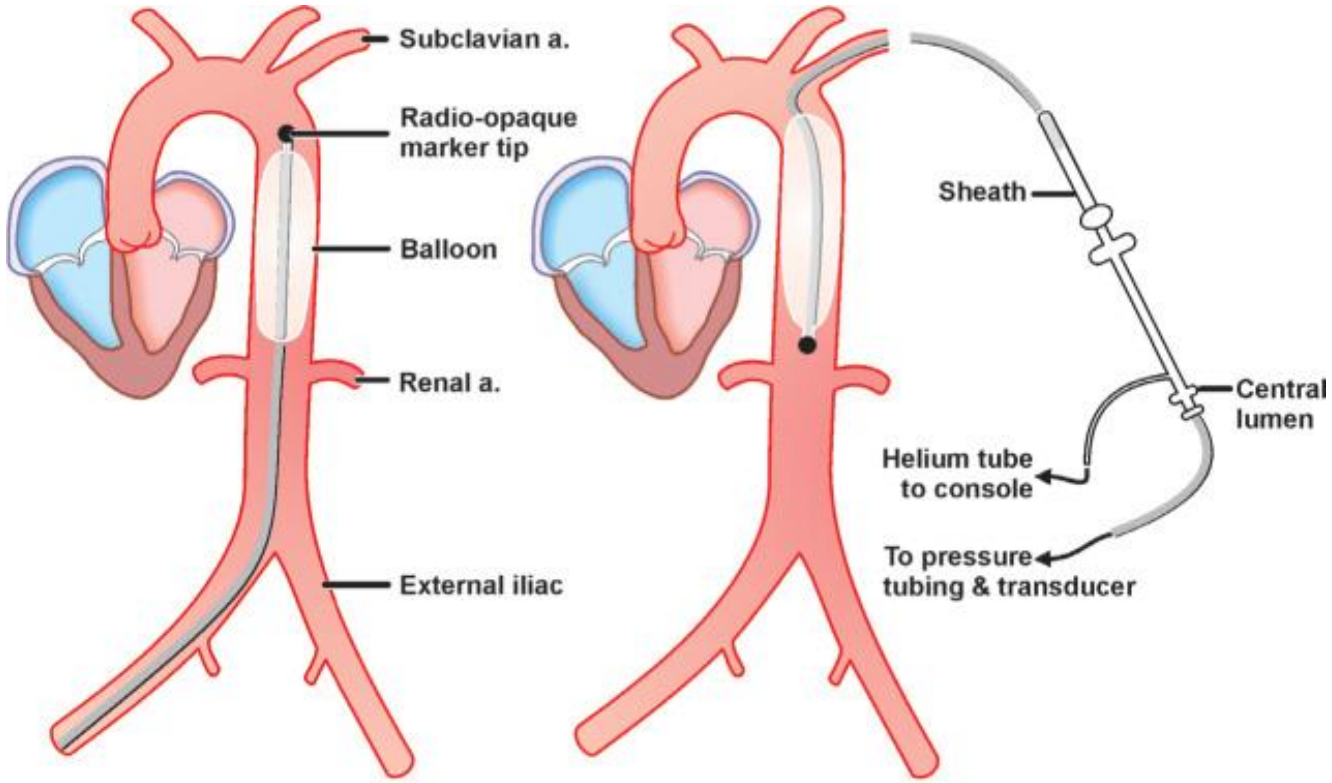
2018 ESC guideline

Mechanical circulatory support



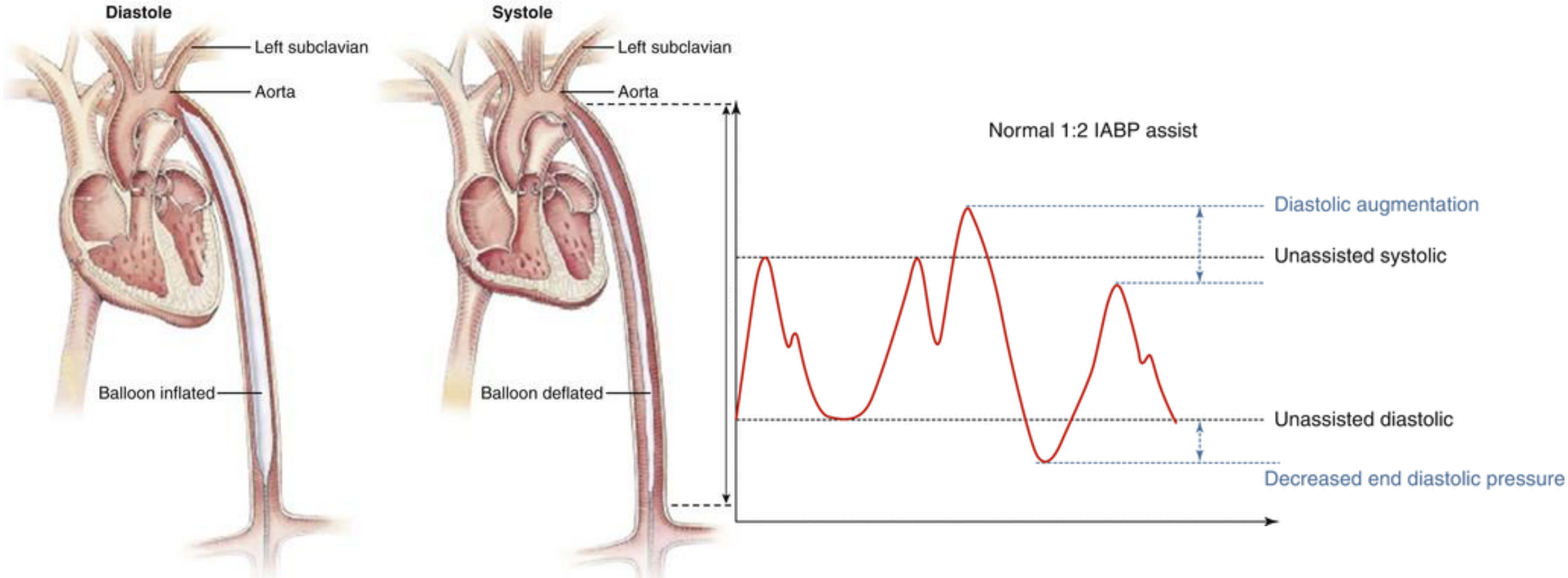
Sanket S., et al. JAMA Netw Open. 2021;4(2):e2037748

Intra-arterial balloon pump, IABP



https://thoracickey.com/intra-aortic-balloon-pump-iabp-placement/

Arterial waveform with IABP support



https://aneskey.com/intra-aortic-balloon-counterpulsation/

Hemodynamic change after IABP

Aorta	↓systolic pressure, ↑diastolic pressure
Left ventricle	↓systolic pressure, ↓end-diastolic pressure, ↓volume, ↓wall tension
Heart	↓afterload, ↓preload, ↑cardiac output
Blood flow	↑⟶ coronary blood flow

Increasing coronary major and micro-perfusion

Unloading LV and cardiac workload

Timing of using IABP

Indication

Cardiogenic shock after MI

Cardiac failure after surgery

Refractory angina

Refractory ventricular arrythmia

Acute MR or VSD

Short-term bridge to heart transplant

Contraindication

Aortic valve insufficiency

Severe PAD

Aortic aneurysm or dissection

The role of IABP in ACS cardiogenic shock

IABP shock I & IABP shock II trial

Randomized, prospective, open-label, multicenter trial,

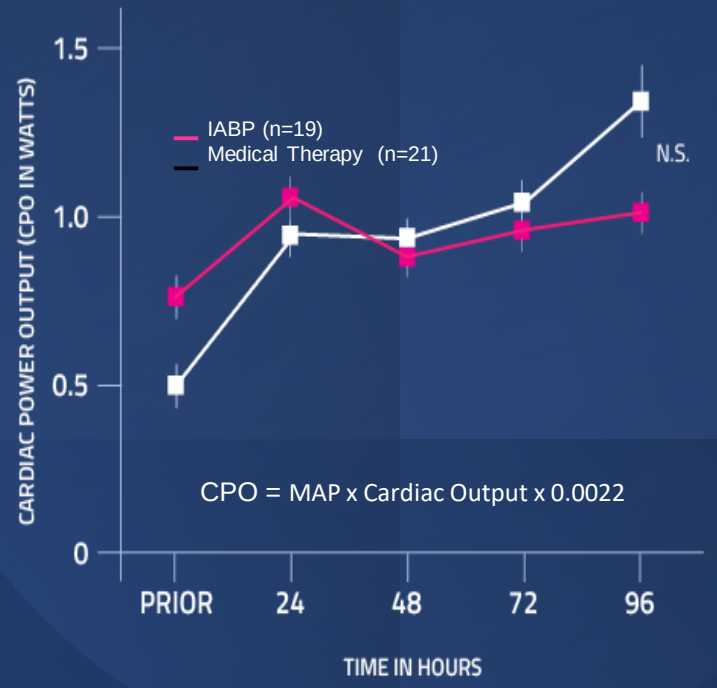
600 patients with cardiogenic shock complicating AMI were randomized to receive IABP (pre-PCI or post-PCI per operator discretion) or no IABP.

Holger M., et al. N Engl J Med 2012; 367:1287-1296

The role of IABP in ACS cardiogenic shock

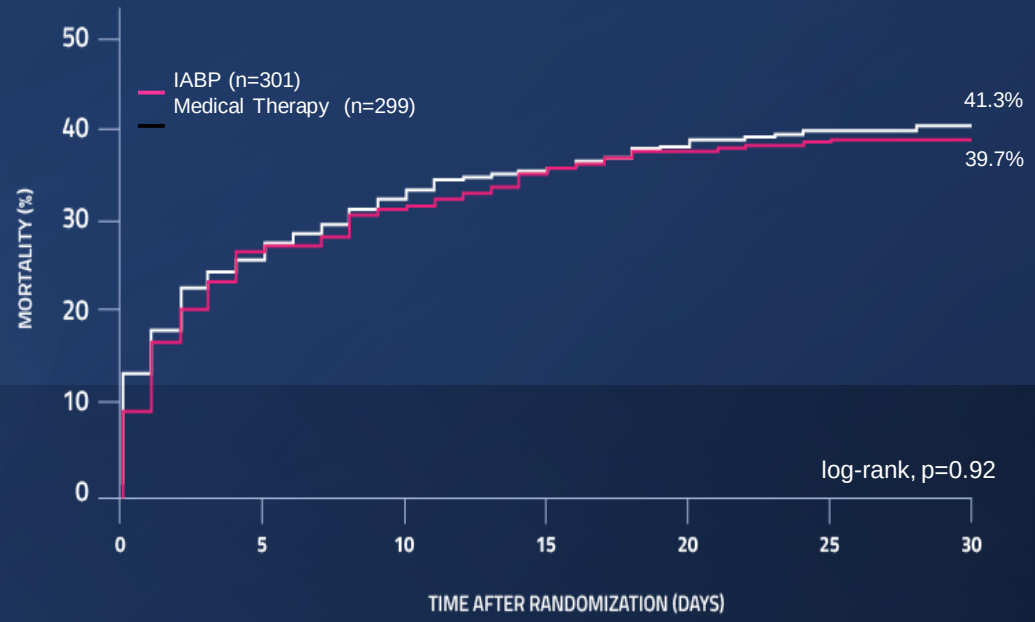
IABP SHOCK I
Randomized Controlled Trial[1]

N = 40



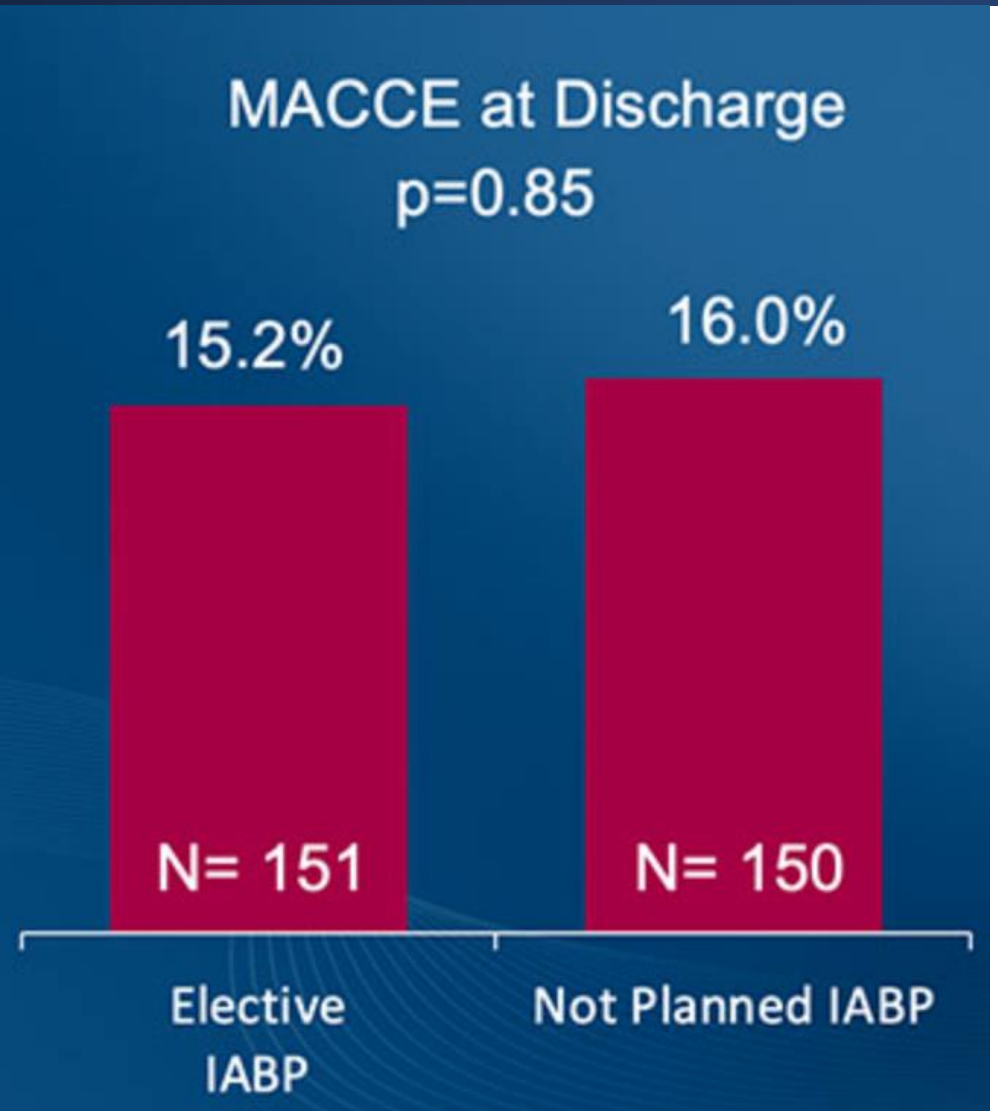
IABP-SHOCK II
Randomized Controlled Trial[2]

N = 600

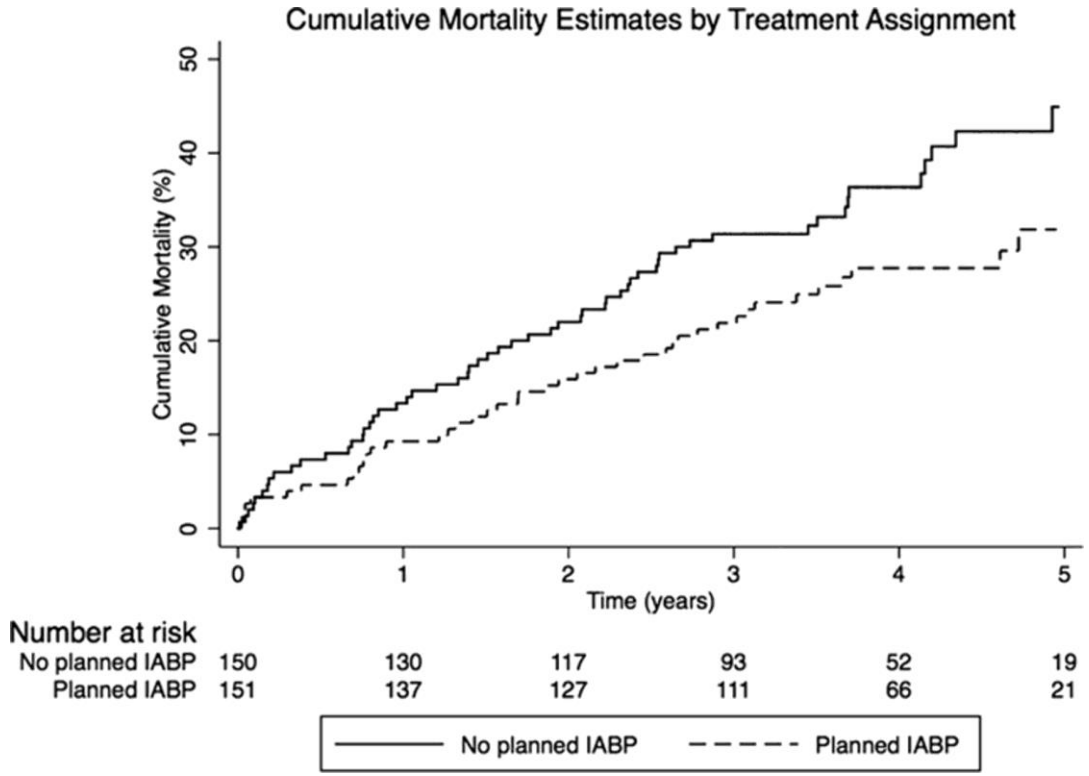


Holger M., et al. N Engl J Med 2012; 367:1287-1296

The role of IABP for planned PCI (BCIS-1 Study)



Result do not support prophylactic use of IABP



Divaka P., et al. Circulation. 2013 Jan 15;127(2):207-12.

Limited role of using IABP in ACS patients

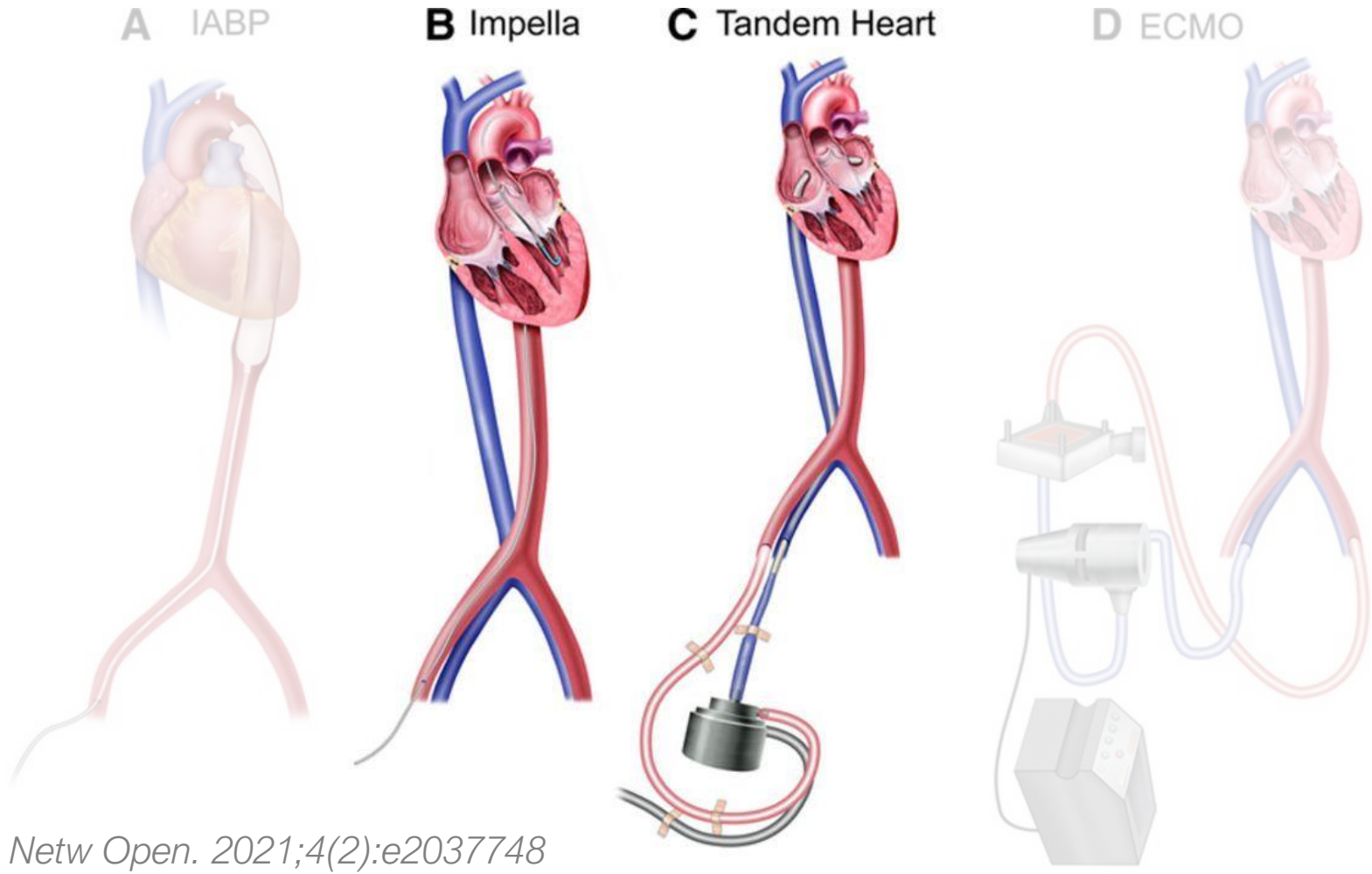
2018 ESC guideline in myocardial revascularization

PAMI-II Trial:

IABP increased hazard risk of stroke and ischemia

In selected patients with ACS and cardiogenic shock, short-term mechanical circulatory support may be considered, depending on patient age, comorbidities, neurological function, and the prospects for long-term survival and predicted quality of life.	IIb	C
Routine use of IABPs in patients with cardiogenic shock due to ACS is not recommended.[260 262]	III	B

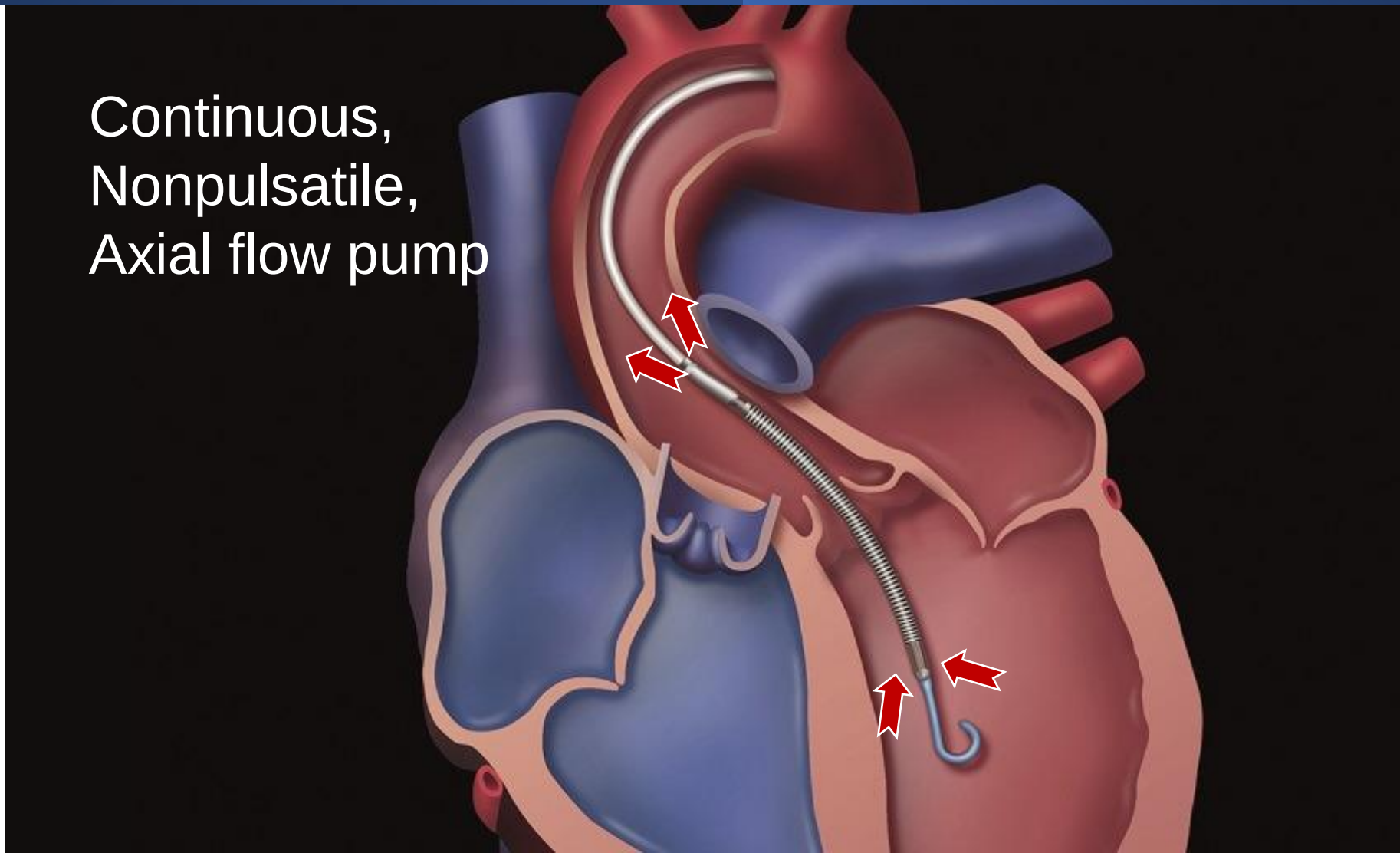
Mechanical circulatory support



Sanket S., et al. JAMA Netw Open. 2021;4(2):e2037748

Impella heart Pump

Continuous,
Nonpulsatile,
Axial flow pump



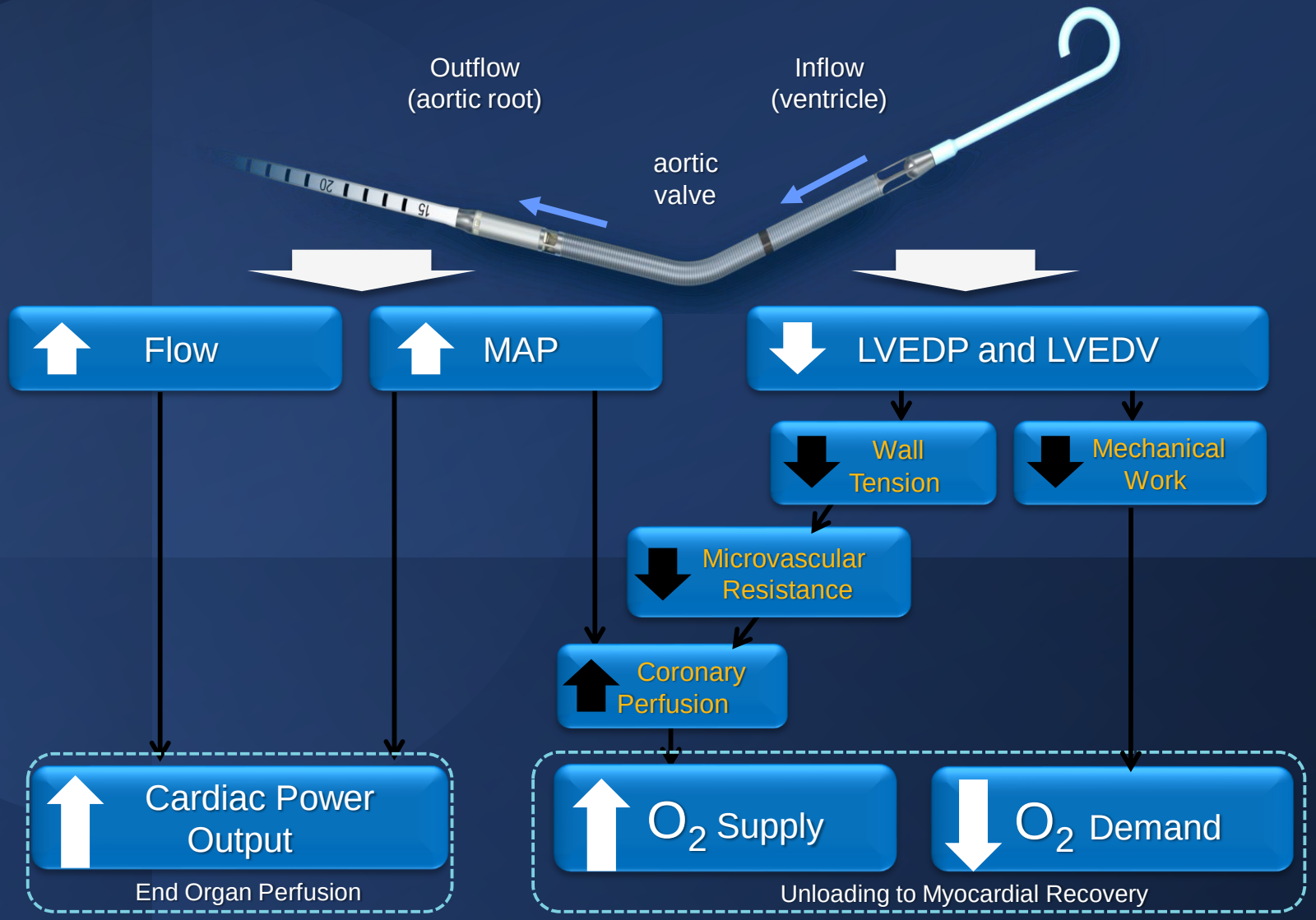
Impella heart Pump

Impella Device	2.5	CP	5.0	LD	5.5	RP
Indication	HRPCI and CS	HRPCI and CS	CS	CS	CS	RHF or decompensation
Introducer diameter	13 Fr	14 Fr	23 Fr	--	23 Fr	23 Fr
Pump motor	12 Fr	14 Fr	21 Fr	21 Fr	19 Fr	22 Fr
Access	Percutaneous femoral or axillary	Percutaneous femoral or axillary	Femoral cutdown or axillary	Direct insertion into AA	Axillary cutdown or direct insertion into AA	Percutaneous femoral vein (to PA)
Maximum average flow (l/min)	2.5	3.7	5.0	5.3	5.5	4.4
Maximum duration of support	HRPCI: ≤6 hours CS: ≤4 days	HRPCI: ≤6 hours CS: ≤4 days	14 days	14 days	14 days	14 days
SmartAssist?	N	Y	N	N	Y	N

All catheter diameters are 9 Fr, with the exception of the Impella RP (11 Fr). AA = ascending aorta; CS = cardiogenic shock; HRPCI = high-risk percutaneous coronary intervention; PA = pulmonary artery; RHF = right heart failure.

Remi z., et al. Interv Cardiol. 2022 Apr 8;17:e05

Hemodynamic change of Impella support



Sahil K., et al. Cardiac Interventions Today 2018.

The role of Impella in ACS cardiogenic shock

Randomization of AMI patients with CS is challenging

Study	Condition	Pts Required (n)	Pts Enrolled (n)	Duration (months)	Status	Reason for Discontinuation
FRENCH TRIAL (2006)	AMI CS	200	19	52	Discontinued	Low Enrollment
ISAR-SHOCK (2006)	AMI CS	26	26	19	Completed	N/A
RECOVER I FDA (2008)	PCCS	Up to 20	17	28	Completed	N/A
RECOVER II FDA (2009)	AMI CS	384	1	18	Discontinued	Low Enrollment
RELIEF I (2010)	ADHF	20	1	33	Discontinued	Low Enrollment
DANSHOCK (2012)	AMI CS	360	~50	40	Enrolling	N/A

The role of Impella in ACS cardiogenic shock

ISAR-SHOCK trial

Randomized, prospective, two-center trial, till 2006

26 patients with cardiogenic shock complicating AMI

IMPRESS trial

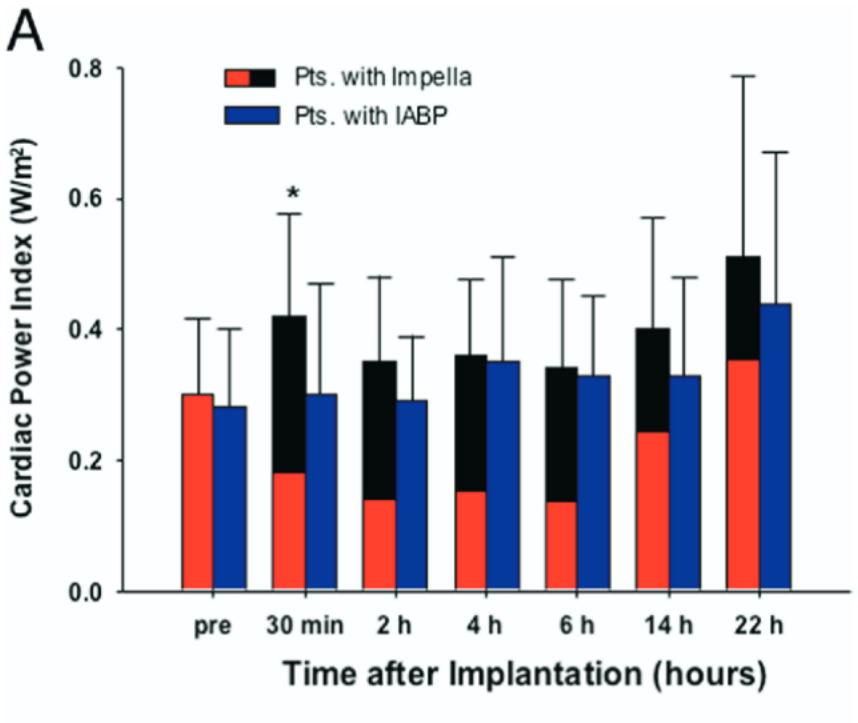
Randomized, prospective, multicenter trial, till 2014

48 patients with cardiogenic shock complicating AMI

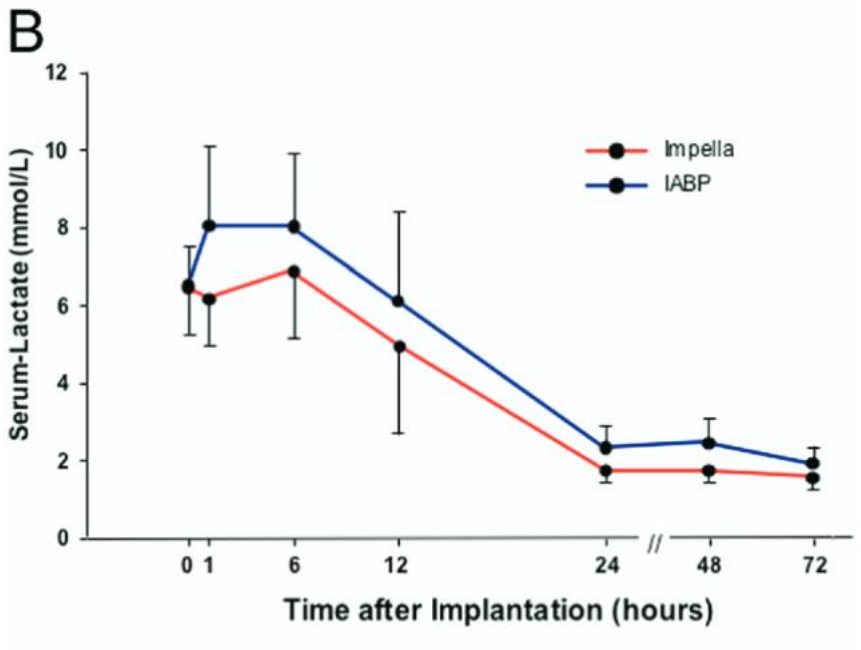
Melchior S., et al. J Am Coll Cardiol. 2008 Nov 4;52(19):1584-8.

Dagmar M., et al. J Am Coll Cardiol. 2017 Jan 24;69(3):278-287

The role of Impella in ACS cardiogenic shock



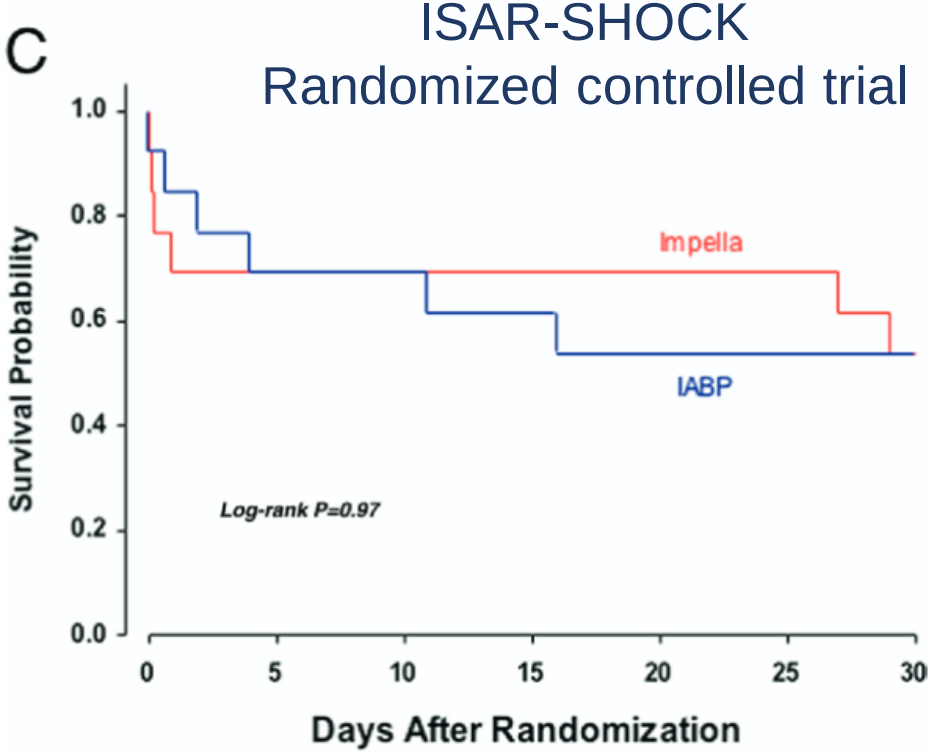
ISAR-SHOCK
Randomized controlled trial



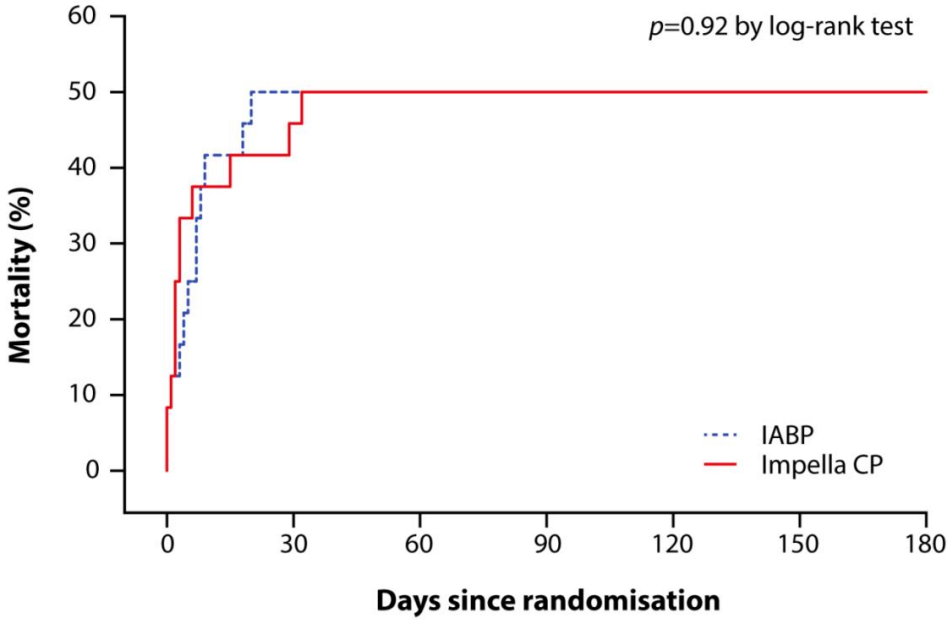
Melchior S., et al. J Am Coll Cardiol. 2008 Nov 4;52(19):1584-8.

The role of Impella in ACS cardiogenic shock

ISAR-SHOCK
Randomized controlled trial



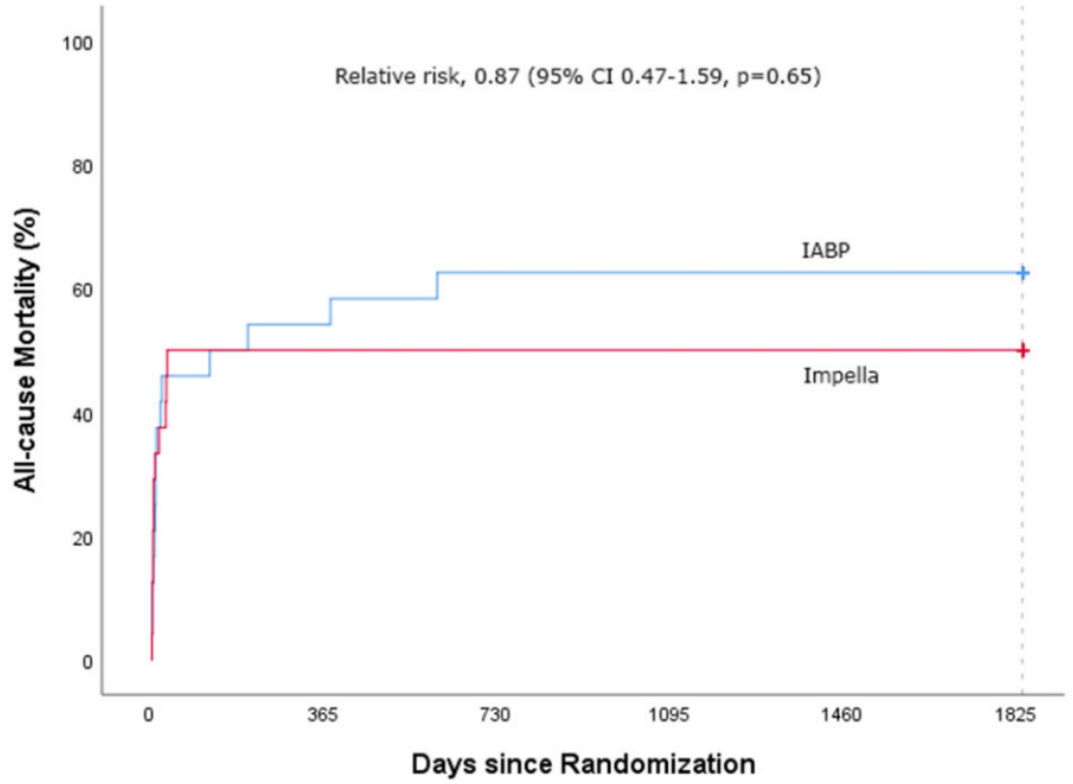
IMPRESS
Randomized controlled trial

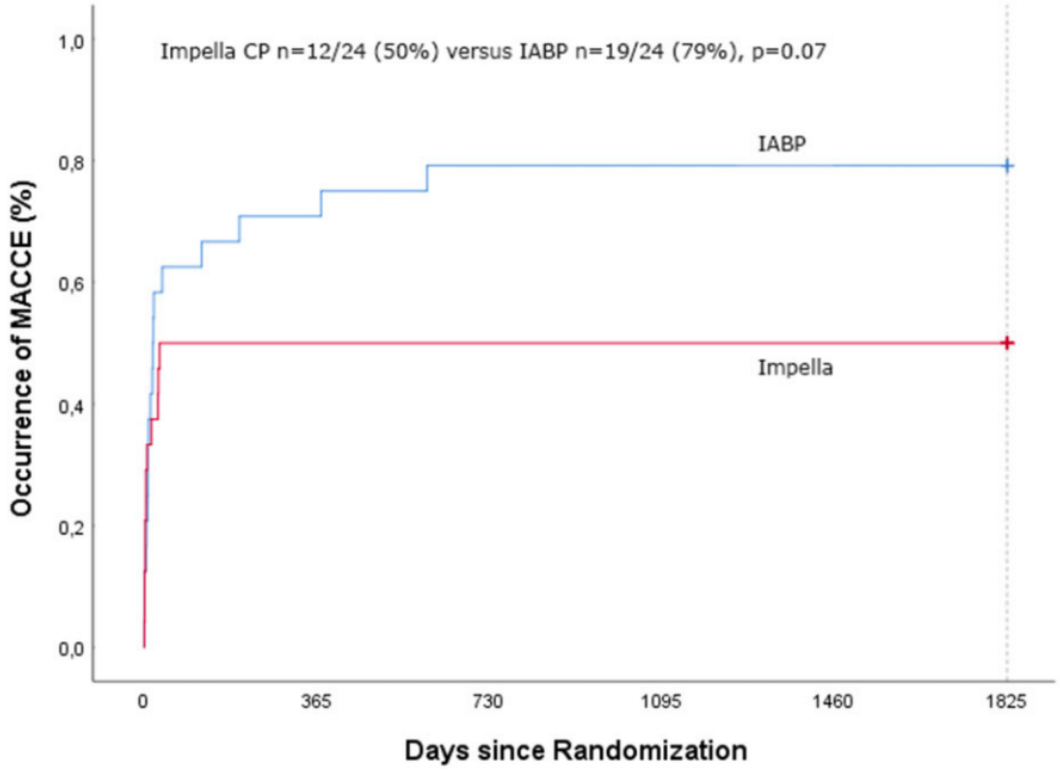


Melchior S., et al. J Am Coll Cardiol. 2008 Nov 4;52(19):1584-8.
Dagmar M., et al. J Am Coll Cardiol. 2017 Jan 24;69(3):278-287

Less Major Adverse Cardiac and Cerebrovascular Events (MACCE) in Impella compared to IABP

5-years follow-up of IMPRESS randomized controlled trial





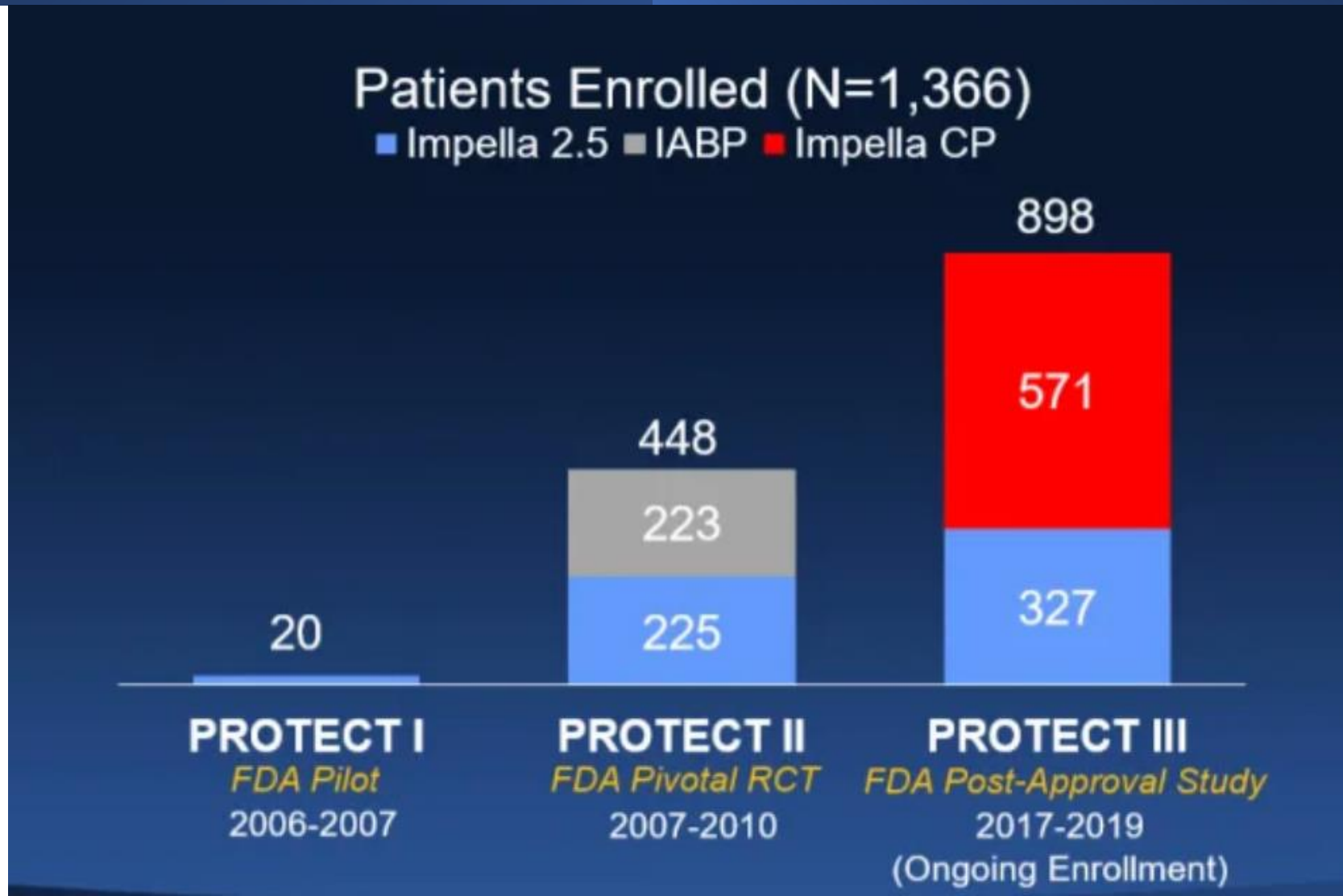
Mina k., et al. Eur Heart J Acute Cardiovasc Care. 2021 Dec 6;10(9):1009-1015

The role of Impella in high-risk PCI

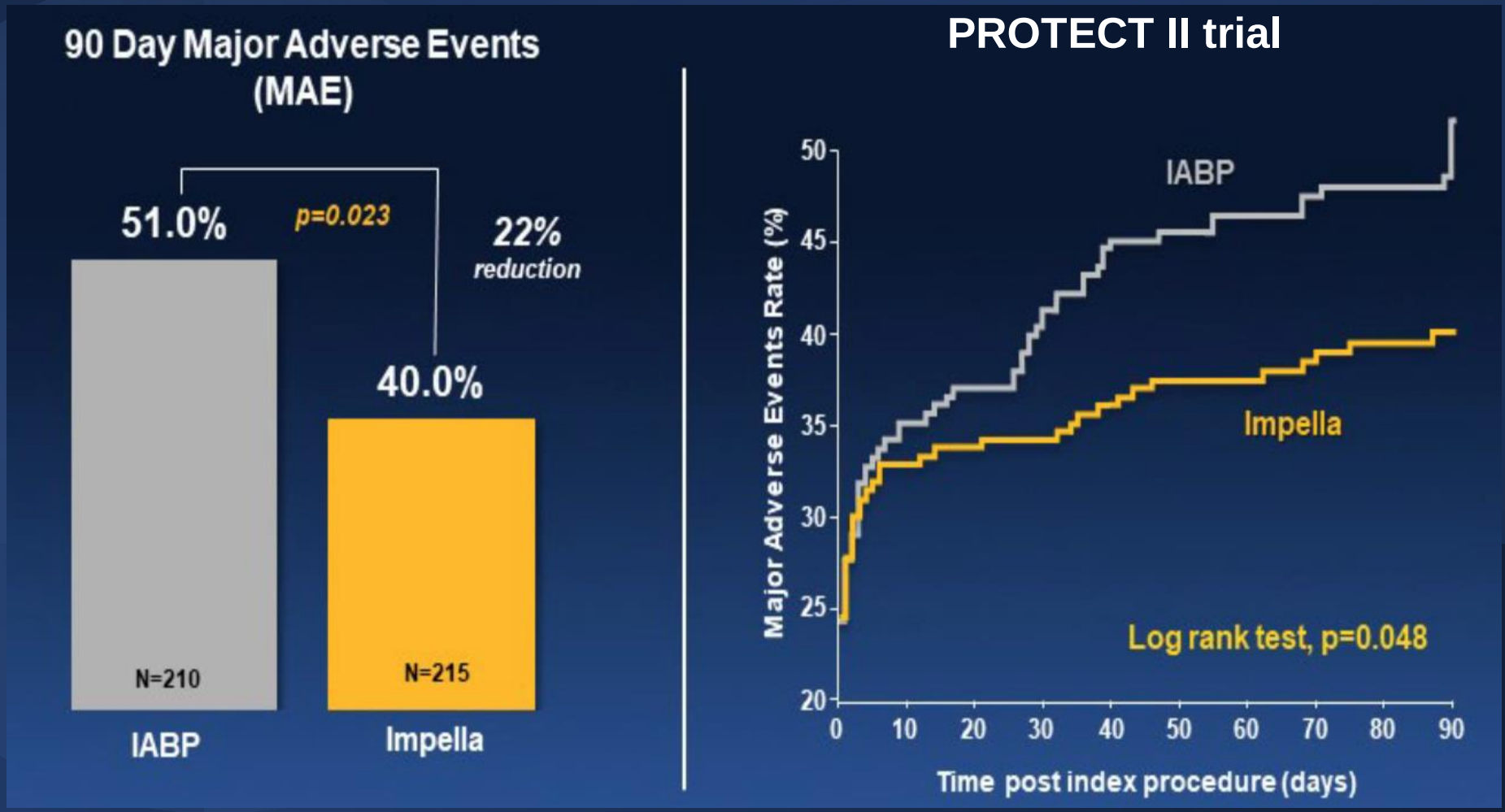
PROTECT trial

Randomized, prospective

High-risk PCI with Impella-supported compared to IABP-supported

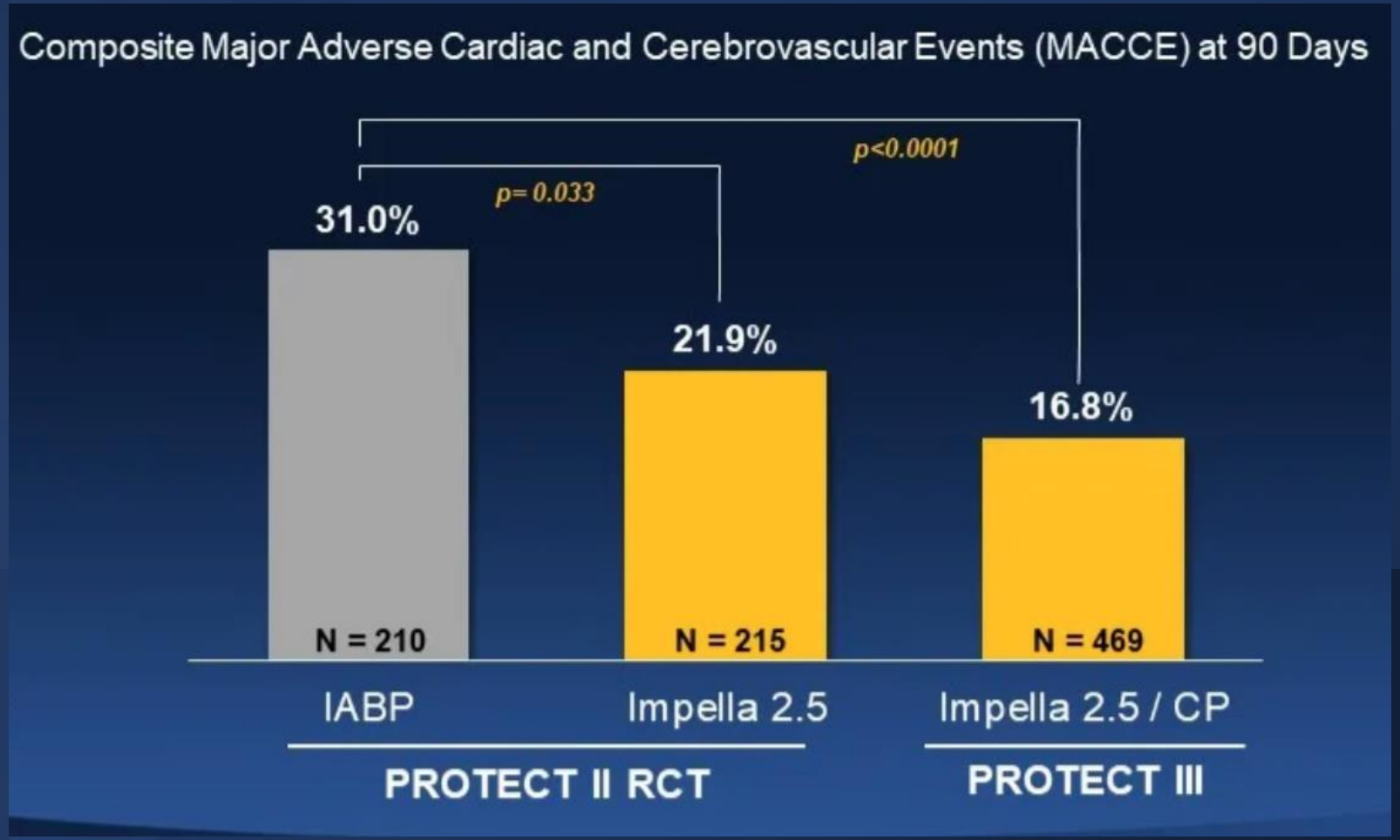


Better outcome of Impella in high-risk PCI



O'Nell, et al. Circulation. 2012;126(14):1417-27

Better outcome of Impella in high-risk PCI

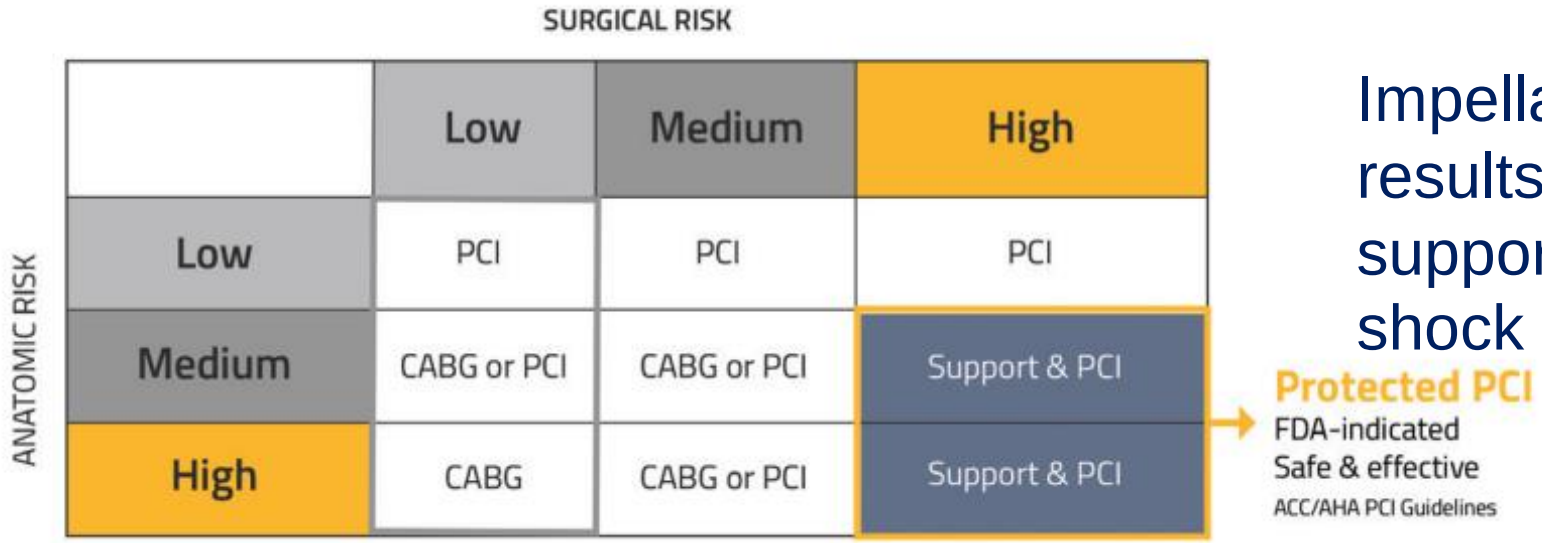


O'Nell, et al. Am Heart J. 2022 Jun;248:139-149

The role of Impella in ACS patients

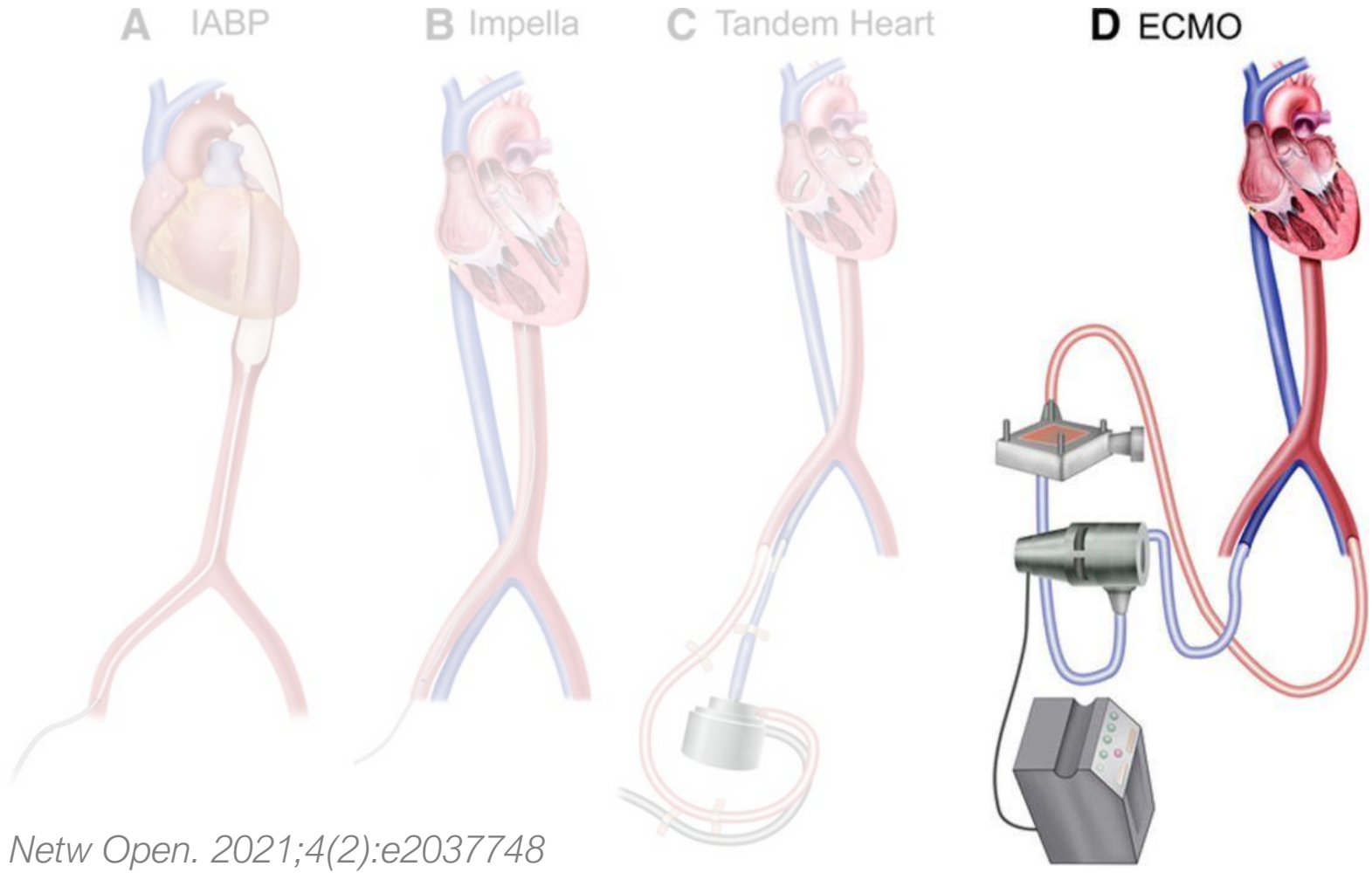
2021 AHA guideline in myocardial revascularization

COR	LOE	RECOMMENDATION
2b	B-R	1. In selected high-risk patients, elective insertion of an appropriate hemodynamic support device as an adjunct to PCI may be reasonable to prevent hemodynamic compromise during PCI (1,2).



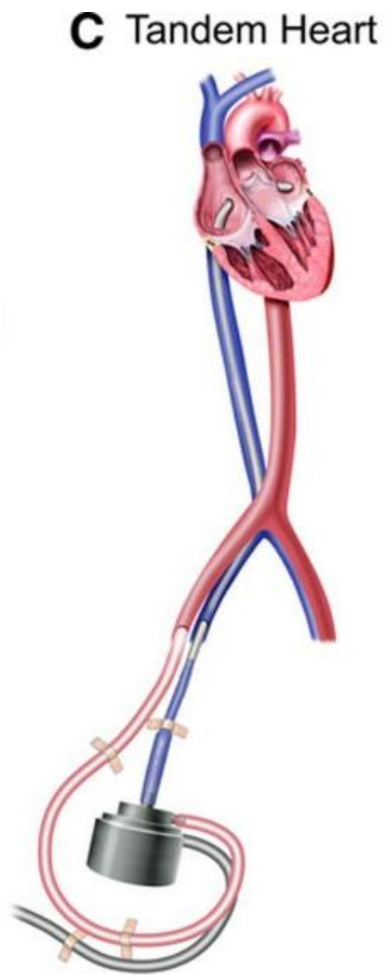
Impella showed non-inferior results compared to IABP in supporting ACS cardiogenic shock

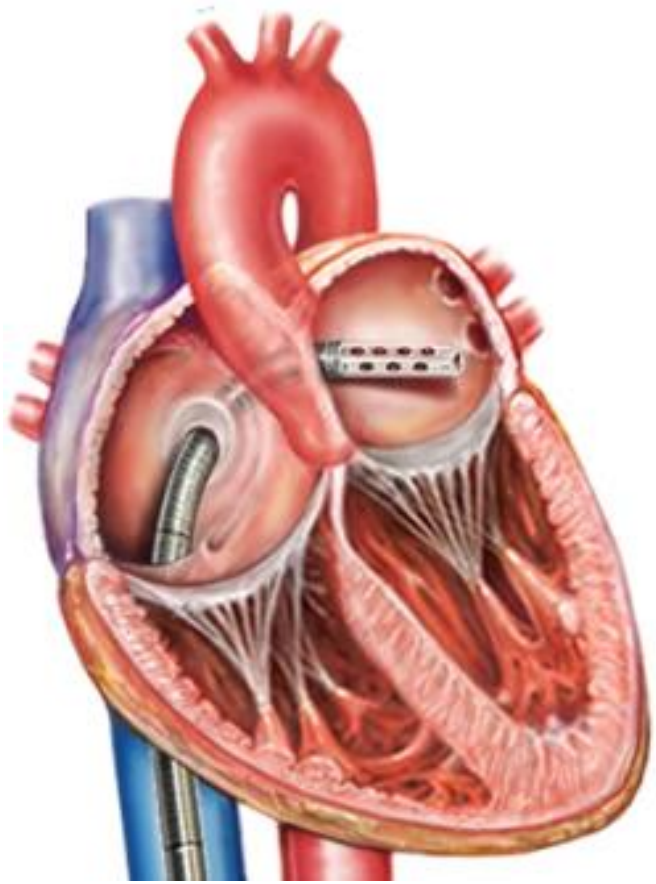
Mechanical circulatory support



Sanket S., et al. JAMA Netw Open. 2021;4(2):e2037748

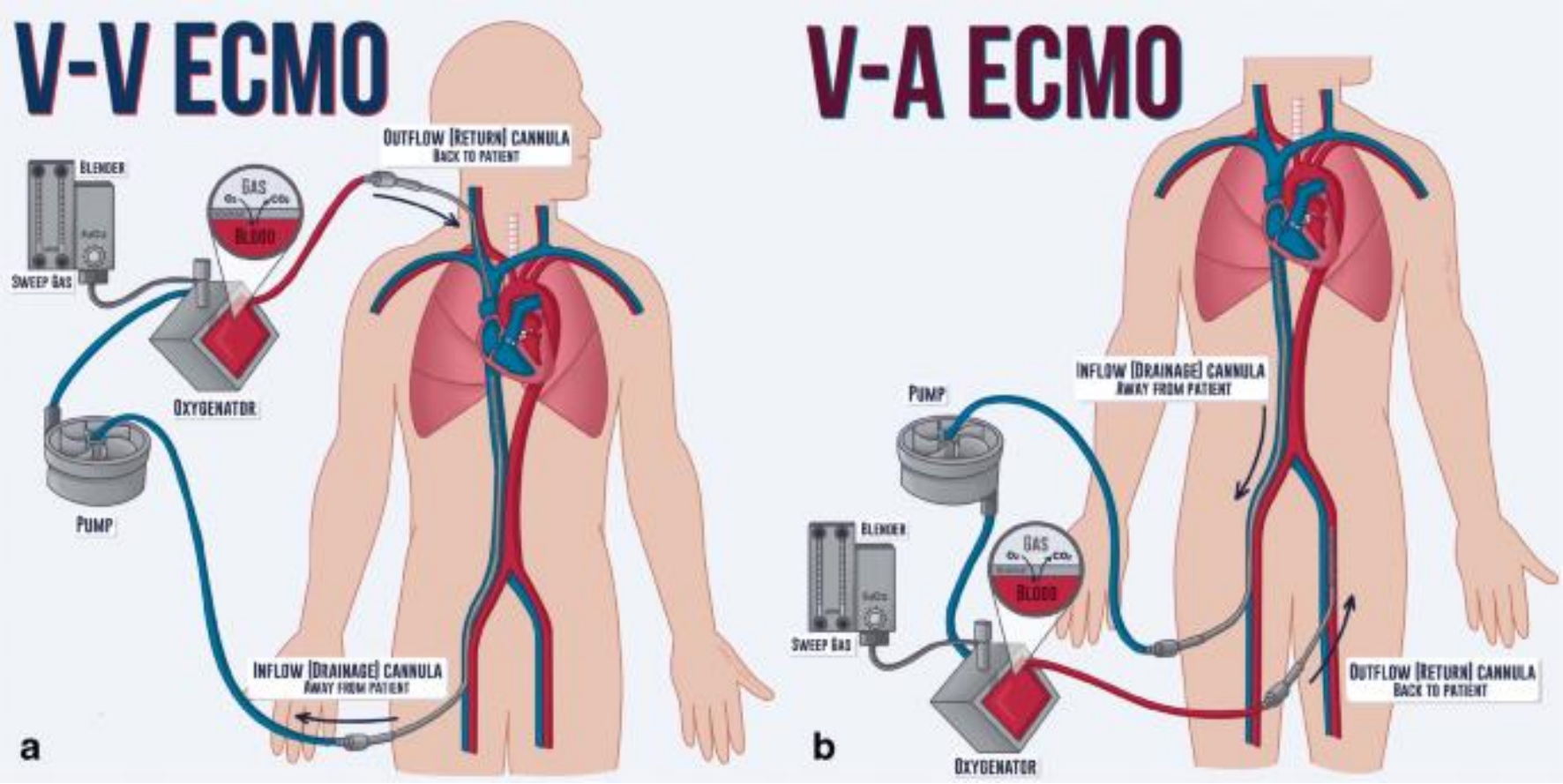
Tandem Heart





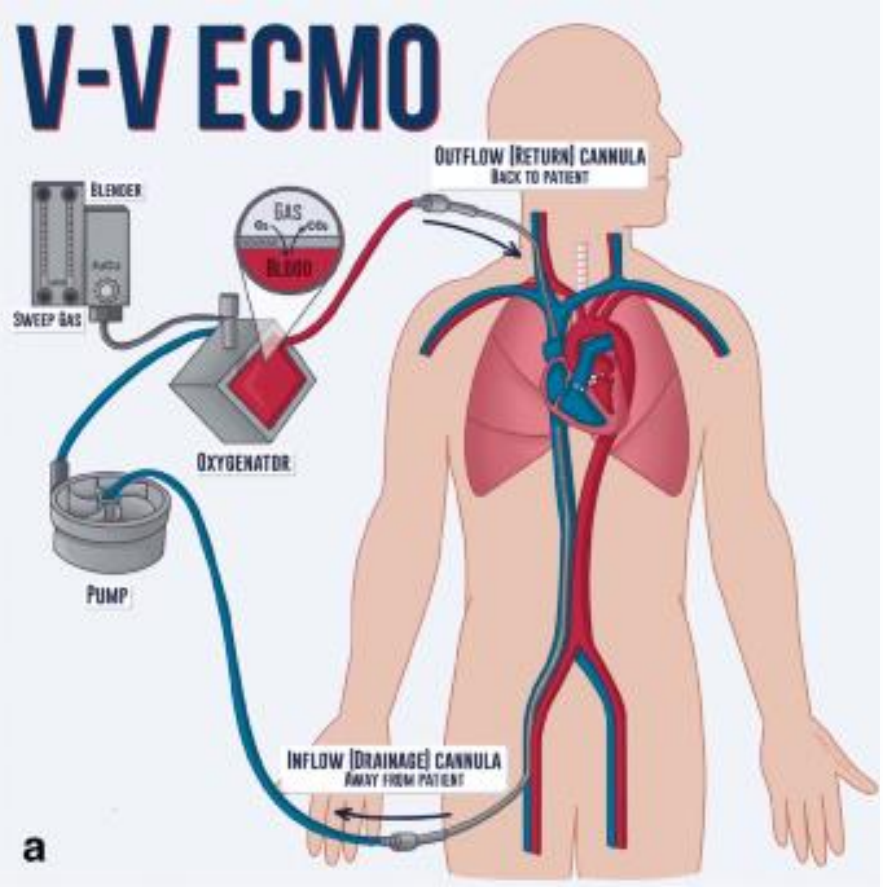
Extracorporeal Membrane Oxygenation , ECMO

Venous-Venous and Venous-Arterial ECMO



Benjamin I., et al. Curr Treat Options Neurol. 2021;23(5):15.

Differences between VV and VA ECMO



Pulmonary bypass

Reversible ARDS

Pulmonary embolism, without hemodynamic unstable

Trauma with lung contusion

Bridge to lung transplant

Benjamin I., et al. Curr Treat Options Neurol. 2021;23(5):15.

Differences between VV and VA ECMO

Cardiopulmonary bypass

(more than 4.5L/min)

Cardiogenic shock, with/without ACS

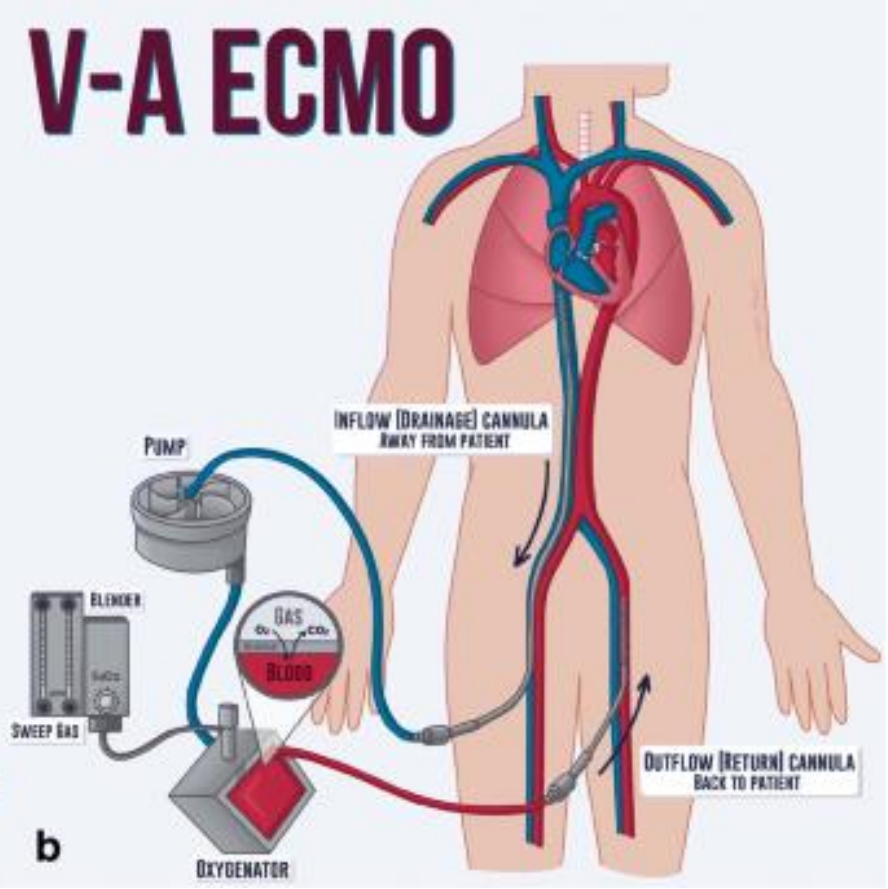
Intractable arrythmia

Acute myocarditis

Post-cardiac arrest (ROSC)

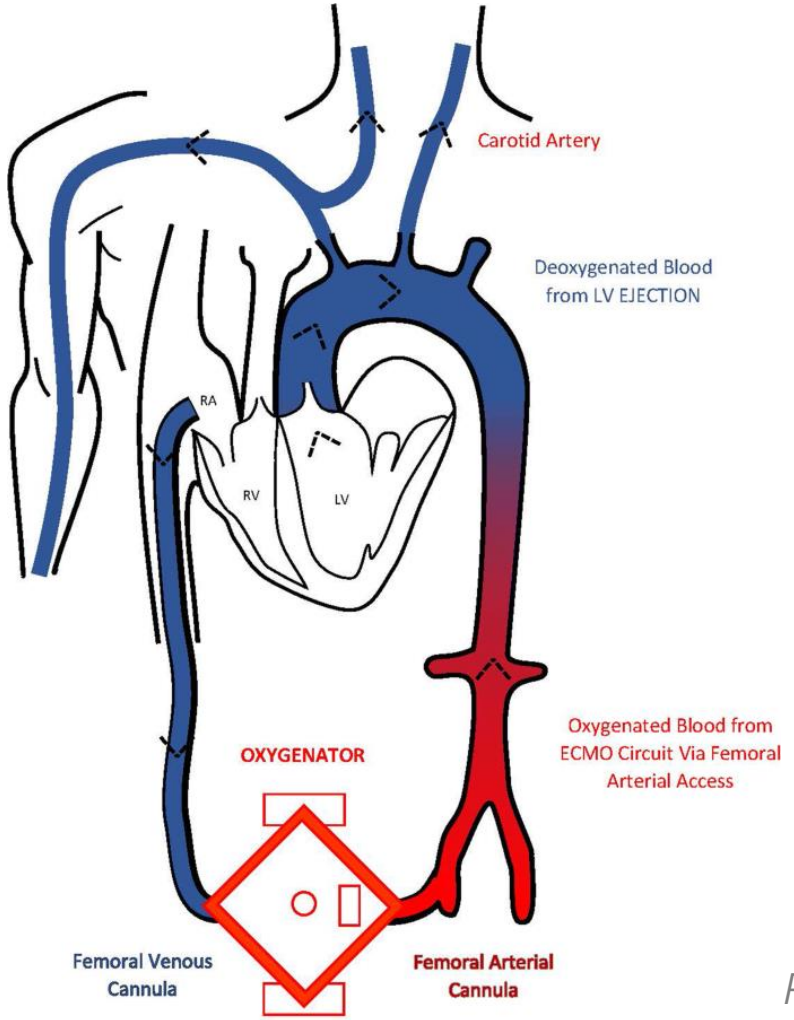
Pulmonary embolism

Short-term bridge to heart transplant



Benjamin I., et al. Curr Treat Options Neurol. 2021;23(5):15.

Hemodynamic change after VA ECMO



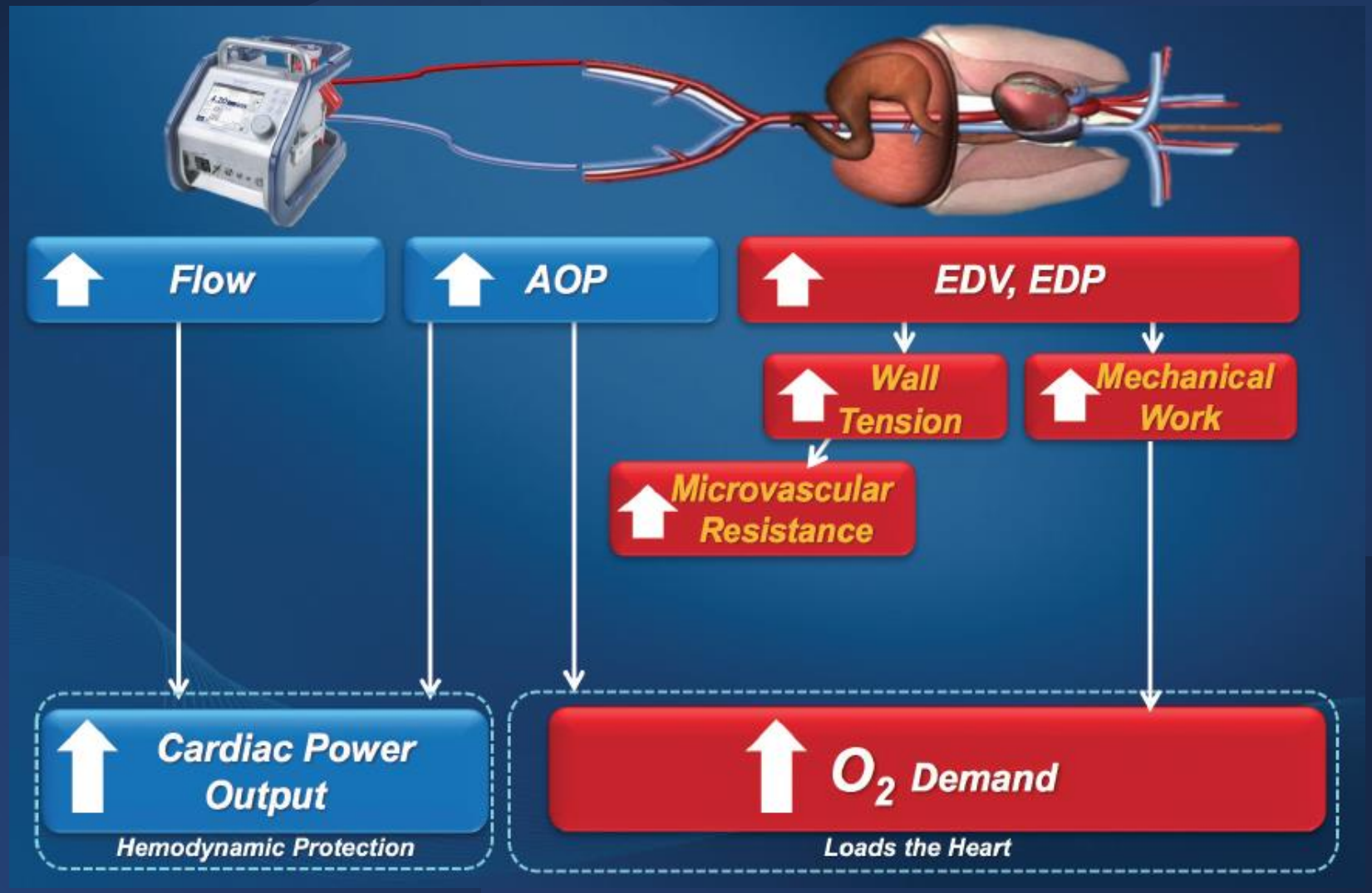
North-South Syndrome

Two circulation syndrome

Harlequin Syndrome

Pooboni, et al. Indian J Thorac Cardiovasc Surg. 2021;37(2): 221–31.

Hemodynamic change after VA ECMO



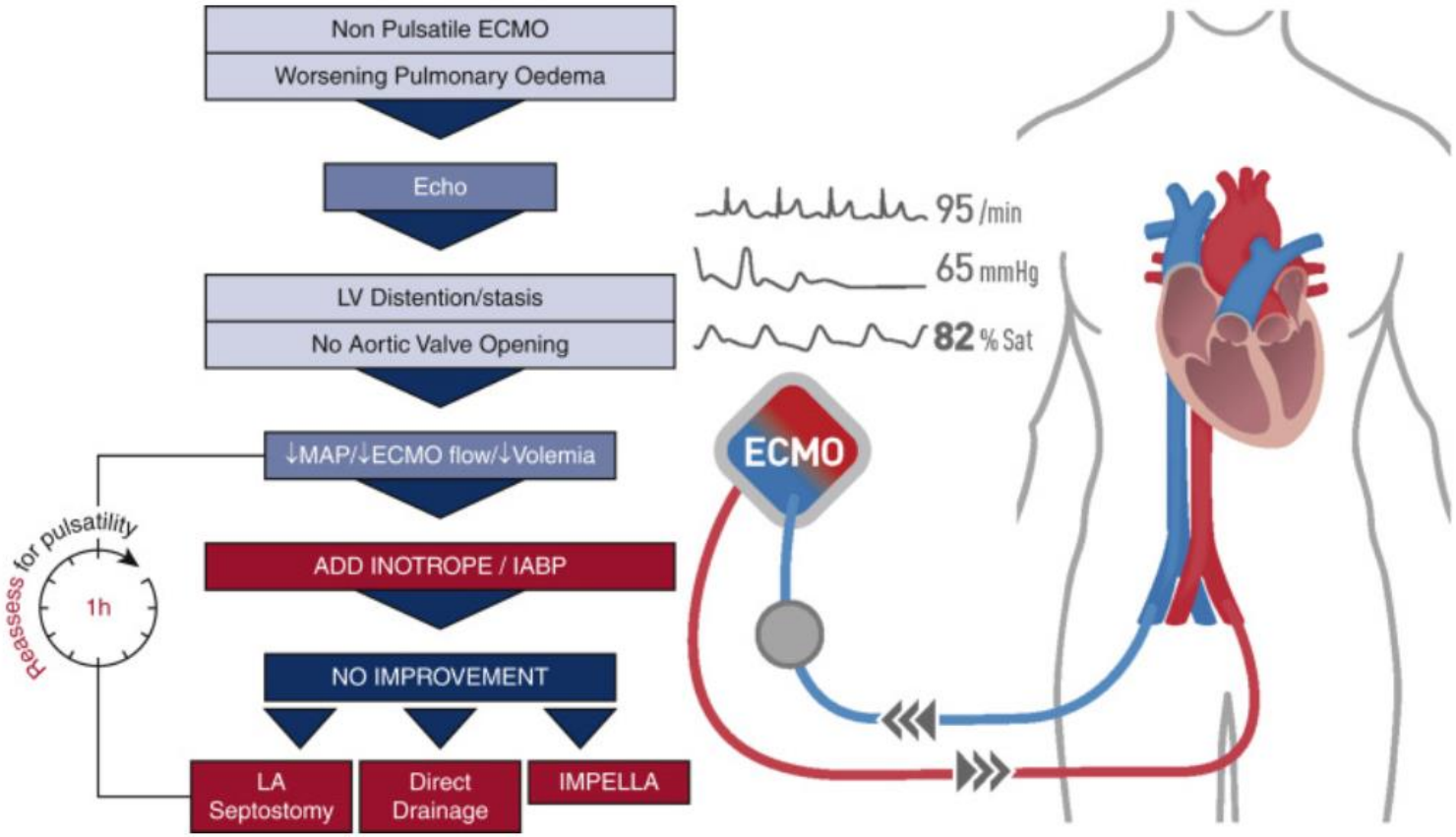
Aortic regurgitation

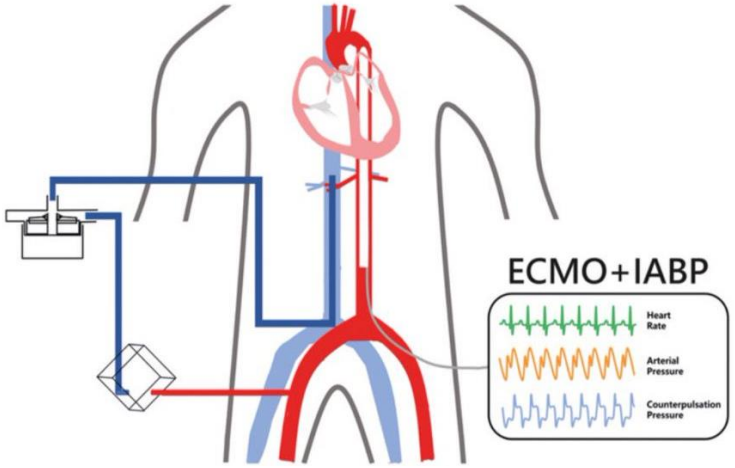
LV distention

Pulmonary edema

Sahil K., et al. Cardiac Interventions Today 2018.

VA ECMO with concomitant LV unloading

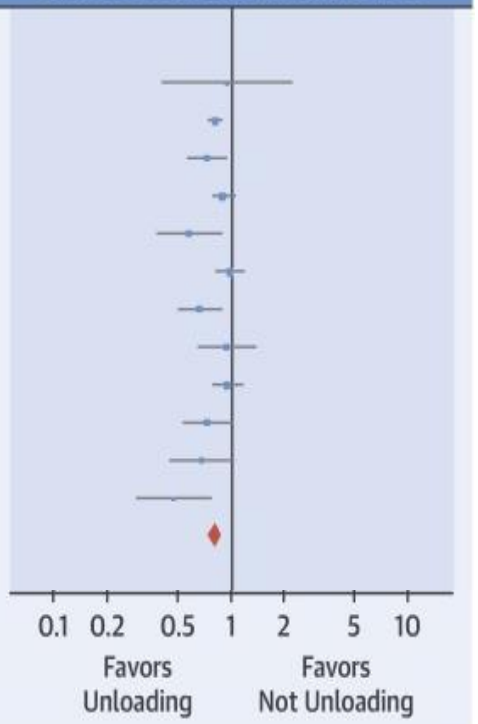




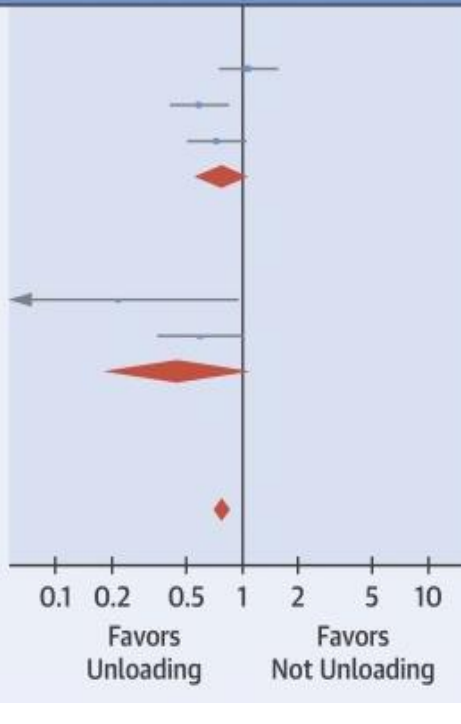
Cavayas YA, et al. JTCVS Open. 2021;8:70-76.

VA ECMO with concomitant LV unloading

Study or Subgroup	Unloading Events	Unloading Total	No Unloading Events	No Unloading Total	Weight
1.1.1 Intra-Aortic Balloon Pump					
Aoyama, 2014	22	35	2	3	1.2%
Aso, 2016	330	604	708	1,046	14.3%
Brechot, 2018	45	104	92	155	7.5%
Doll, 2004	105	143	62	76	11.7%
Kai Chen, 2018	17	38	17	22	3.9%
Lin, 2016	144	302	110	227	10.3%
Overtchouk, 2018	33	63	34	43	6.7%
Park, 2014	21	41	30	55	4.5%
Ro, 2014	41	60	139	193	9.7%
Sakamoto, 2012	62	94	4	4	5.6%
Tepper, 2018	15	30	22	30	3.9%
Wang, 2013	13	41	31	46	3.0%
Subtotal (95% CI)		**1,555**		**1,900**	**82.3%**
Total events	848		1,251		

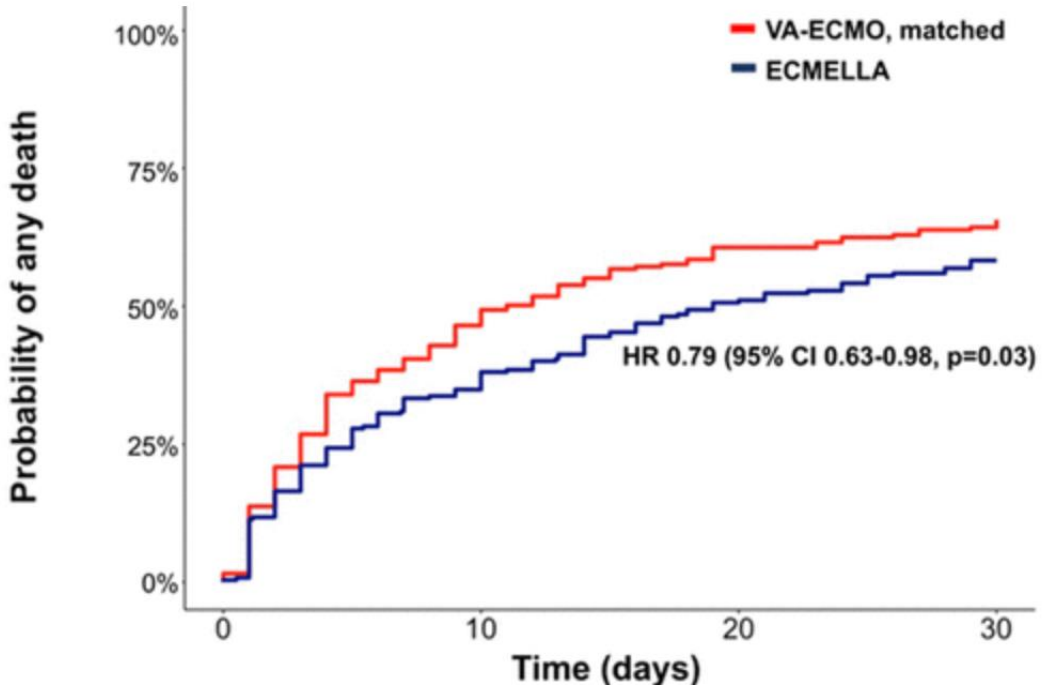


Study or Subgroup	Unloading Events	Unloading Total	No Unloading Events	No Unloading Total	Weight
1.1.2 Percutaneous Left-Ventricular Support					
Akanni, 2018	16	29	100	196	5.0%
Pappalardo, 2017	16	34	98	123	4.7%
Patel, 2018	17	30	28	36	4.9%
Subtotal (95% CI)		**93**		**355**	**14.6%**
Total events	49		226		
1.1.3 Right Upper Pulmonary Vein or Transseptal Left Atrial Cannula					
Poptsov, 2014	2	28	6	18	0.4%
Shmack, 2017	9	20	21	28	2.7%
Subtotal (95% CI)		**48**		**46**	**3.1%**
Total events	11		27		
Total (95% CI)		**1,696**		**2,301**	**100.0%**
Total events	908		1,504		



Russo J., et al. J Am Coll Cardio. 2019;73(6):654-62.

VA ECMO with Impella LV unloading



Randomized, Multicenter trial

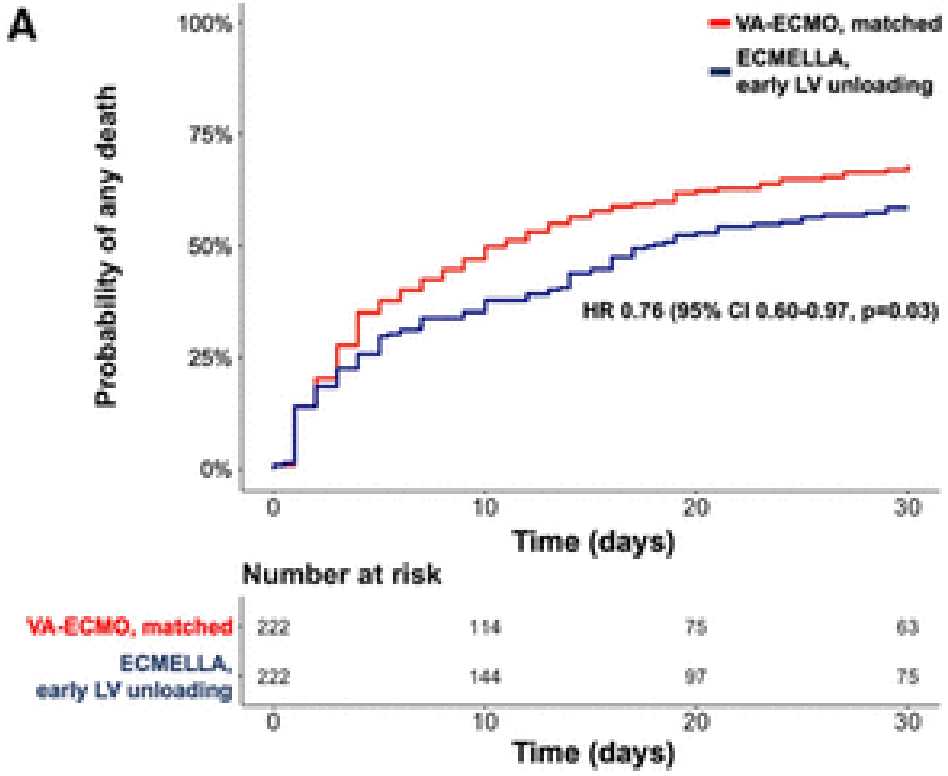
Propensity matched

444 patients with CS

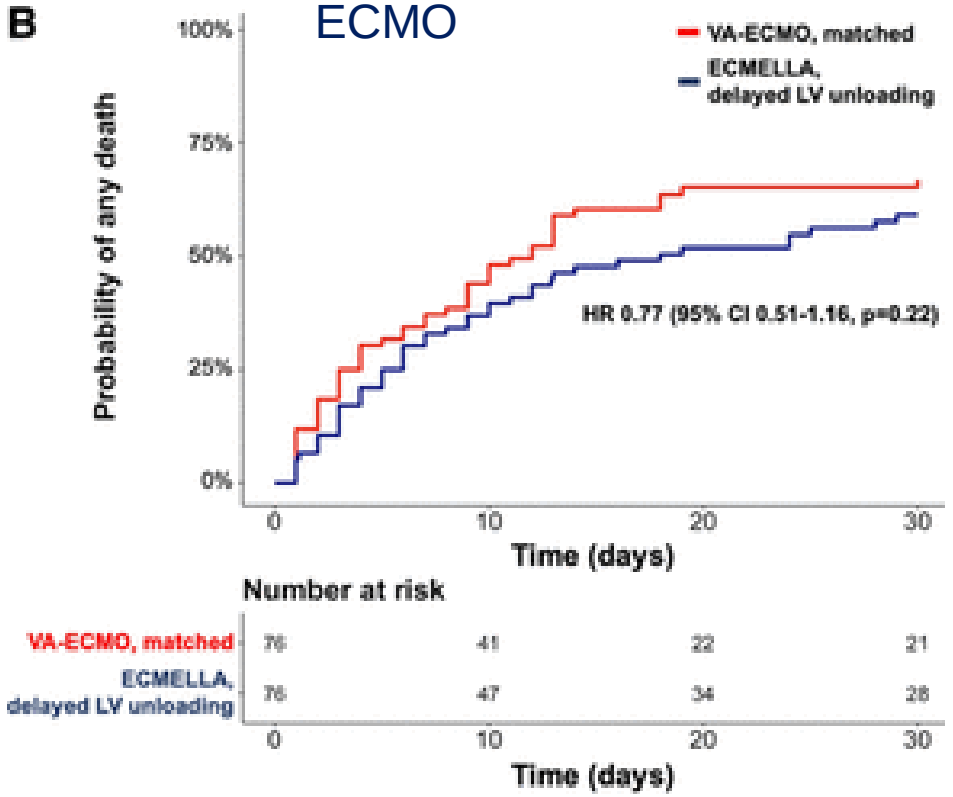
Benedikt, et al. Circulation. 2020 Dec;142(22):2095-2106.

VA ECMO with early Impella LV unloading

Within 2hrs after ECMO



More than 2hrs after ECMO



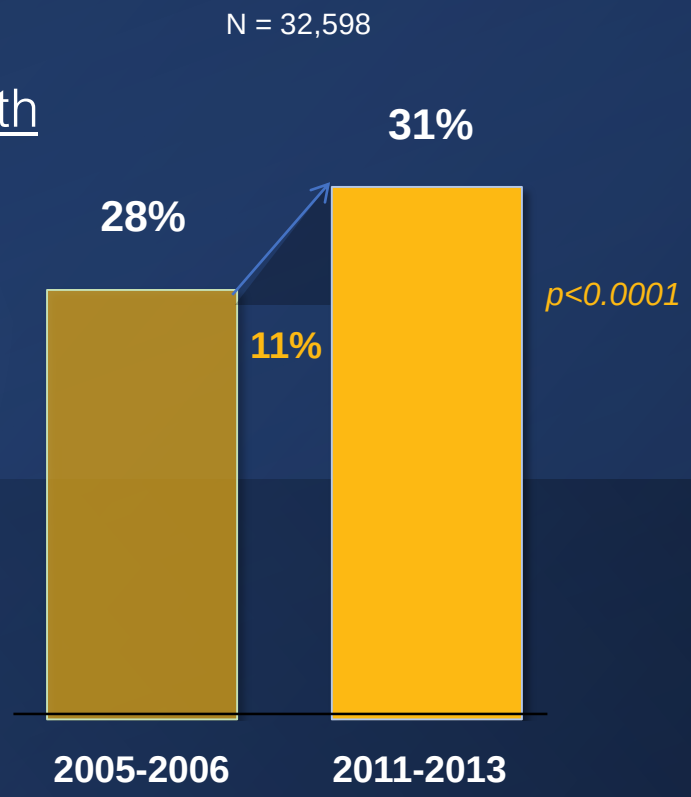
Benedikt, et al. Circulation. 2020 Dec;142(22):2095-2106.

Take Home Message

- ACS with cardiogenic shock remains challenge to be treated

Mortality in PCI with cardiogenic shock remains challenge at all time

In-Hospital Mortality
AMI Cardiogenic Shock with PCI[1]



S. A Wayangankar, et al. J Am Coll Cardiol. 2016 Feb 22;9(4):341-351.

Take Home Message

- ACS with cardiogenic shock remains challenge to be treated

Wise choice of Mechanical Circulatory Support

pLVAD	Access	Cardiac Output Support	Indications	Limitation	Contraindications
IABP	8–9 Fr through femoral artery	Up to 0.5 l/min	-Cardiogenic shock - High-risk PCI	Requires stable rhythm	-Aortic insufficiency -Aortic pathology (aneurysm/dissection)
Impella®	12–21 Fr typically femoral possible axillary artery	2.5 to 5.0 l/min	-Cardiogenic shock following AMI -High-risk PCI	Large cannula	-LV mural thrombus - Significant ASD or VSD -Moderate to severe aortic stenosis
VA-ECMO	15–23 Fr through femoral artery and femoral vein	Up to 7.0 l/min	-Acute, severe cardiac failure/cardiogenic shock with high risk of death. -Typically used for bridging to LVAD/ transplant	Requires two access sites and usually requires venous/arterial cut-down	-non-recoverable cardiac disease -Unwitnessed arrest -Advanced malignancy

AMI = acute myocardial infarction; ASD = atrial septal defect; ECMO = extracorporeal membrane oxygenation; IABP = intra-aortic balloon pump; LV = left ventricular; LVAD = left ventricle assisting devices; PAD = peripheral arterial disease; PCI = percutaneous coronary intervention; pLVAD = percutaneous left-ventricle-assisting devices; RV = right ventricular; VSD = ventricular septal defect.

Ahmed M., et al. US Cardiology Review 2017;11(2):86–94.

Take Home Message

- ACS with cardiogenic shock remains challenge to be treated
- In selected ACS with cardiogenic shock patients, MCS may be considered