ASIAN INTERVENTIONAL CARDIOVASCULAR THERAPEUTICS

THE OFFICIAL CONGRESS OF APSIC

Mechanical Circulatory support in Cardiogenic Shock

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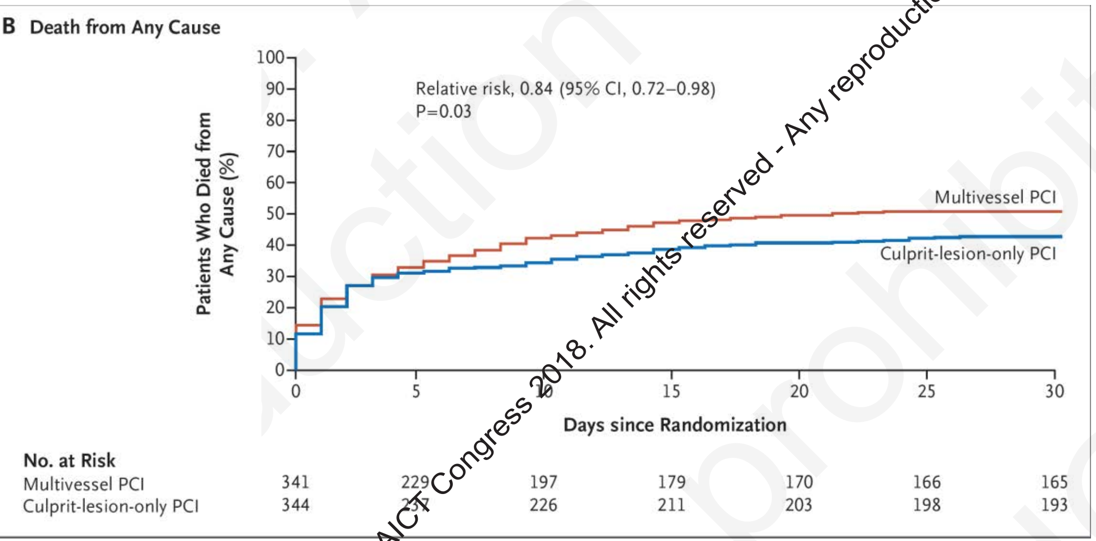
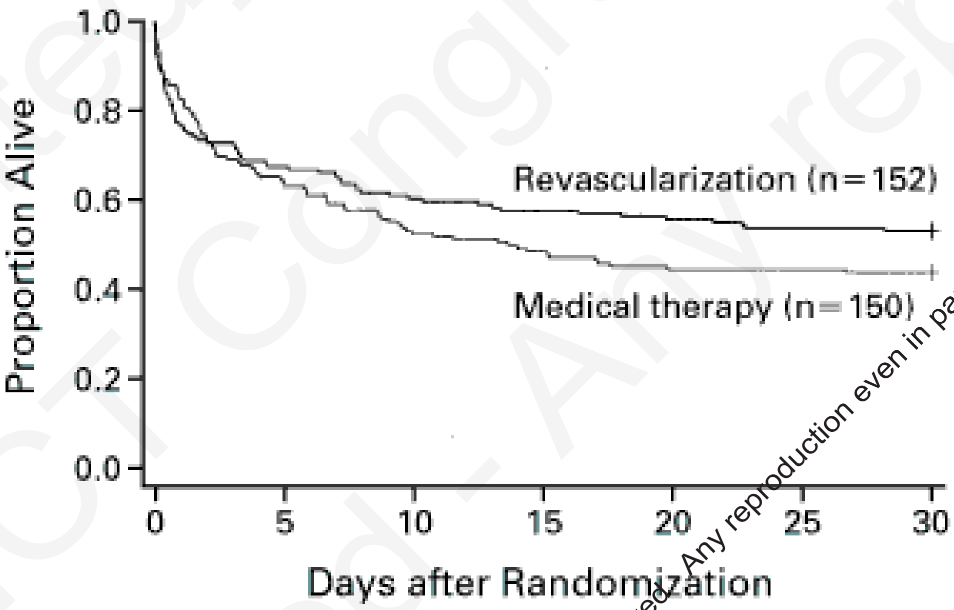
20 years down: Culprit Shock vs SHOCK Trial



30-day Mortality – 43.3% vs 51.6%

Early intervention vs. Conservative medical management



80% IABP

30-day Mortality – 44.0% vs 53.3%

Mortality in the PCI/IABP era is still 50%

Hochman et al. NEJM 1999

Thirty-Year Trends (1975 to 2005) in the Magnitude of, Management of, and Hospital Death Rates Associated With Cardiogenic Shock in Patients With Acute Myocardial Infarction

A Population-Based Perspective

Robert J. Goldberg, PhD; Frederick A. Spencer, MD; Joel M. Gore, MD; Darleen Lessard, MS; Jorge Yarzebski, MD, MPH

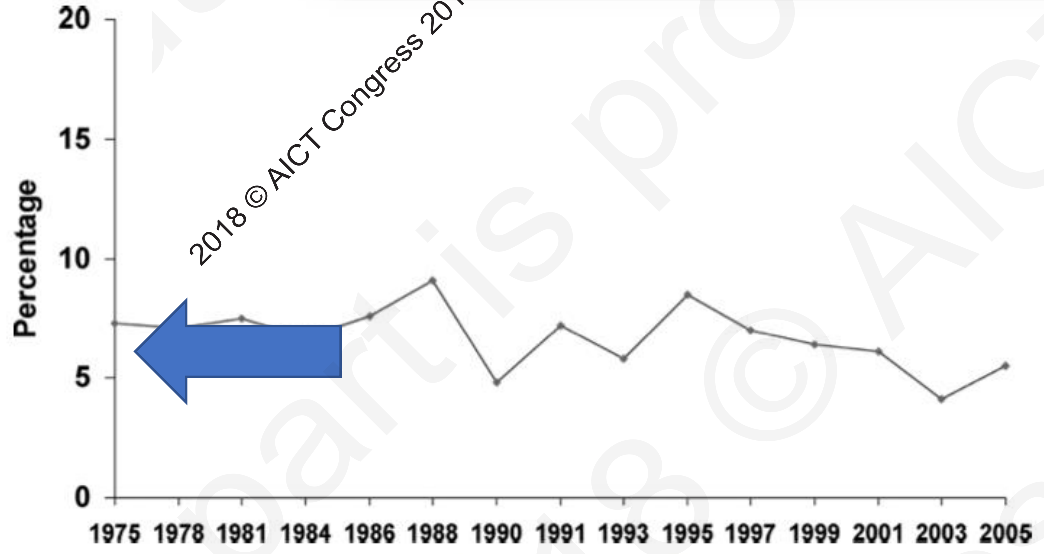
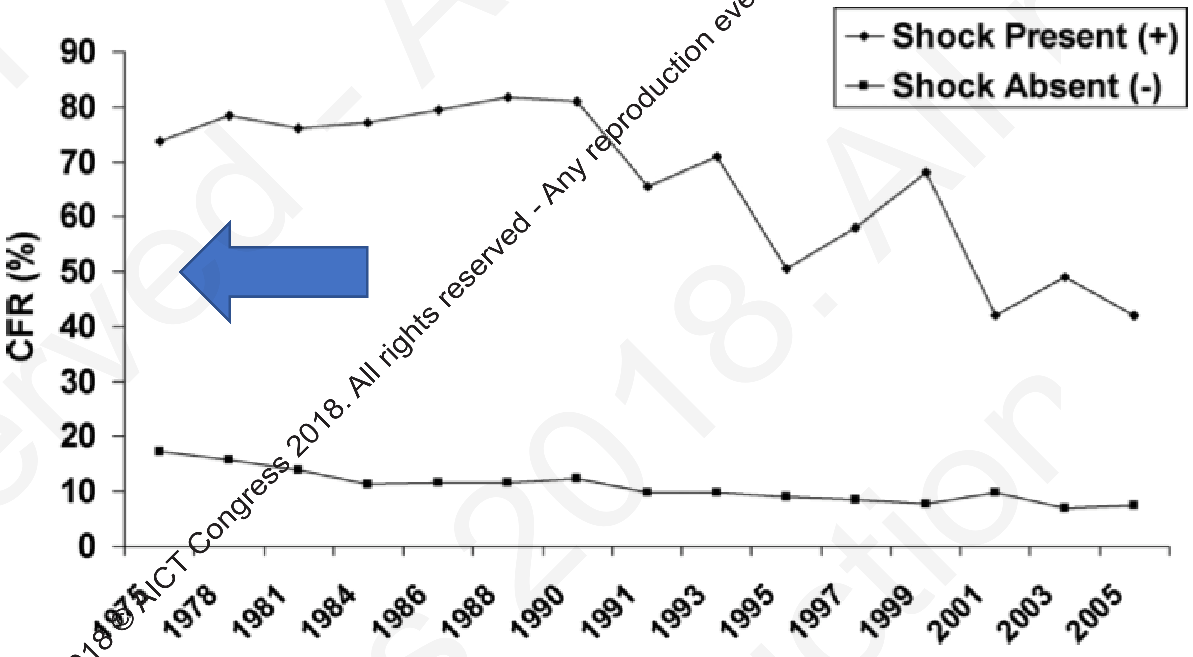


Figure 1. Trends in the incidence rates of cardiogenic shock in patients with AMI.



What we should do about STEMI Cardiogenic Shock

- Emergency angiography and revascularisation: Primary PCI preferably
  - All patients <75 years
  - Selected patients ≥75 years
- On-table echo to rule out mechanical defects
- IABP early? Class 3 as routine
- PCI culprit artery. Other vessels if shock persists? Culprit Shock -ve
- Consider percutaneous LVAD/ECMO if shock persists and early before collapse
- Mortality >50%

N Engl J Med 2013;369:901-9

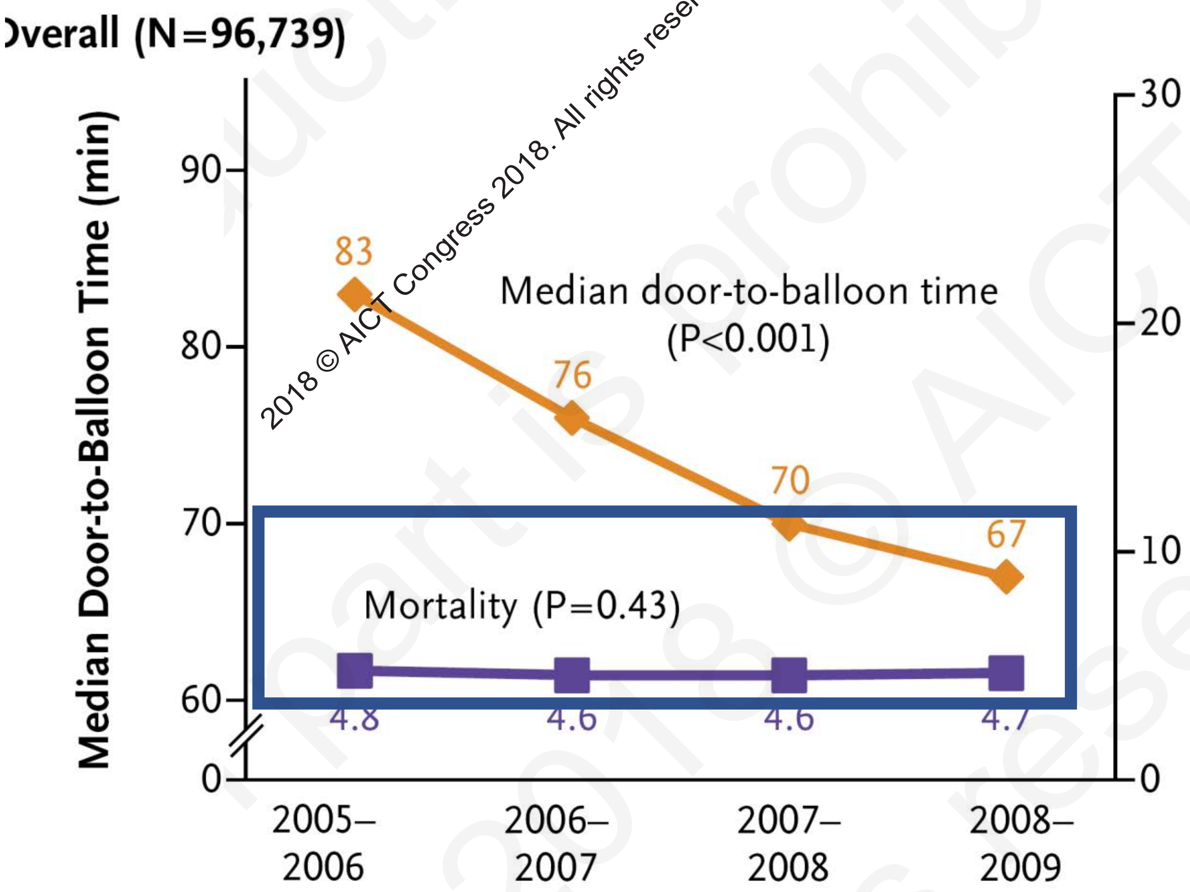
- Mortality determined by CS and not DTB

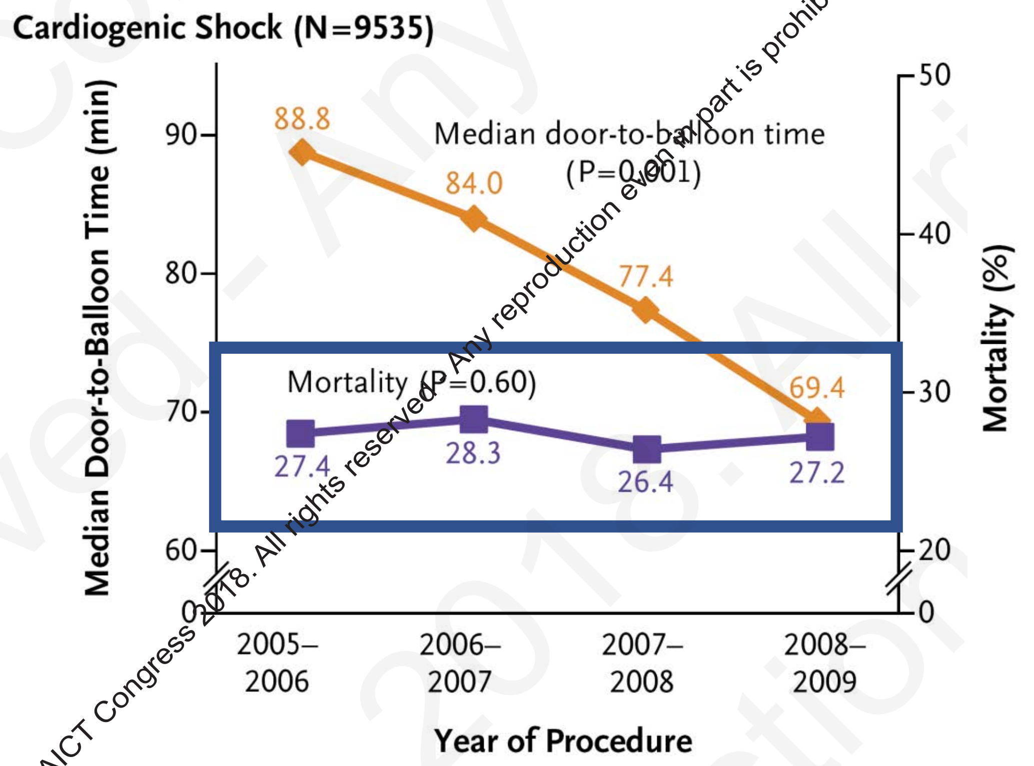
The NEW ENGLAND JOURNAL of MEDICINE

ESTABLISHED IN 1812 SEPTEMBER 5, 2013 VOL. 369 NO. 10

Door-to-Balloon Time and Mortality among Patients Undergoing Primary PCI

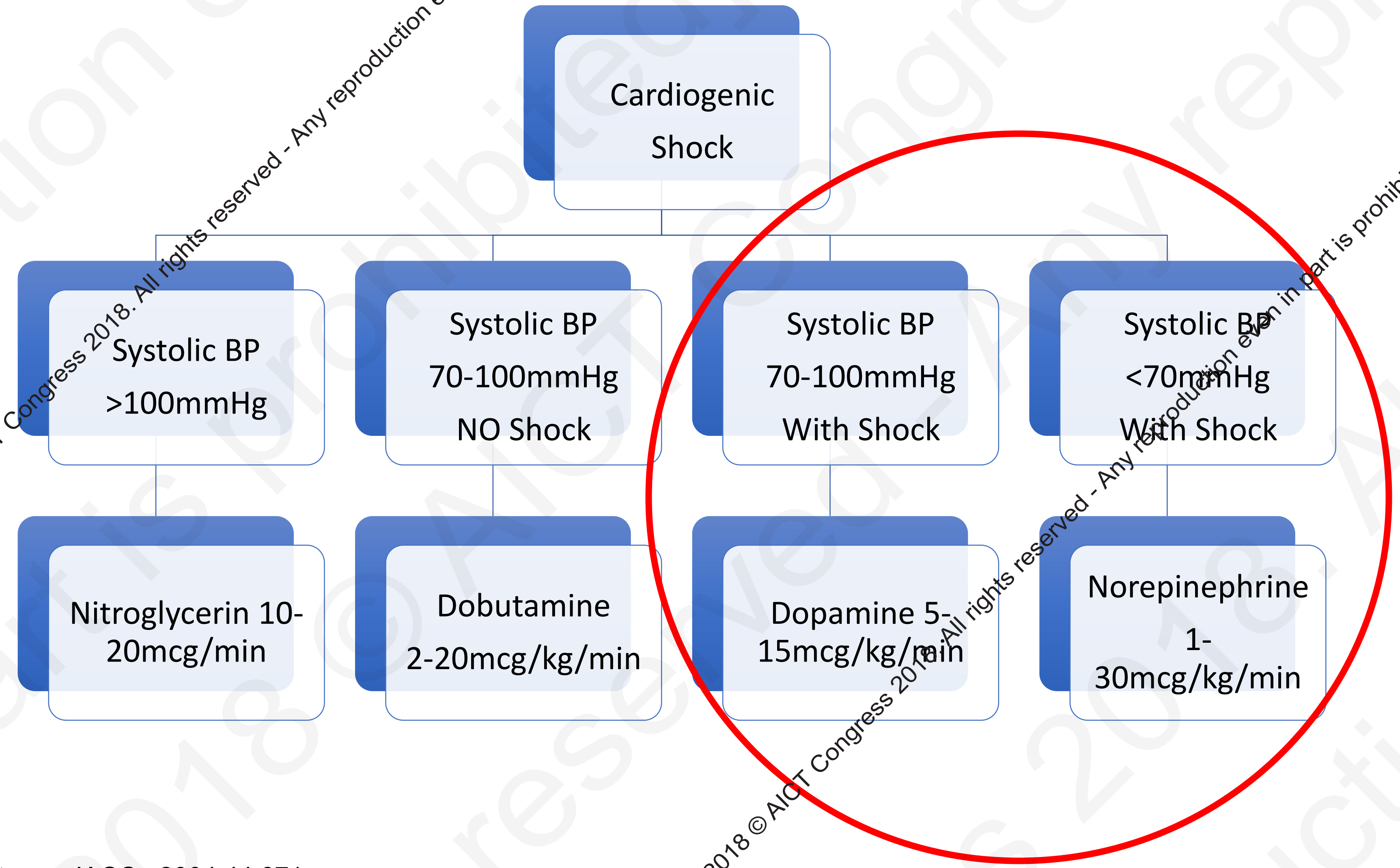
Daniel S. Menees, M.D., Eric D. Peterson, M.D., Yongfei Wang, M.S., Jeptha P. Curtis, M.D., John C. Messenger, M.D., John S. Rumsfeld, M.D., Ph.D., and Hitinder S. Gurm, M.B., B.S.





No. of Patients				
Shock	1907	2348	2633	2647
Deaths	522	664	695	720

ACC/AHA Guidelines for the Management of Patients With ST-Elevation Myocardial Infarction—Executive Summary



Antmen, JACC, 2004;44:671

SOAP II – Comparison of Dopamine and Norepinephrine in Shock

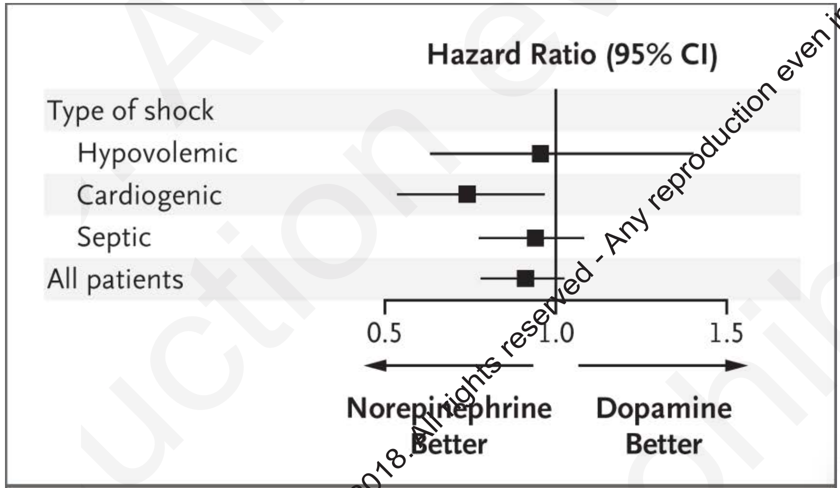
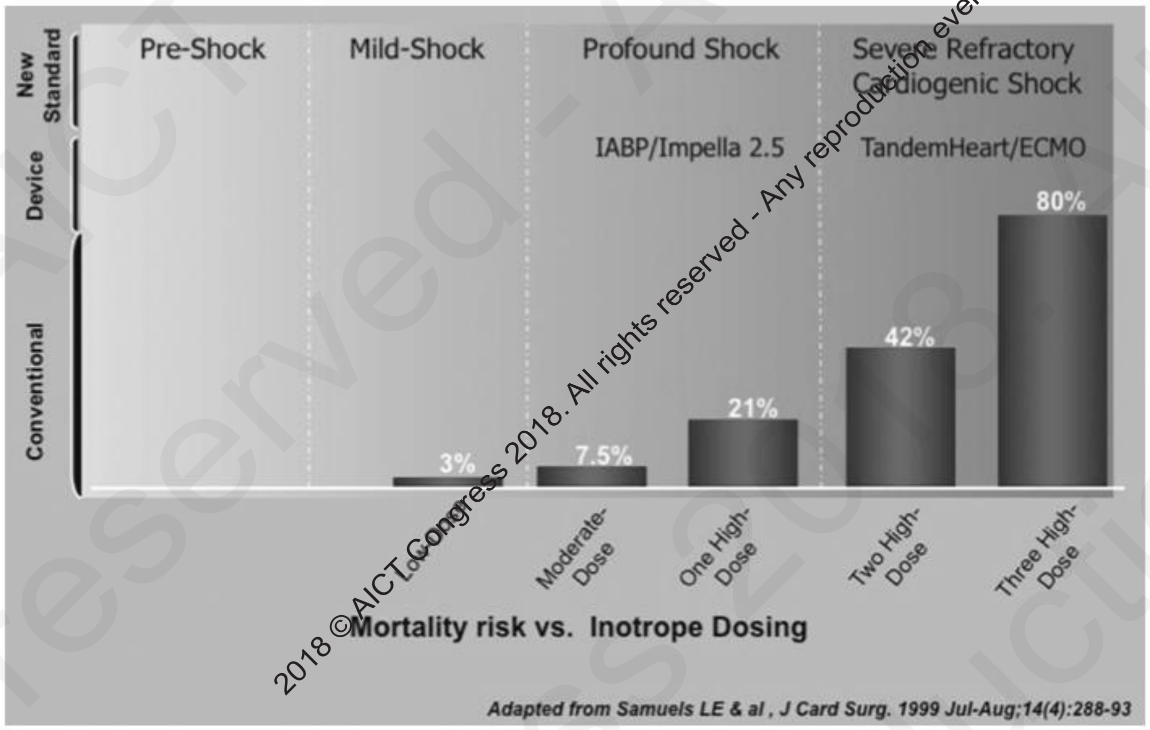


Figure 3. **Forest Plot for Predefined Subgroup Analysis According to Type of Shock.**
A total of 1044 patients were in septic shock (542 in the dopamine group and 502 in the norepinephrine group), 280 were in cardiogenic shock (135 in the dopamine group and 145 in the norepinephrine group), and 263 were in hypovolemic shock (138 in the dopamine group and 125 in the norepinephrine group). The P value for interaction was 0.87.

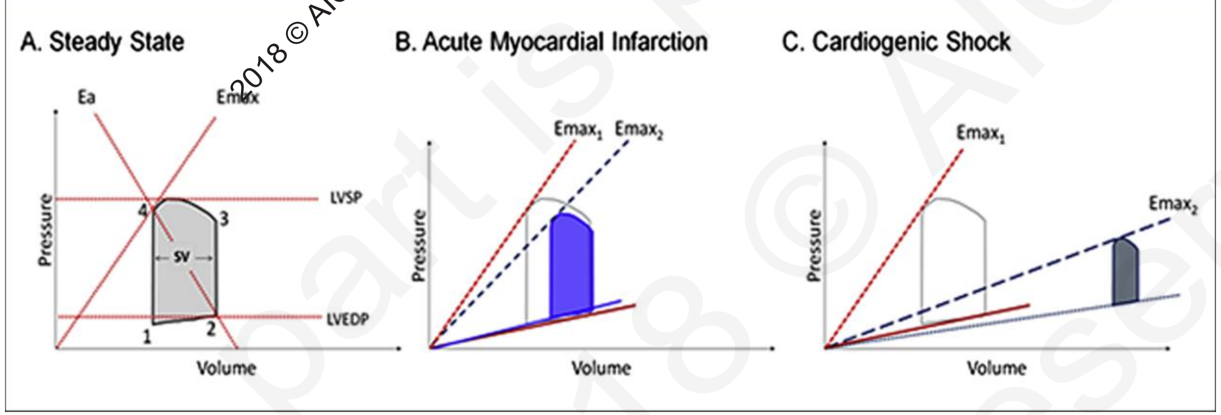
- 280 patients with cardiogenic shock
- Suggest NE>Dopamine (higher risk for arrhythmias and death)
- Likely all bad in severe cardiogenic shock

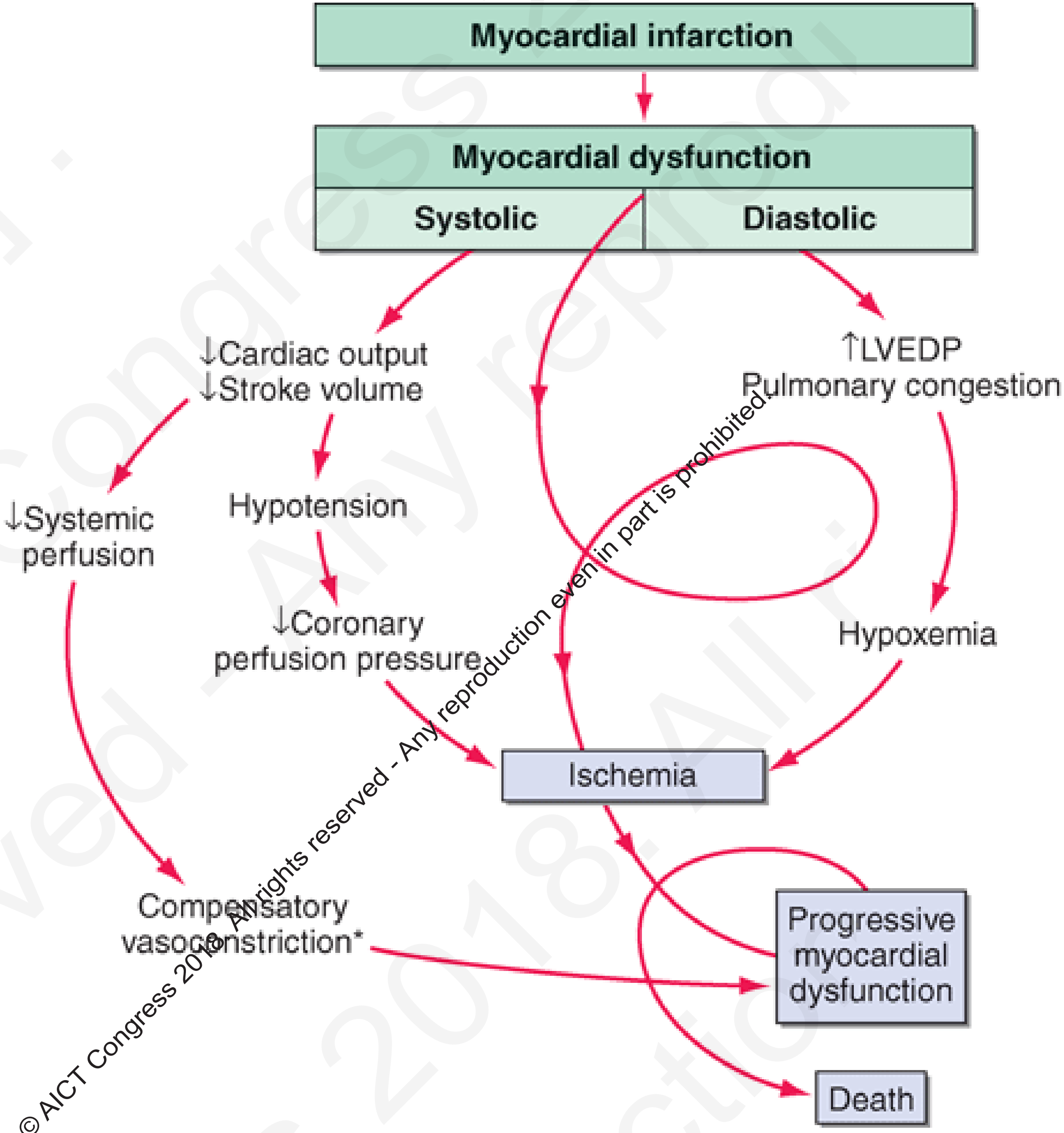


De Backer, NEJM, 2010;362:779.

- Drop in CO, increased LVEDP
- Poor perfusion, drop in BP, increase HR
- **Vasoconstriction → organ failure**
- Vicious spiral
- Need to intervene to prevent the downward spiral

FIGURE 1 Normal and Abnormal Pressure Volume Loops



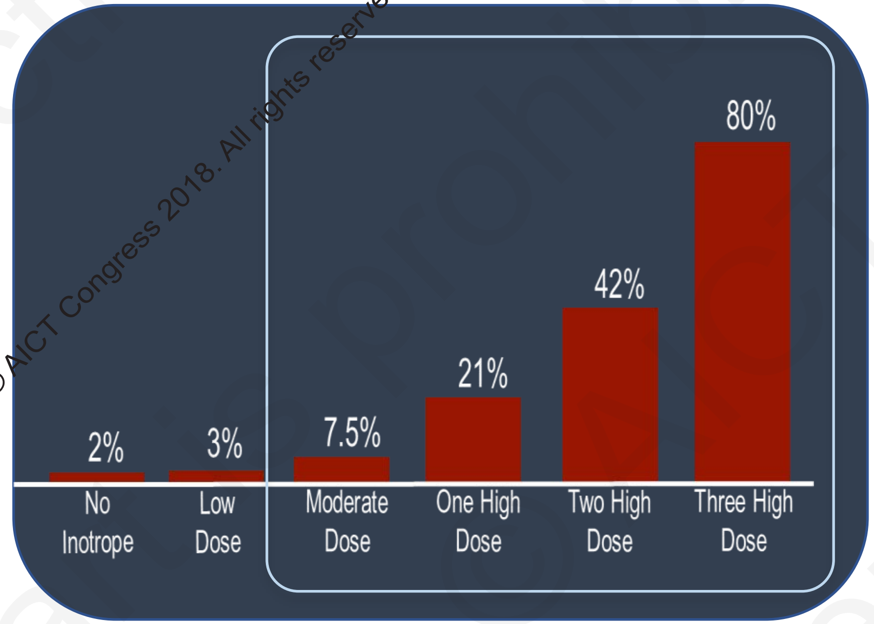


Source: Longo DL, Fauci AS, Kasper DL, Hauser SL, Jameson JL, Loscalzo J: *Harrison's Principles of Internal Medicine, 18th Edition*: www.accessmedicine.com

Limitations of Conventional Therapy

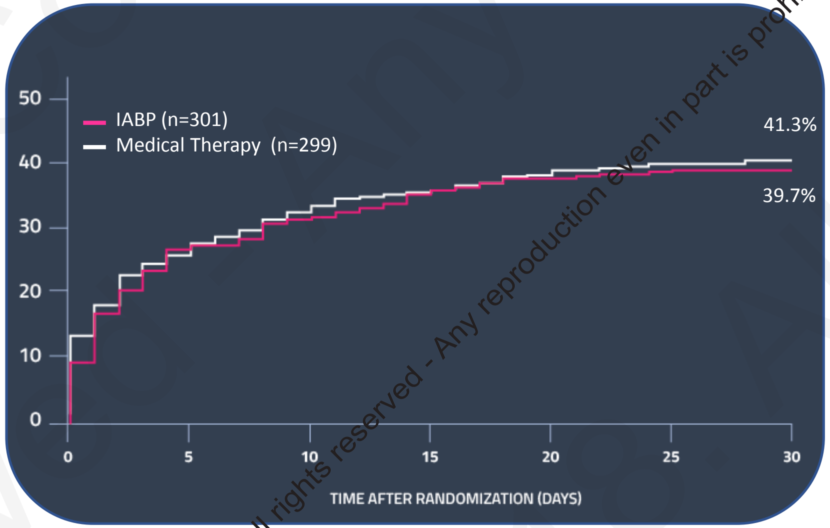
Mortality Risk with Inotropes/Vasopressors[1]

N = 3462



IABP-SHOCK II Randomized Controlled Trial[2]

N = 600



1- Samuels LE et al , J Card Surg. 1999
2- Thiele H et al. NEJM 2012 - Clinicaltrial.gov # NCT00491036

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EXPERT CONSENSUS DOCUMENT

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

- Acute decompensated heart failure (ADHF)
- High-risk PCI (HR-PCI)
- Acute cardiogenic shock
- Residual or concomitant cardiac dysfunction from myocardial infarction despite reperfusion e.g large AMI

AMICS

ESC Guidelines: IABP Class III, Level Evidence A *Recommends Short Term MCS for AMI Cardiogenic Shock*

JCS Guidelines: IABP Class III, Level Evidence B *Updated March 2018*

European Heart Journal
doi:10.1093/eurheartj/ehu278

ESC/EACTS GUIDELINES

2014 ESC/EACTS Guidelines on myocardial revascularization

The Task Force on Myocardial Revascularization of the European Society of Cardiology (ESC) and the European Association for Cardio-Thoracic Surgery (EACTS)

Recommendations	Class	Level
Routine use of IABP in patients with cardiogenic shock is not recommended	III	A

Windecker S, et al. Eur Heart J. 2014;35(37):2541-2619.

Recommendations regarding management of patients with cardiogenic shock.

表 56　心原性ショック患者に対する治療の推奨とエビデンスレベル

	推奨クラス	エビデンスレベル	Minds推奨グレード	Mindsエビデンス分類
補助循環の装着できる設備の整ったICU/CCUへの搬入	I	C	B	VI
心電図と動脈血圧の連続モニター	I	C	B	VI
体液貯留が認められない患者における生理食塩水あるいはリンゲル液の急速輸液（15～30分で200 mL以上）	I	C	B	
心拍出量を増加させるための強心薬（ドブタミン）投与	IIa	B	B	III
末梢循環不全が改善しない患者で収縮期血圧を維持するための血管収縮薬（ノルアドレナリン）投与	IIa	B	B	III
IABPのルーチン使用	III	B	D	II
患者の年齢，高次脳神経機能，合併症，社会的要因を考慮したうえでの補助循環の短期使用	IIb	C	C1	VI

Routine use of IABP in patients with cardiogenic shock is NOT recommended.
Class III / Evidence level B

Short term MCS may be considered depending on patient age, neurological function, comorbidities and social factors.
Class IIb / Evidence level C

51 years old Taxi driver

- Non smoker
- Previously well
- Admitted for on going chest pains and anterior ST elevation on ECG
- 2017 Chinese Lunar new year holidays
- On arrival in CVL, collapsed with refractory VF
- >20 shocks, IV adrenaline bolus given. CPR for 10 mins with intermittent ROSC

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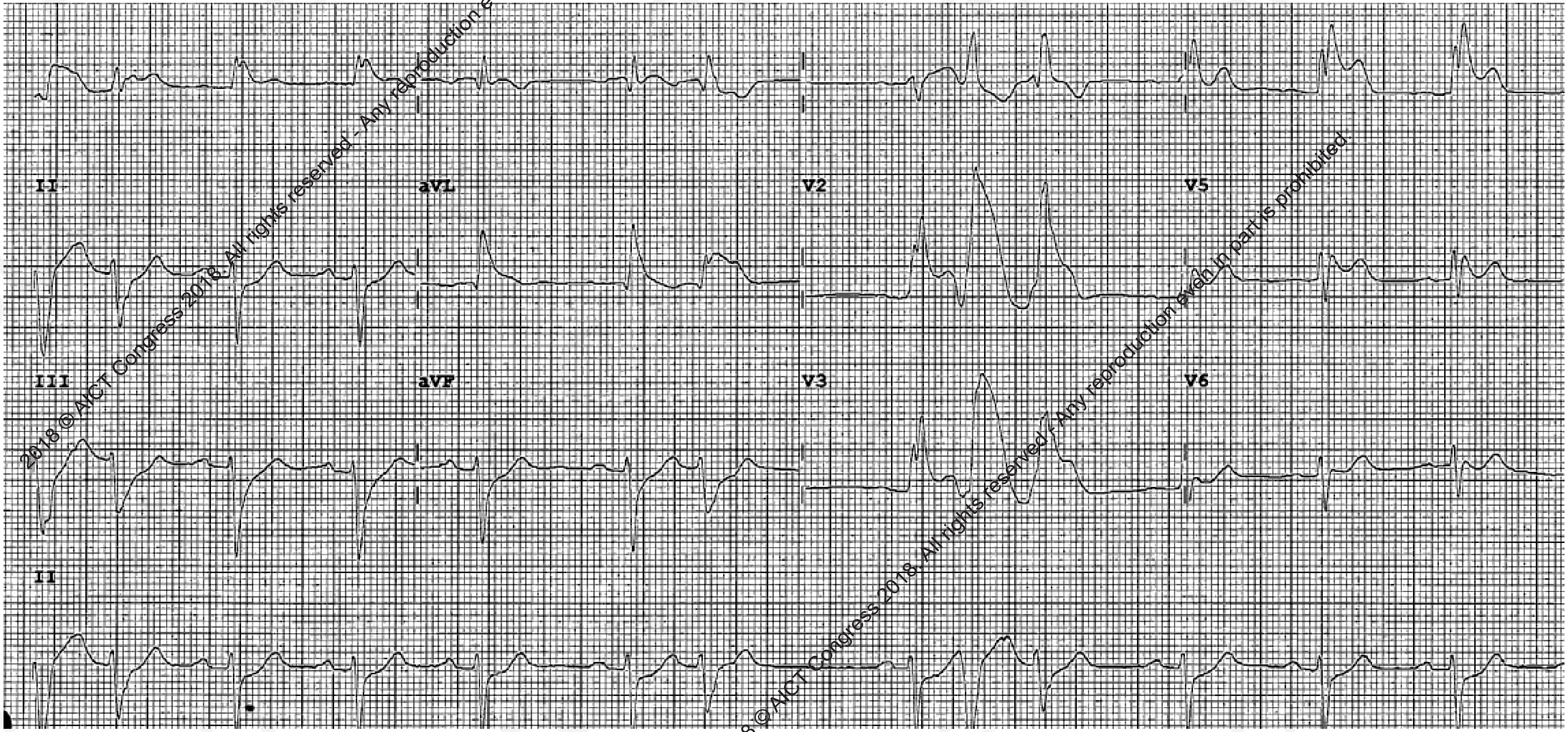
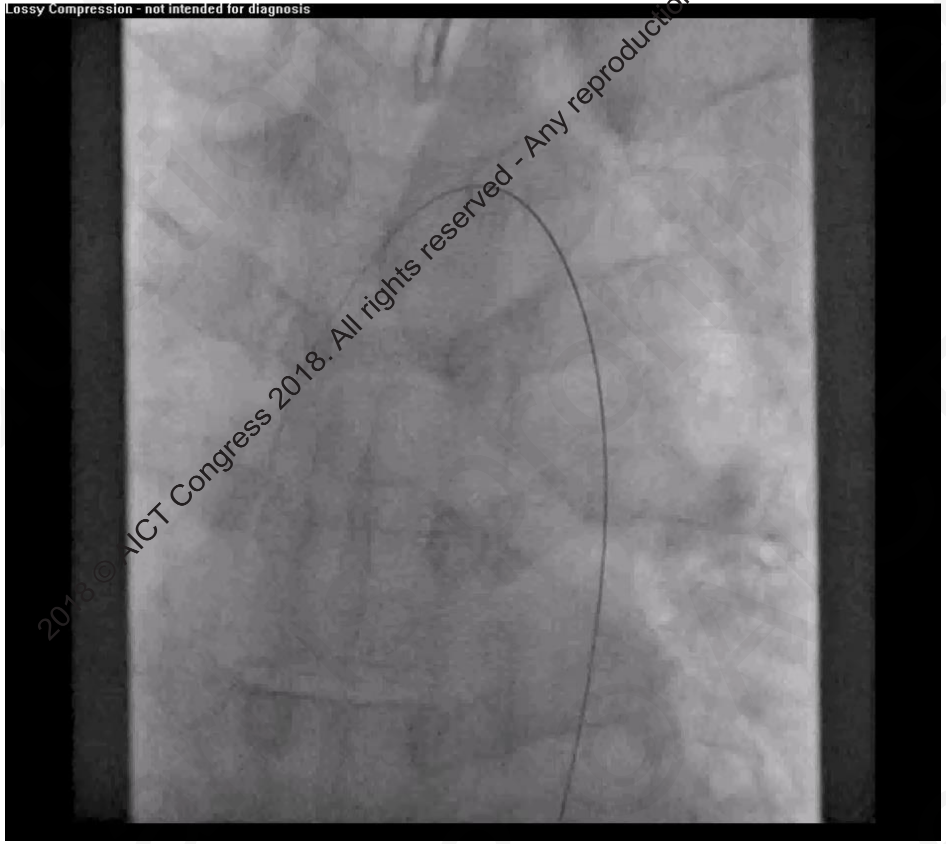
Presenting ECG



Intubated, Placed on table, CPR for refractory VF



- Ultrasound guided puncture both groins, venous and arterial
- IABP inserted
- ECMO team activated

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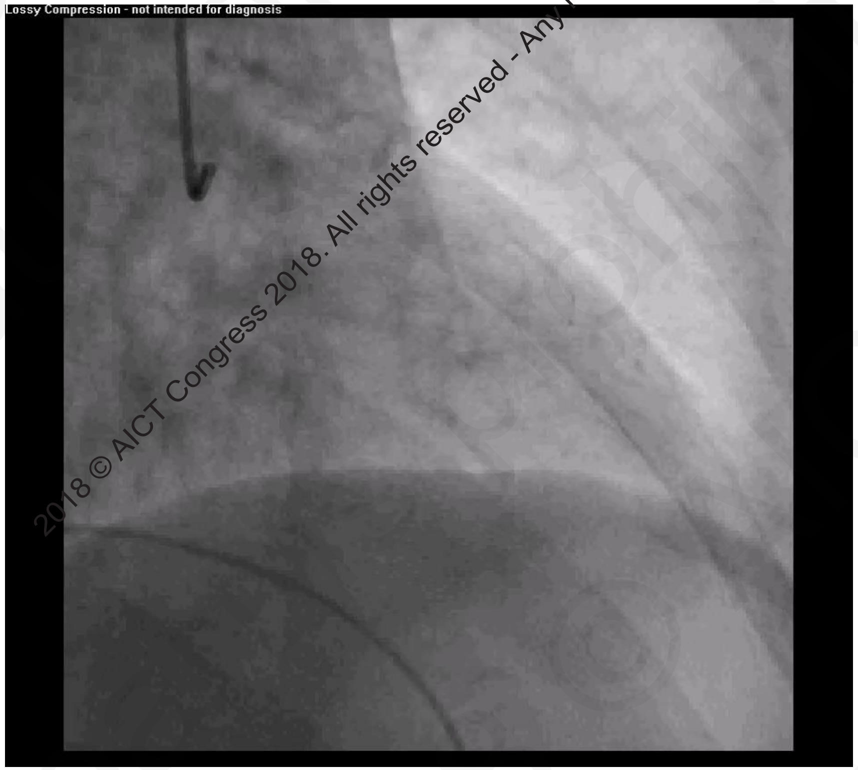
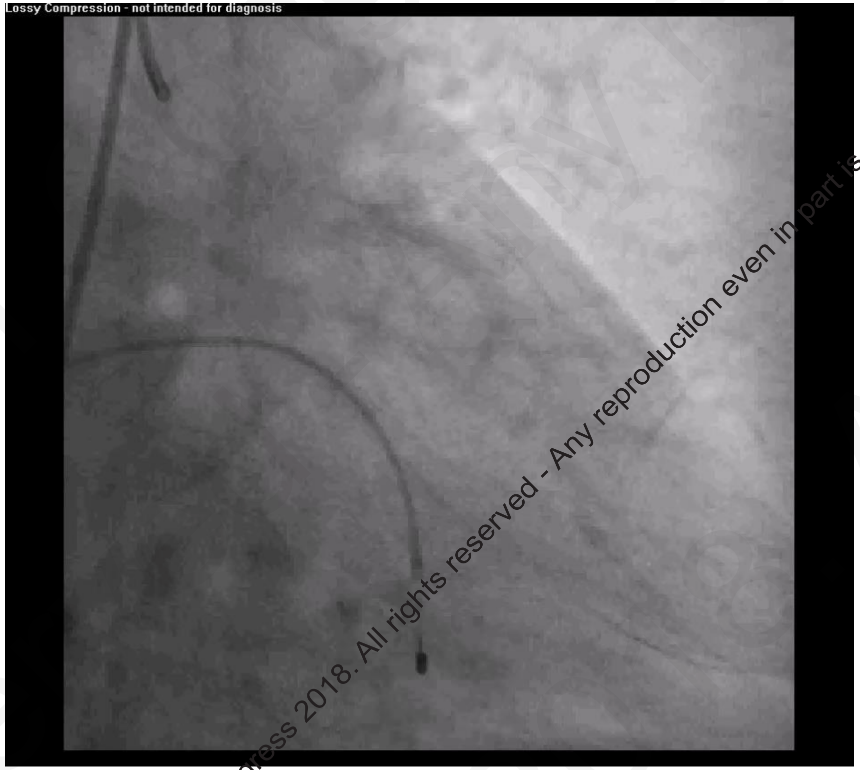
Culprit vessel?

TIMI 2 flow in LAD

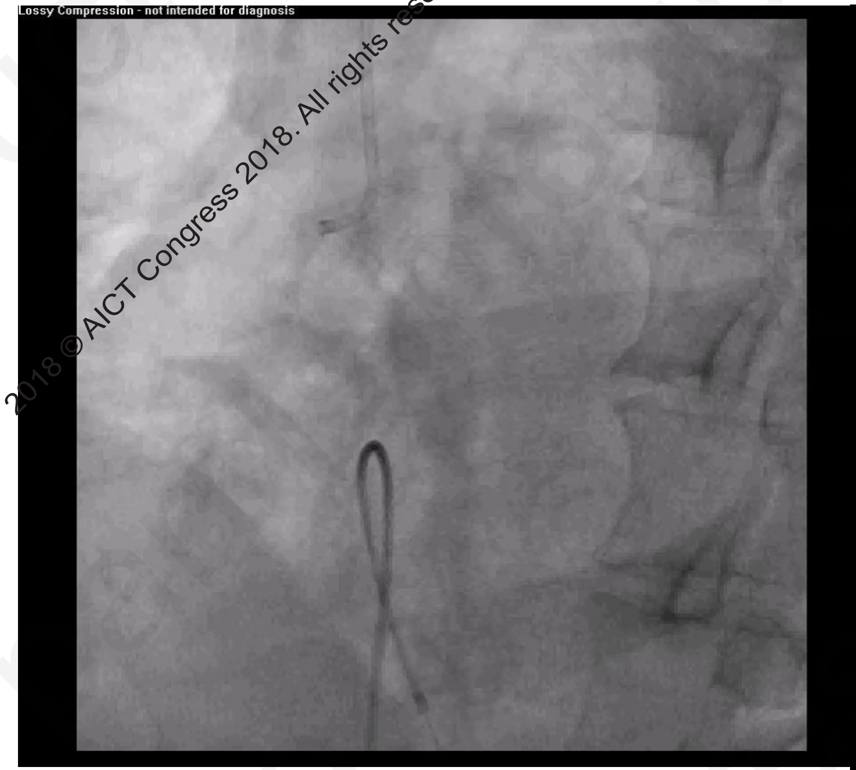


Tight LCX

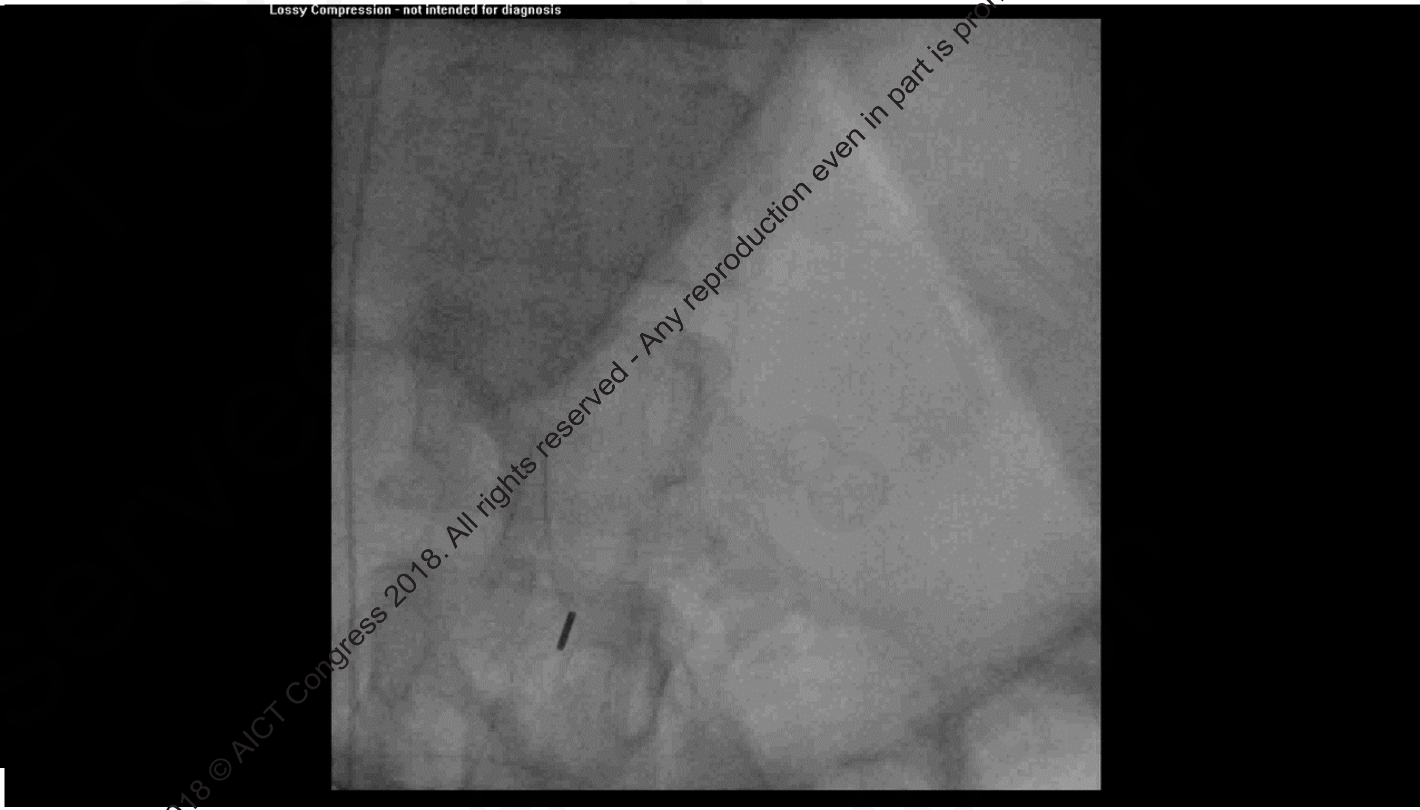


Severe TVD, still going into VF

Tight RCA

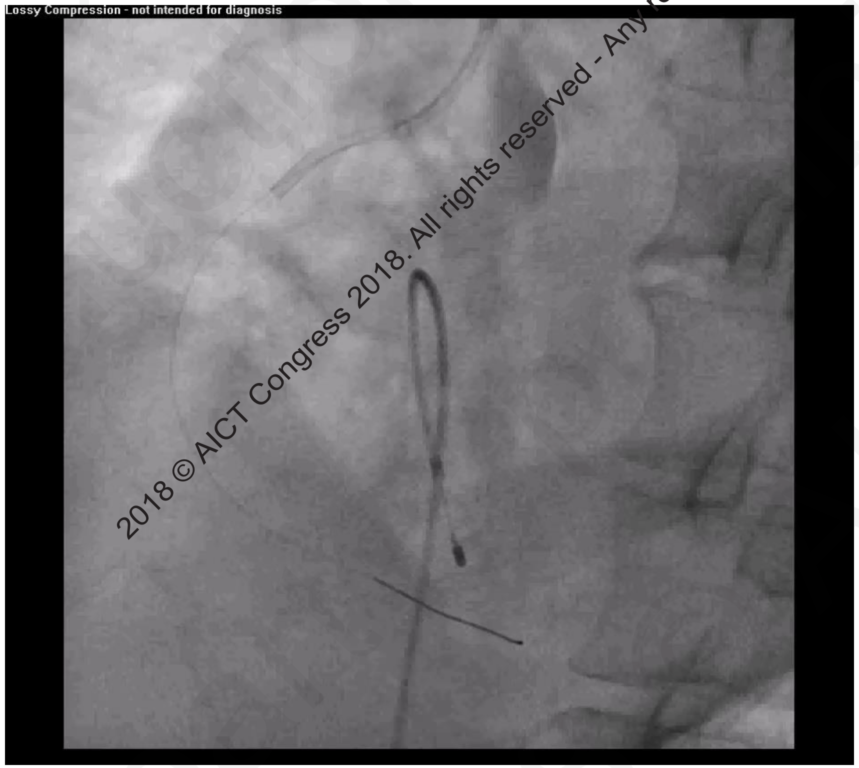


ECMO inserted



Persistent VF

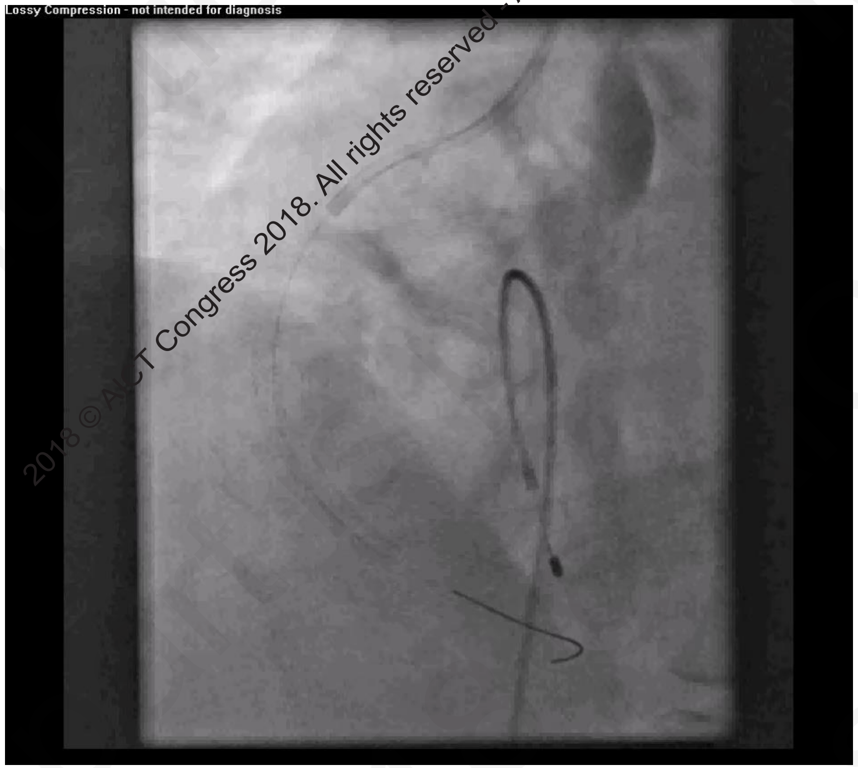
AL1 SH: AV not opening



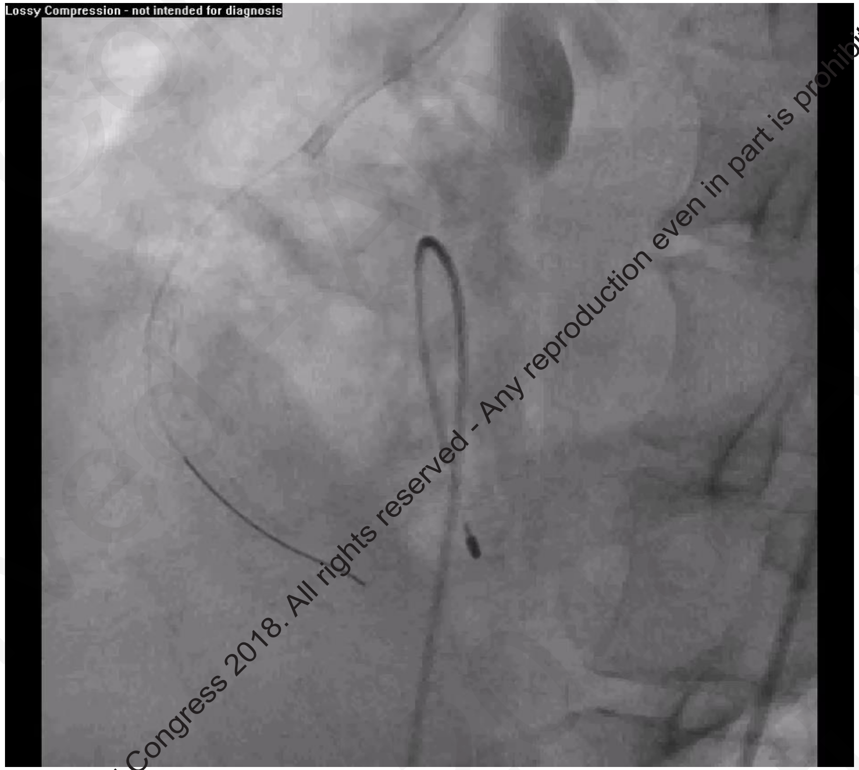
No further attempt at cardioversion

RCA intervention: Persistent VF

3.5x36mm +4.0x18mm

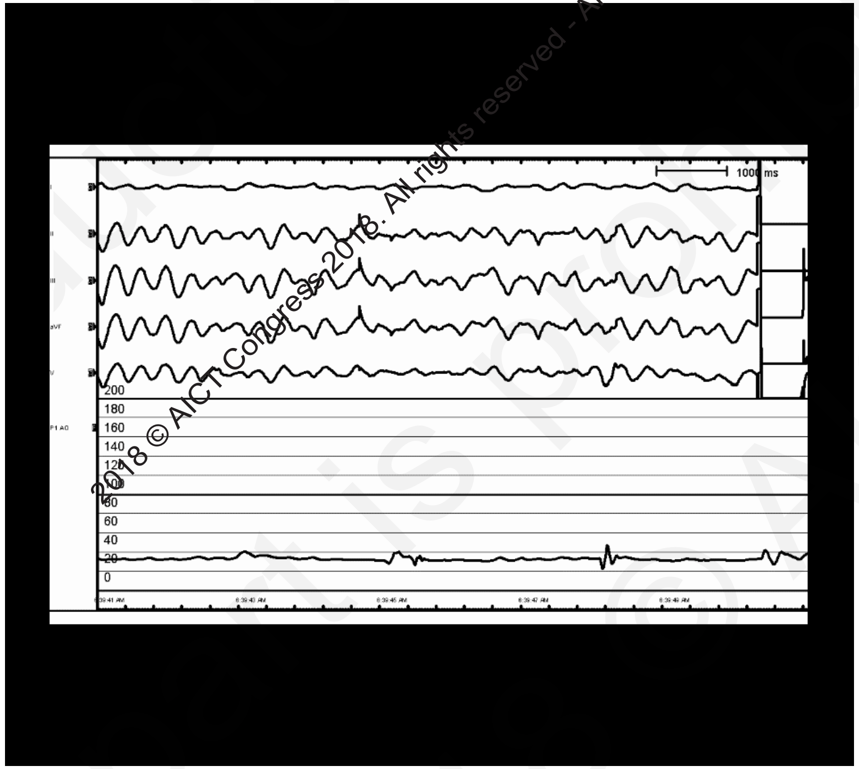


Post dilated with 4.0mm NC

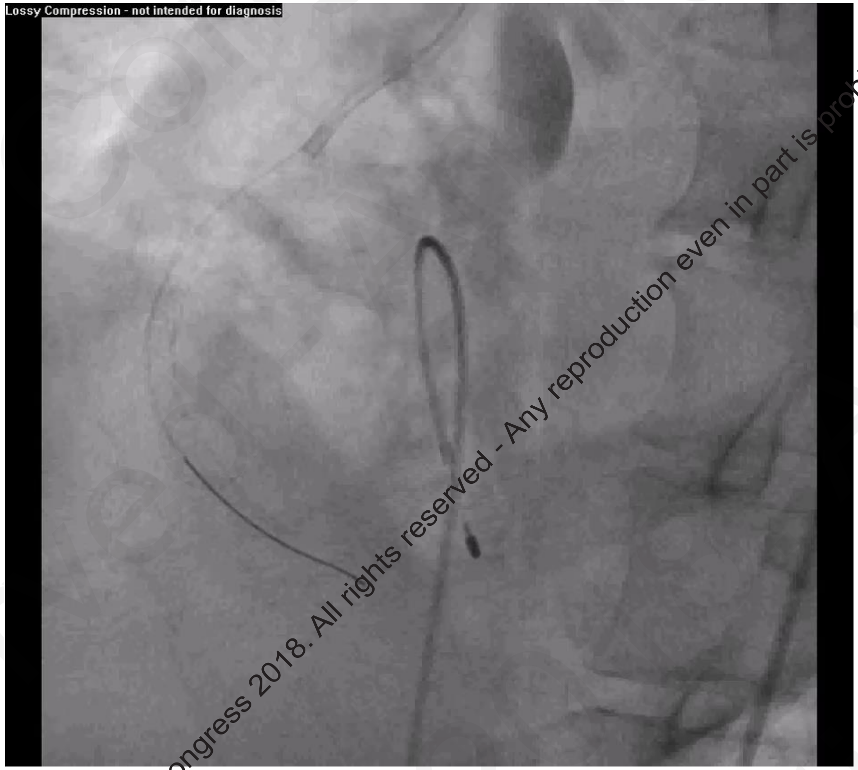


Persistent VF for at least 3-5 minutes

VF with no ejection



Cardioverted post RCA PCI



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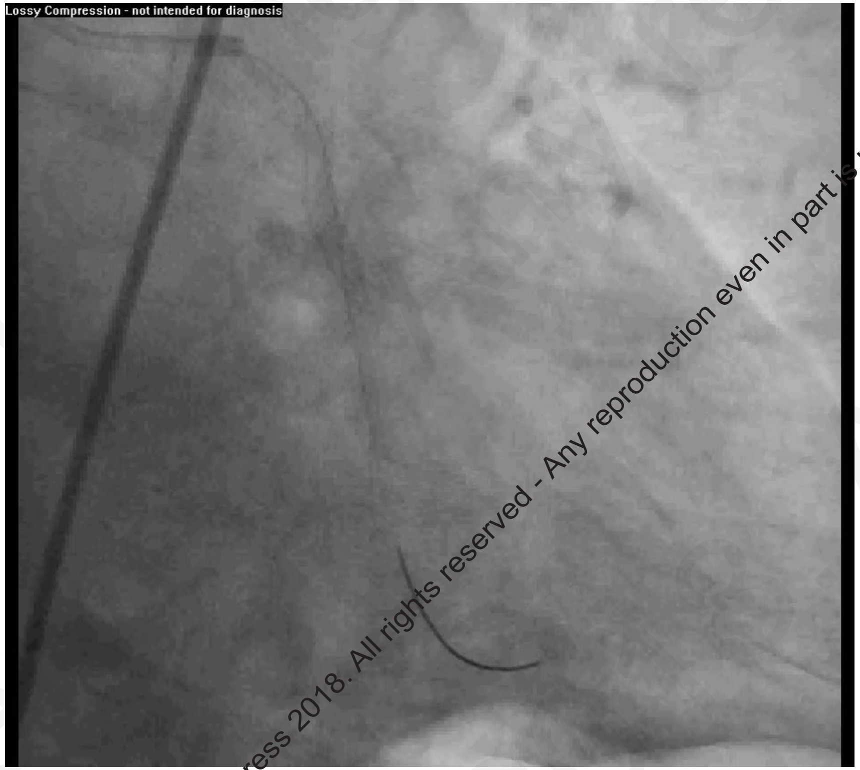
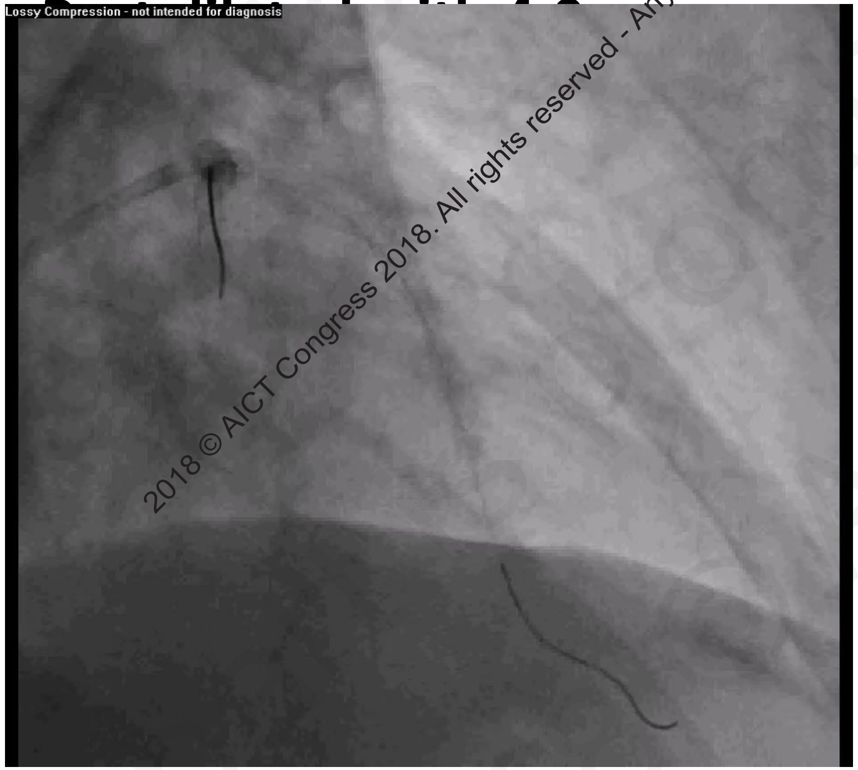
Complete revascularization

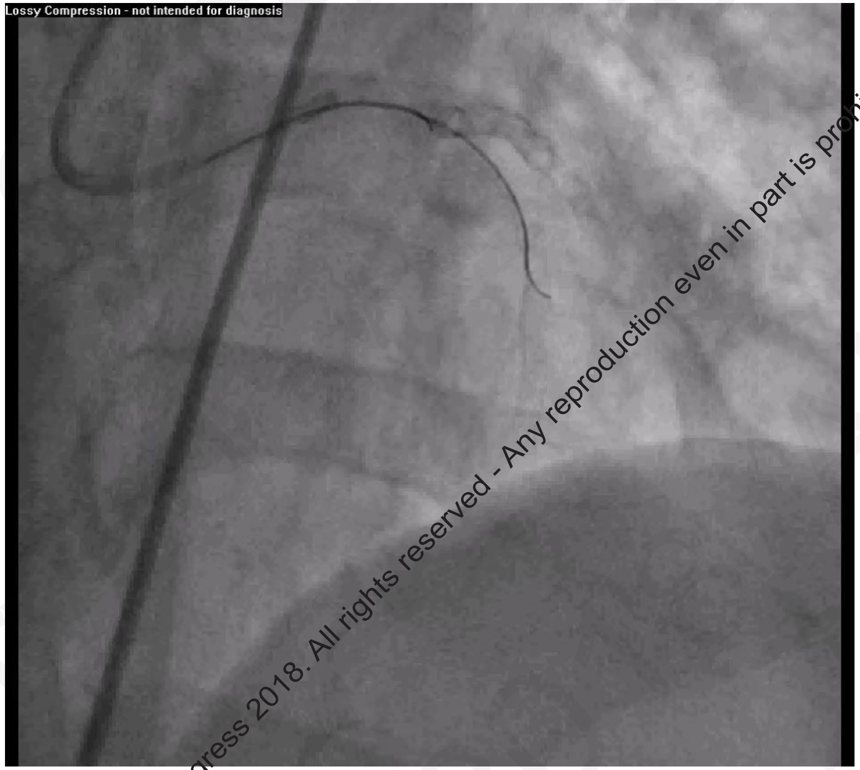
TPW parked in IVC

Lcx: 2.75+3.5mm x28mm



LAD intervention





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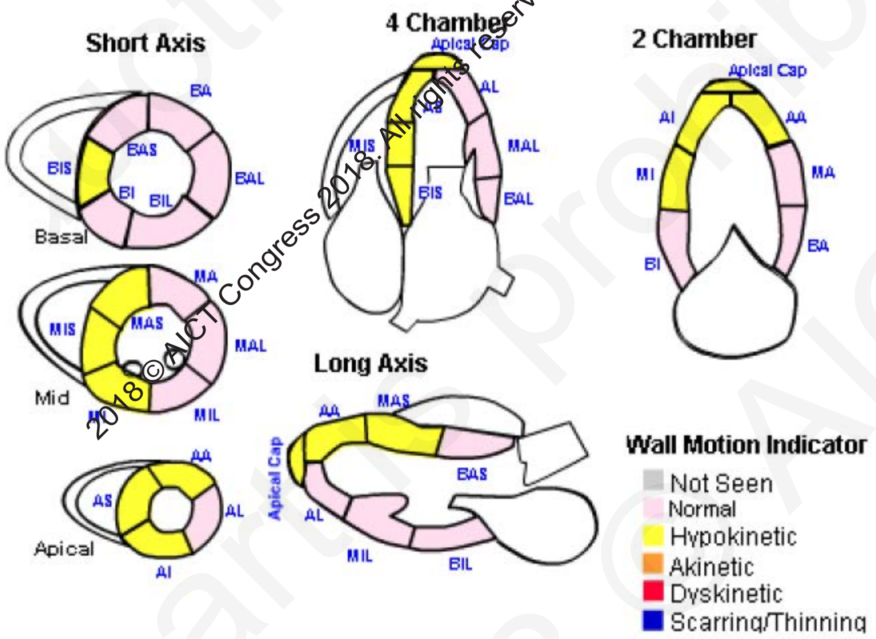
Inpatient course

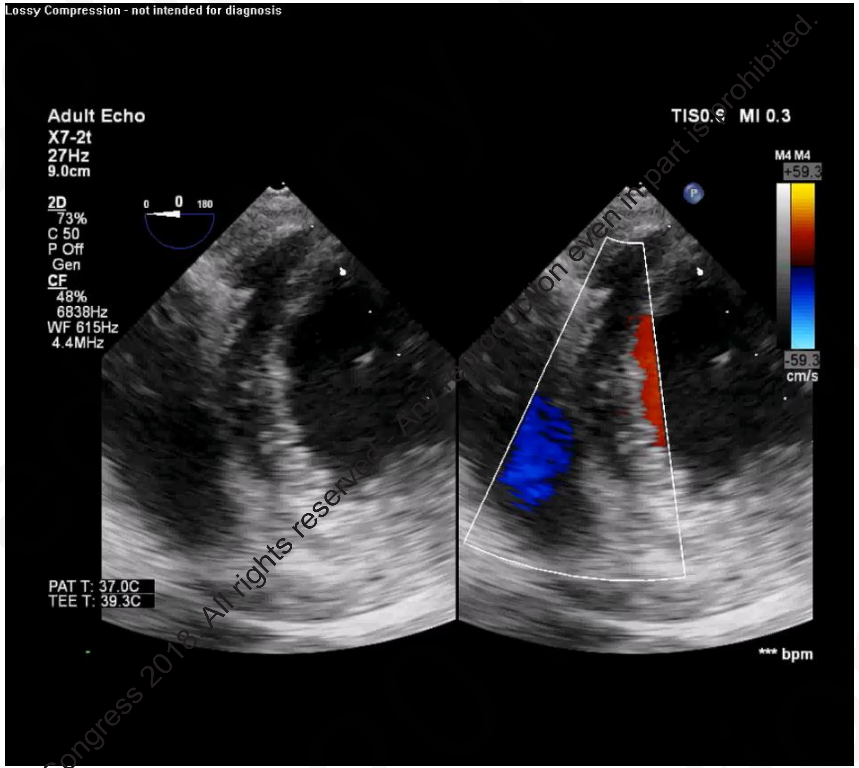
- Antegrade perfusion catheter for arterial ECMO line
- Cooled to 33 degrees for 24hours
- Paralyzed
- ECMO explanted Day 3 with intraop TEE
- Discharged without neurological deficits Day 7

TTH: Cooled with ECMO to 33 degrees for 24Hours

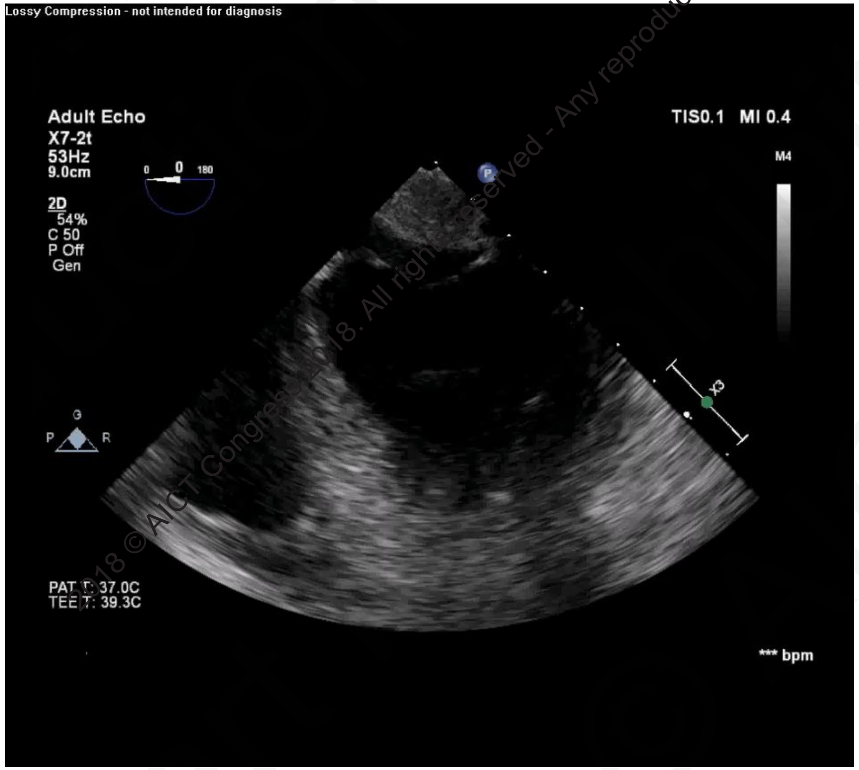
LVEF 40-45% Day 2

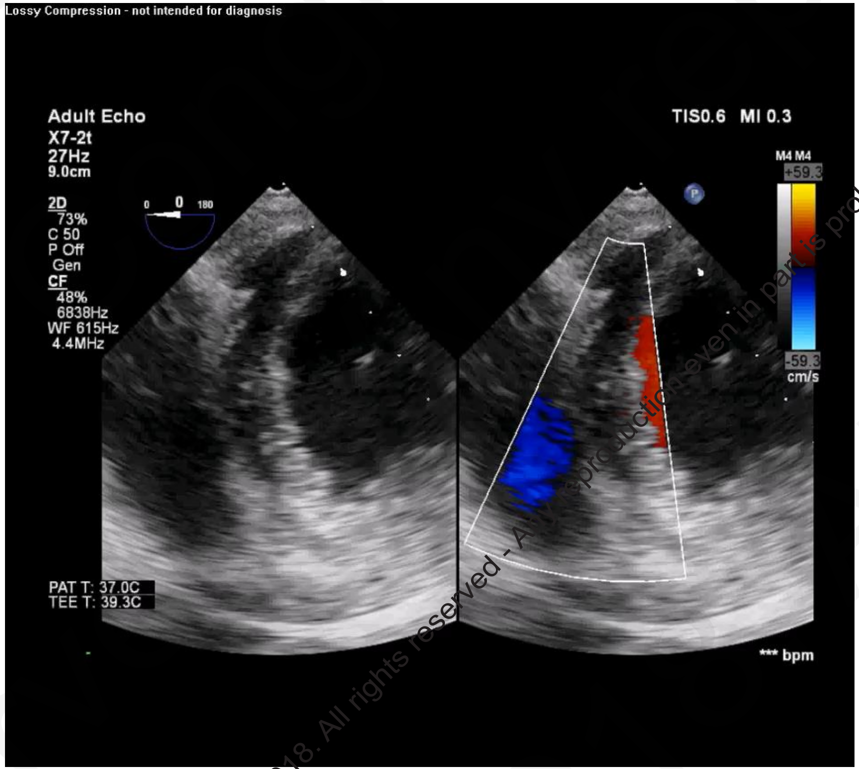


TEE during ECMO explant Day 3



TEE during ECMO explant day 3





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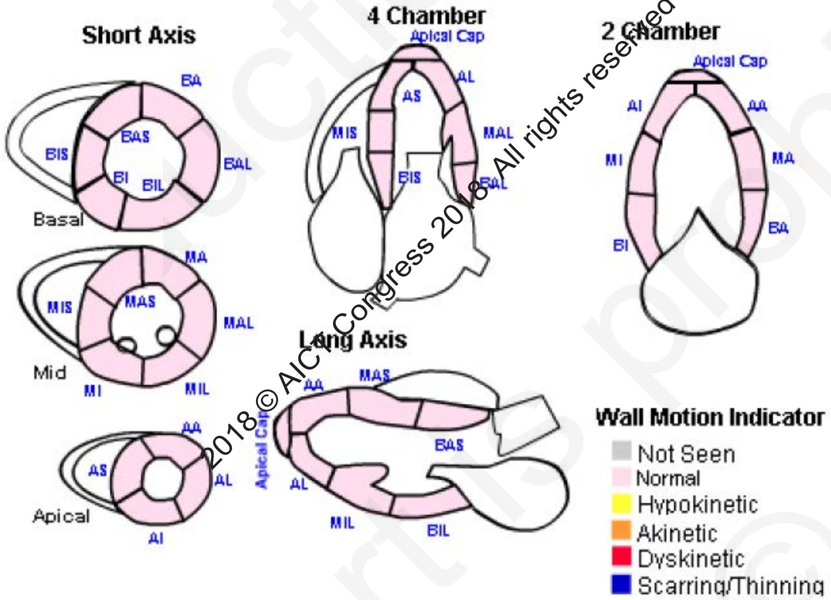
Rewarmed after 24hours: Normal LVEF day 7

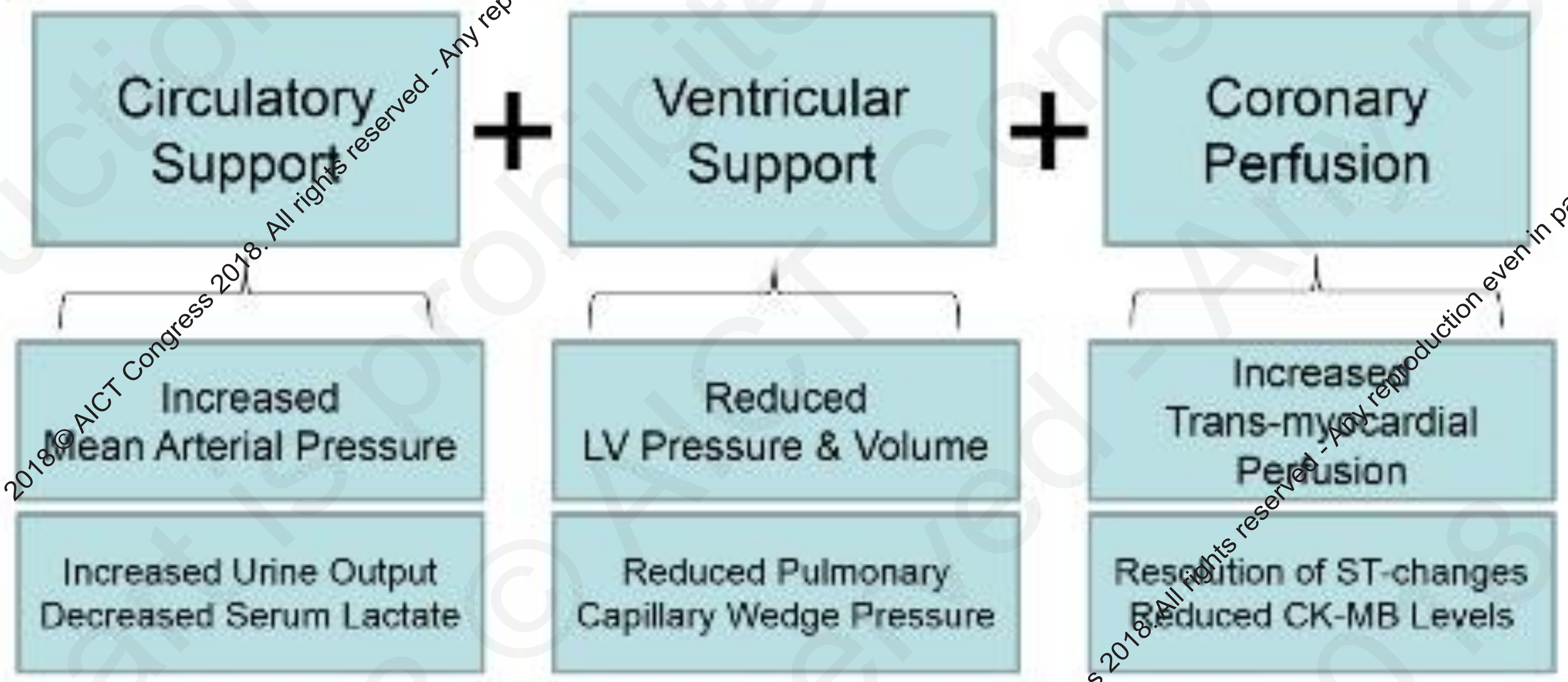


Day 7 pre discharge

Conclusion :

- Normal LV cavity size. EF 50-55%. No apparent wall motion abnormality!
- Normal RV cavity size. Impaired RV global systolic function. TAPSE 2.4 cm. TA S wave 0.13 m/s.
- Normal left and right atrial cavity size.
- Morphologically normal valves.
- Normal LV diastolic function. Normal LV filling pressure by Doppler.
- Pulmonary artery systolic pressure is 19 mmHg, assuming mean right atrial pressure of 3 mmHg.
- Normal aortic root dimension
- No intracardiac thrombus or mass.

Targets for MCS therapy



Kapur et al. ACC 2016

Ways of Achieving Goals

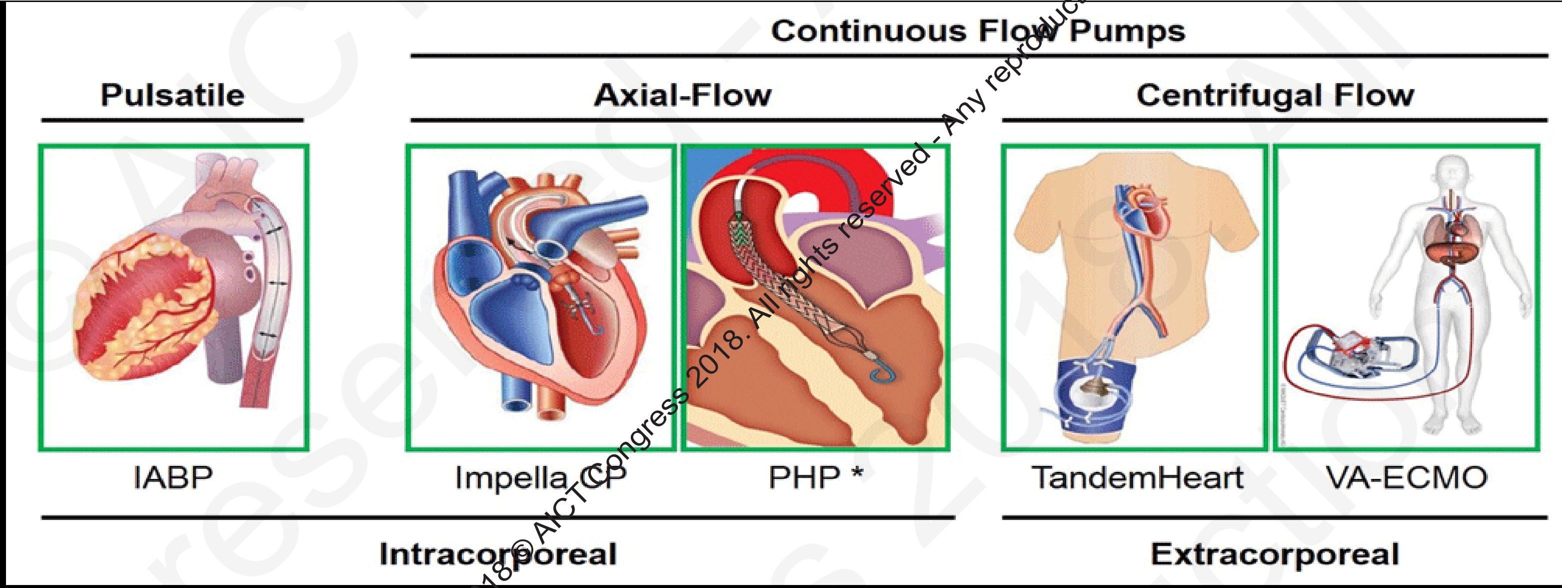
Pharmacology

- Inotropic agents
- Pressors

Devices

- IABP → Trials show to be ineffective. Class III
- RA→Ao (ECMO)
- LV→Ao (Impella)
- ECMO + Impella (Ecpella)

} Very Different Hemodynamic Effects



Esposito ML and Kapur NK 2017 [version 1; referees: 3 approved] F1000Research 2017

ECMO vs Impella: Beyond cost effectiveness

the information entered. The calculation should not be decisive for the use of an Impella pump and is not a substitute for medical decision-making. These are legally non-binding notes. The author is not liable for any damage that may occur and can not assume any responsibility for the actuality, correctness or completeness of the information provided.

SINGAPORE

Projected # of patients treated: 3

Impella vs Surgical alternatives (ECMO/extracorporeal VAD)

Peer reviewed, statistically significant data point	Absolute Impact for projected # of Pts	Verified SINGAPORE Cost info			Average cost Saving per patient treated S$
Anson Cheung et. al: JACC Vol 60/17/Suppl B | October 22–26, 2012 | TCT Abstracts/POSTER/Heart Failure, LV Dysfunction, and Shock — "Impella cardiac assist device. Related, there was a 100% reduction in perfusion costs, as Impella patients do not require perfusion assistance. Additionally, ICU costs were reduced in the Impella arm by 25%, driven primarily by 4.8 fewer ICU days of stay for Impella patients."	Length of Stay reduction in days 4.8	Per day COST for ICU		$ 4,500	4.8 days @ S$ 4500/ day $ 21,600
Maini B, et al. Catheter Cardiovasc Interv. 2014;83(6):E183-E192.					
Cardiovascular Surgery, 2011;142:60-5 (Canada)	**Product Type**	Per unit price	Diff units	Total saving	Cost saving per patient
	Red blood cells	$ 100	14	1400	
	Clinical fresh frozen plasma (FFP)	$ 100	12	1200	$ 5,100
	Platelets	$ 500	5	2500	
	Source: https://www.blood.gov.au/national-product-list		31	$ 5,100	
		Average cost		$ 165	
Lamarche et al, Journal of Thoracic and Cardiovascular Surgery, 2011;142:60-5 (Canada) — "agement of patients with the microaxial VADs did not need 24-hour onsite coverage with perfusionists, which was necessary with ECLS. The ability of the Impella system to relieve ventricular distension is a potential advantage over other"	Overhead cost saving Impella vs ECLS (hours) ^ 240.0 **average ECMO support time in CS**	PERFUSIONIST COST		40/HR	Cost saving per patient (46.3 hr * $40/hour) $ 9,600
		Average Overhead cost per hour ($)		$ 40	
Lamarche et al, Journal of Thoracic and Cardiovascular Surgery, 2011;142:60-5 (Canada) — "were subsequently discharged from the hospital. Arterial thrombotic events were more frequent in patients receiving ECLS (18.8% vs 3.4%; $P = .04$). The arterial thromboem-"	events reduction absolute % (18.8%-3.4%) **15.4%** Thrombotic events Reduction for Proj # of Patients trtd **0.46**	ESTIMATED COST WEIGHTS FOR AR-DRG VERSION 8.0, Round 19 (2014-15)			(Reduction*DRG/Proj Pts)
		DRG		B69B/F65A	$ 924
		Description		TIA/PVD	
		ALOS (Days)		3.0	
		Average Cost per DRG ($)		$ 6,000	
	Cost of ECMO			$ 10,000	Savings per patient $ 10,000
Per patient cost saving					$ 47,224

Maini B, et al. — TABLE I. Index Admission Empirical Comparative Data Between the Traditional Surgical Hemodynamic Support Alternatives, Percutaneous Cardiac Assist Devices, and PinnacleHealth pVAD Program Arms

	Surgical alternatives (n = 305)	pVAD therapy (n = 883)	PinnacleHealth pVAD (n = 30)
Mean cost (USD)	$144,257	$90,929 ($P$ < 0.0001)	$53,050 ($P$ < 0.0001)
Length of stay (days)	17.9	13.2 (P = 0.055)	6.0 (P = 0.003)
Survival (percent)	42%	56% (P < 0.0001)	60% (P = 0.056)

TABLE 3. Blood product use: Extracorporeal life support, packed red blood cells, and fresh frozen plasma

	ECLS (n = 32)	Impella (n = 29)	P
PRBC (median [IQR])	18.0 (9–34)	4 (2–9)	< .001
FFP (median [IQR])	14 (8–28)	2 (0–8)	< .001
Platelets (median [IQR])	5 (0.5–8.5)	0 (0–2)	< .001
Factor VIIa (%)	21.8	13.8	.51

ECLS, Extracorporeal life support; *FFP*, fresh frozen plasma; *PRBC*, packed red blood cells.

TABLE 2. Outcomes: ventricular assist device, extracorporeal life support, interquartile range, and standard deviation

	ECLS (n = 32)	Impella (n = 29)	P
Duration of support (hr) (median ± IQR)	46.3 (27–88)	63.3 (41–142)	.16

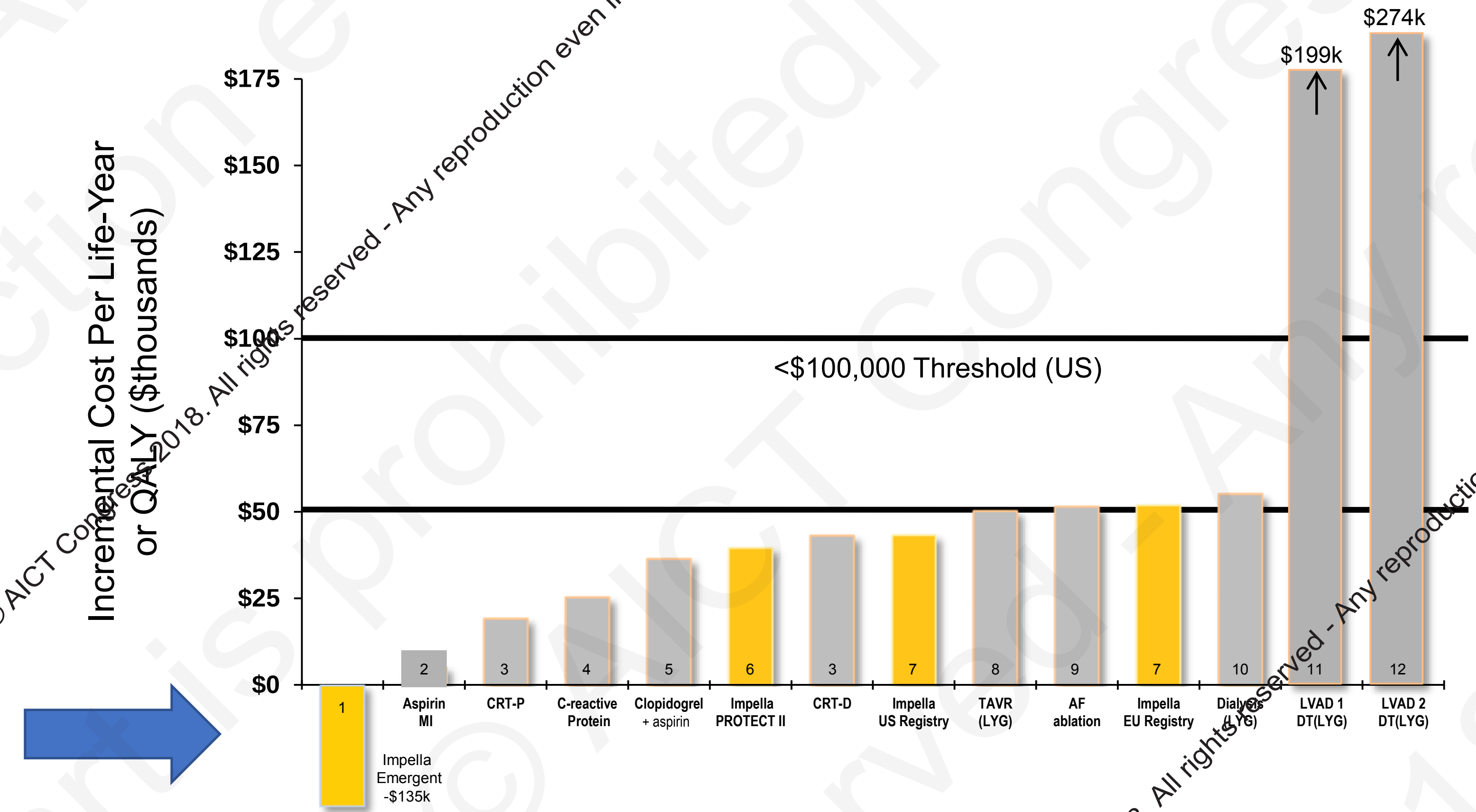
AUSTRALIA

Projected # of patients treated: 3

Impella vs Surgical alternatives (ECMO/extracorporeal VAD)

Peer reviewed, statistically significant data point	Absolute Impact for projected # of Pts	Verified AUSTRALIAN Cost info			Average cost Saving per patient treated A$
Gregory D, et al. Am Health Drug Benefits. 2013;6(2):88-99 — "nificant (p = 0.006). The mean length of stay (LOS) for the index hospitalization was 30.9 days for the surgical cases versus 20.4 for the pVAD cases (p = 0.053). While not quite achieving statistical signifi-"	Length of Stay reduction in days 10.5 4.7 11.9 AVG of 3 9.0	2016-17 QEP per Queensland WAU QEP $4,755.66 = 1 QWAU[Phase 19]. Adjustment for critical care For each hour in an eligible ICU, a QWAU of 0.0436 will apply.			9 days @ A$ 4,976/ day $ 44,784
		Queensland Health, Health funding principles and guidelines, 2016-17			
		Per Day Charge for ICU			
		24*.0436*$4755.66		4976	
Maini B, et al. Catheter Cardiovasc Interv. 2014;83(6):E183-E192.		Per day COST for ICU		$ 4,976	
Cardiovascular Surgery, 2011;142:60-5 (Canada)	**Product Type**	Per unit price	Diff units	Total saving	Cost saving per patient
	Red blood cells	417.41	14	5843.74	
	Clinical fresh frozen plasma (FFP)	268.91	12	3226.92	$ 10,492
	Platelets	284.26	5	1421.3	
	Source: https://www.blood.gov.au/national-product-list		31	$ 10,492	
		Average cost		$ 338	
Lamarche et al, Journal of Thoracic and Cardiovascular Surgery, 2011;142:60-5 (Canada)	Overhead cost saving Impella vs ECLS (hours)	ESTIMATED COST WEIGHTS FOR AR-DRG VERSION 8.0, Round 19 (2014-15)			Cost saving per patient (46.3 hr * $40/hour) $ 1,945
		DRG		A40B	
		Description		ECMO, Minor Complexity	
		ALOS (Days)		14.7	
		Overhead Cost in DRG A40B ($)		$ 14,628	
		Average Overhead cost per hour ($)		$ 42	
Lamarche et al, Journal of Thoracic and Cardiovascular Surgery, 2011;142:60-5 (Canada)	events reduction absolute % (18.8%-3.4%) **15.4%** Thrombotic events Reduction for Proj # of Patients trtd **0.46**	ESTIMATED COST WEIGHTS FOR AR-DRG VERSION 8.0, Round 19 (2014-15)			(Reduction*DRG/Proj Pts)
		DRG		B69B	$ 523
		Description		TIA	
		ALOS (Days)		1.9	
		Average Cost per DRG ($)		$ 3,394	
*Critical care cost of A H1N1 1009 pandemic ANZ, Anae & Crit Care 2011 — "respectively. The mean (SD) additional cost of providing ECMO services was AU$13,646"	**Cost of ECMO**	$		13,646	Savings per patient $ 13,646
Per patient cost saving (for the volume projected)					$ 71,389
Total cost saving, for the volume projected					$ 214,168

Impella® Is Cost-Effective (ICER)?



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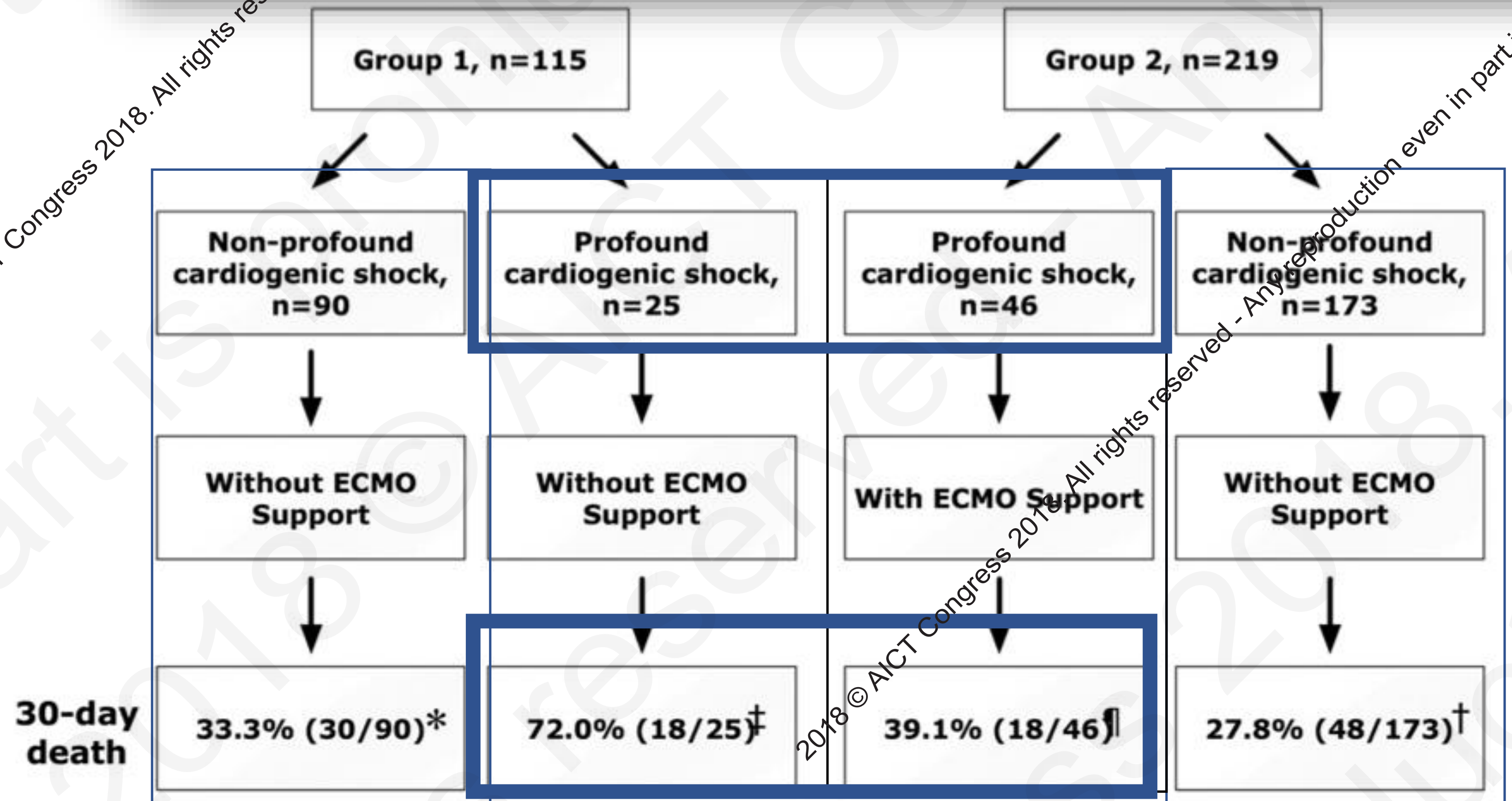
Early extracorporeal membrane oxygenator-assisted primary percutaneous coronary intervention improved 30-day clinical outcomes in patients with ST-segment elevation myocardial infarction complicated with profound cardiogenic shock

Jiunn-Jye Sheu, MD; Tzu-Hsien Tsai, MD; Fan-Yen Lee, MD; Hsiu-Yu Fang, MD; Cheuk-Kwan Sun, MD, PhD; Steve Leu, PhD; Cheng-Hsu Yang, MD; Shyh-Ming Chen, MD; Chi-Ling Hang, MD; Yuan-Kai Hsieh, MD; Chien-Jen Chen, MD; Chiung-Jen Wu, MD; Hon-Kan Yip, MD



Cardiac ECMO Evidence: Case Series

Outcomes and long-term quality-of-life of patients supported by extracorporeal membrane oxygenation for refractory cardiogenic shock*

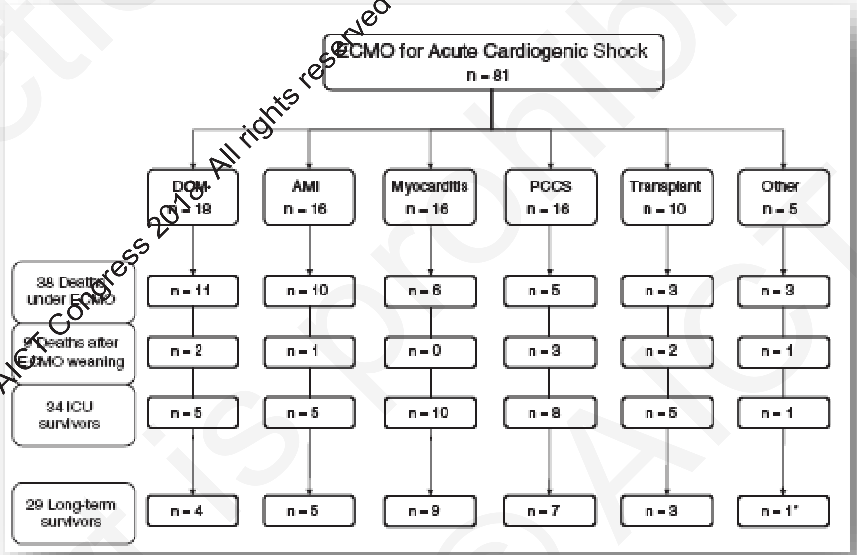
Alain Combes, MD, PhD; Pascal Leprince, MD, PhD; Charles-Edouard Luyt, MD, PhD; Nicolas Bonnet, MD; Jean-Louis Trouillet, MD; Philippe Léger, MD; Alain Pavie, MD; Jean Chastre, MD

Experienced French Centre (1980)

Last 3 years (~ 27 pa) CS refract to inotropes

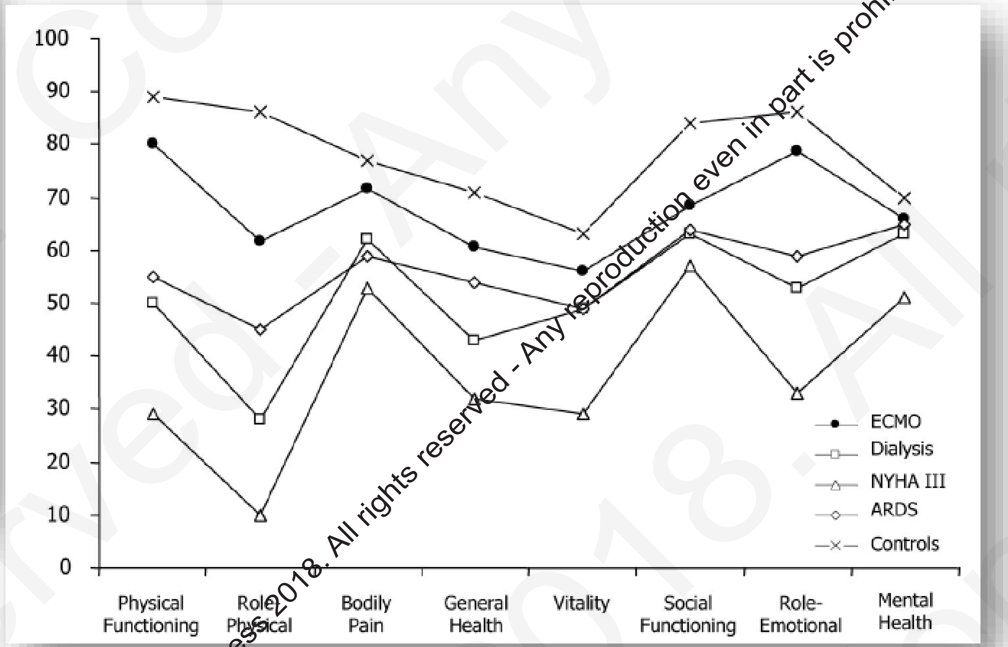
Includes 15 ECMO-CPR (1 survivor)

81



22%	31%	56%	43%	30%	20%
DCM	AMI	Myo	PC/CS	Tx	O

42% survival



Alain Combes Crit care Med 2008 36: (5) 1404-1411

NHCS

- Started ECMO service 2001
- Around 500 cases
- 450 cases V-A ECMO
- 2012-2016 survival to discharge
- VA-ECMO for cardiogenic shock 38%
- VA-ECMO for cardiac arrest (both OHCA and IHCA) 28%

2016 ESC guidelines for Cardiogenic Shock

- Routine use of IABP for management of cardiogenic shock (Class III,B)
- Consider IV dolbutamine to increase CO (Class 2b, C)
- If there is a need to maintain systolic BP. NE preferred over dopamine (Class 2b, B)
- Rapid transfer to tertiary center with round the clock PCI/CCU/MCS support (Class 1, C)

MCS(Excluding IABP): 3 major indications

- HR-PCI/Protected PCI
- **Cardiogenic shock**
- **Cardiac arrest**

- **Impella**, ***TandemHeart*** (Not available),and extracorporeal membrane oxygenation (**ECMO**)

Shock definition for MCS? Classic or severe

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.

Severe shock
Clinical
SBP <90 mm Hg
HR >120 beats/min
Lactate >4
Obtunded
Cool extremities
Hemodynamic
CI <1.5
PCWP >30
LVEDP >30
CPO <0.6 W
Vasoactive medications
2 or more

What is High Risk?

A 80yr old Severe AS with LVEF 25% and tight LM/MVD with CRF in LVF

Clinical

- LVEF <35%
- Electrical instability
- Congestive heart failure

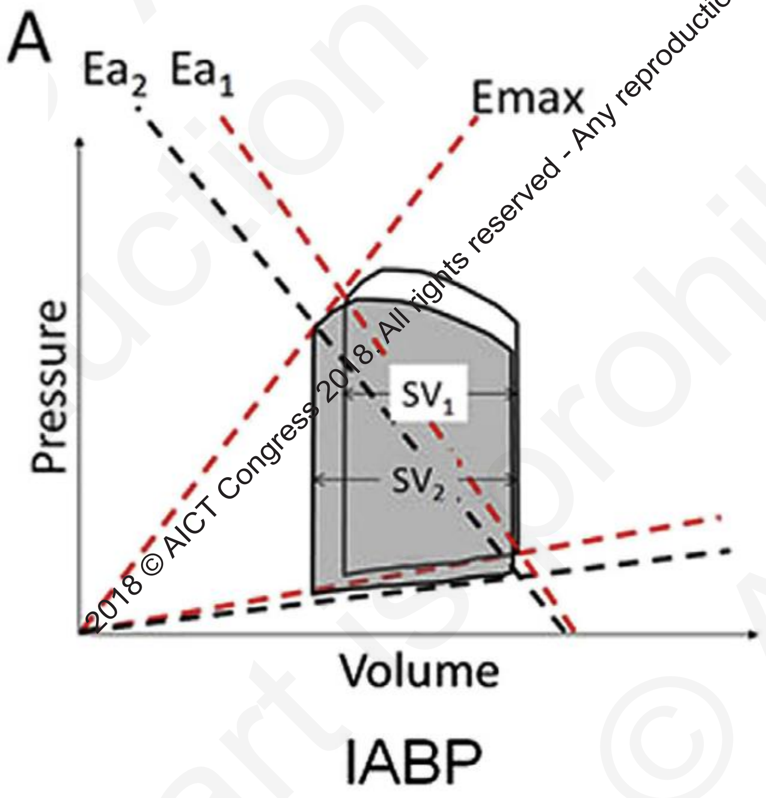
Comorbidities

- 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

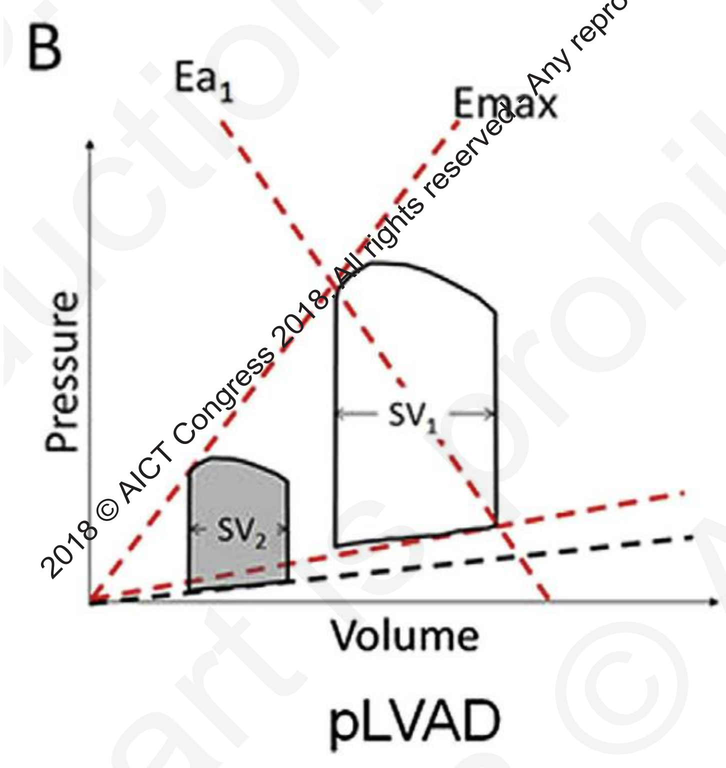
- Last patent vessel
- UPLMN
- 3 vessel disease, SYNTAX score >33
- Target vessel providing collaterals to a territory, which supplies >40% of the myocardium
- Distal left main bifurcation

IABP



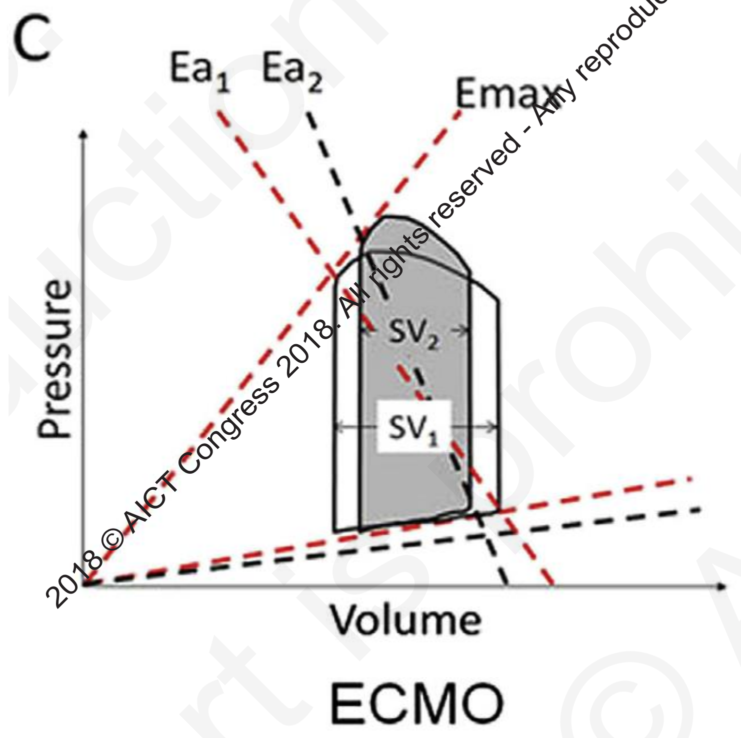
- (IABP) counterpulsation reduces both peak LV systolic and diastolic pressures and increases LV stroke volume. The net effect is a reduced slope of arterial elastance (Ea2)
- **<15% change in SV**

pLVAD: Percutaneous LV assist devices→LV venting devices

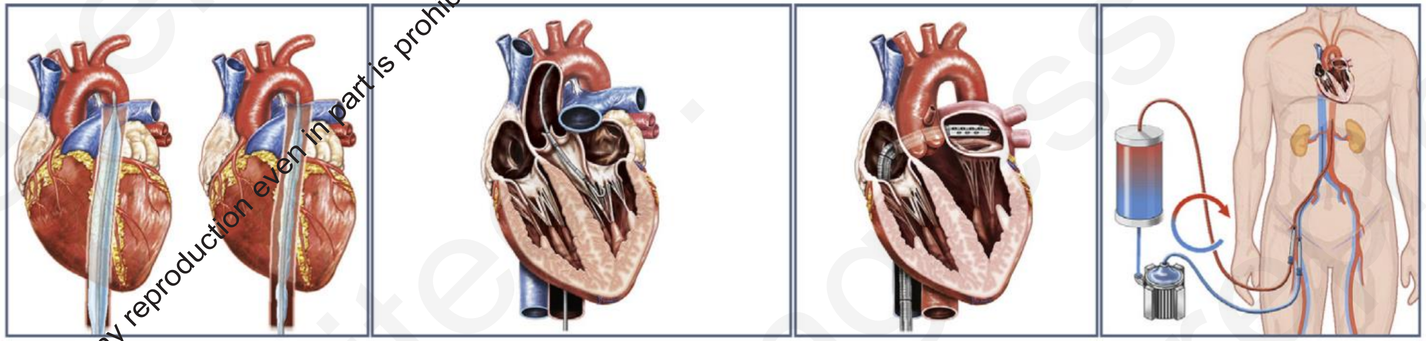


- pLVAD: (Impella and TandemHeart) significantly reduce LV pressures, LV volumes, and LV stroke volume. The net effect is a significant reduction in cardiac workload.
- **If oxygenation is not an issue and not in cardiac arrest**

VA-ECMO



- Veno-arterial extra-corporeal membrane oxygenation (VA-ECMO) without a LV venting strategy increases LV systolic and diastolic pressure, while reducing LV stroke volume. The net effect is an increase in arterial elastance (Ea).
- **Complete perfusion and oxygenation**
- Often with IABP
- Does not off load the LV



	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	↓	↓↓	↔↓	↔

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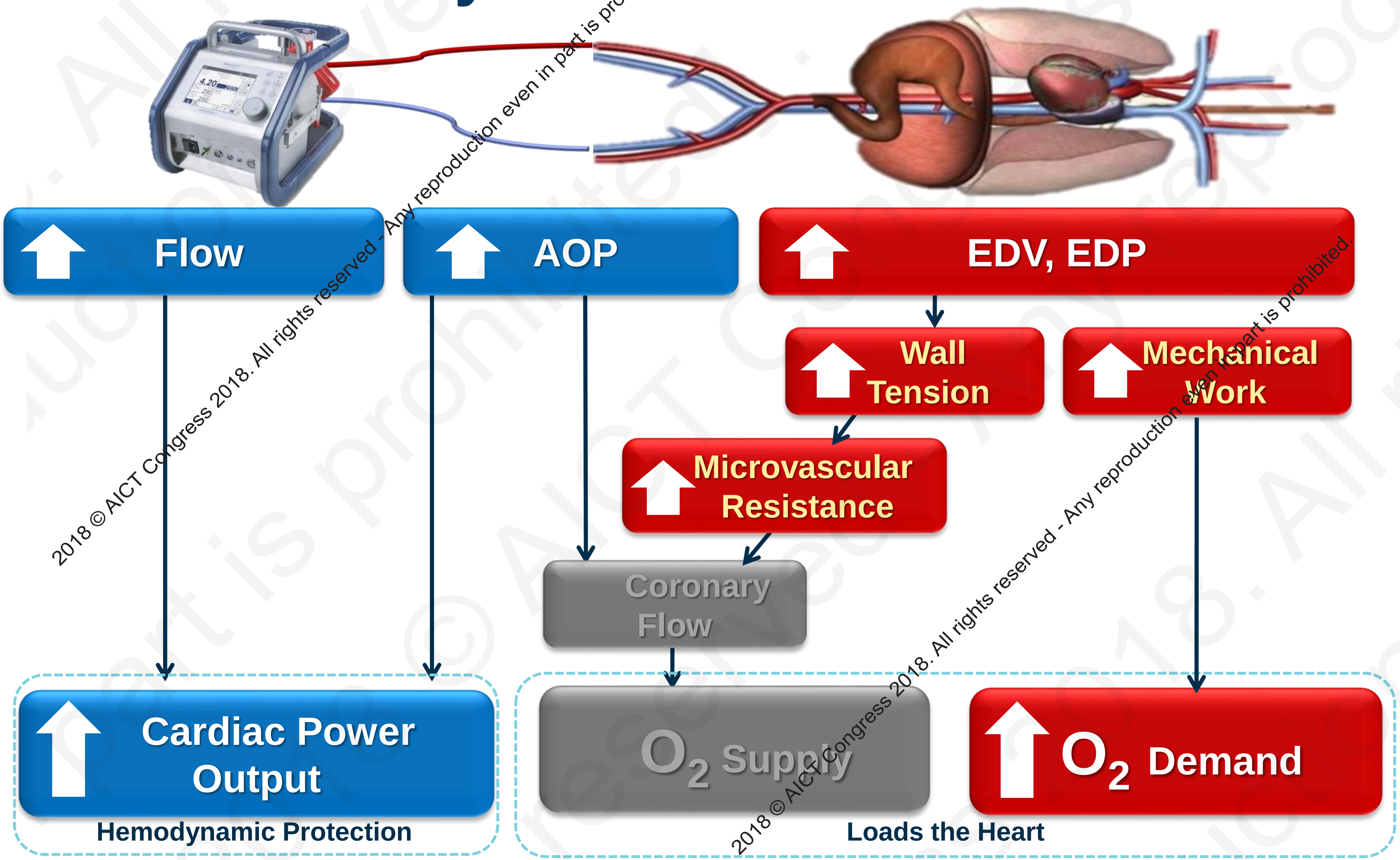
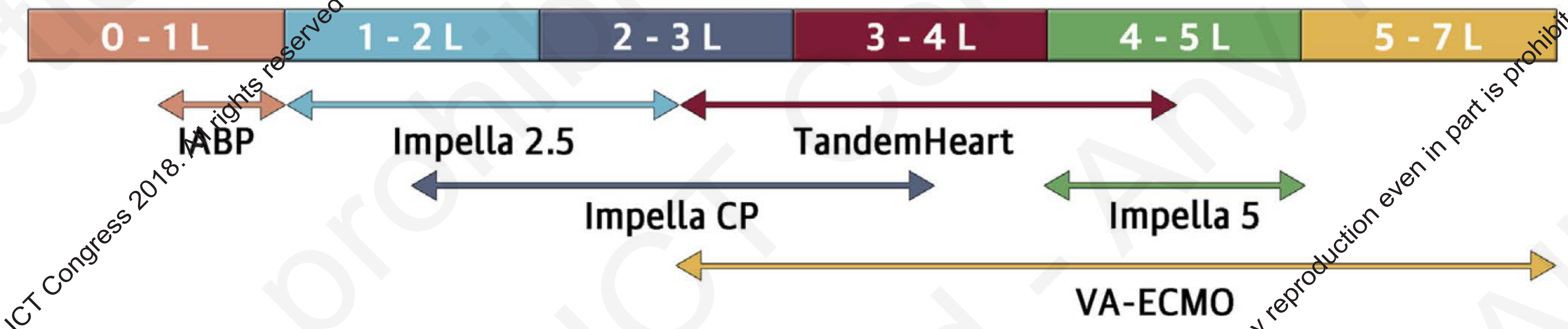
Hemodynamic Effects of ECMO



CO support with MCS

FIGURE 2 **Comparison of MCS Devices and Their Impact on Cardiac Flow**



Four main families of devices exist for percutaneous MCS, which includes IABP, Impella (Abiomed Inc., Danvers, Massachusetts), TandemHeart (CardiacAssist, Inc., Pittsburgh, Pennsylvania), and VA-ECMO. Each device provides a different level of cardiac flow and device selection should be tailored to the level of support needed. Abbreviations as in Figure 1.

Contraindications and Complications

	IABP	Impella	TandemHeart	VA-ECMO
Contraindications	Moderate to severe AR Severe PAD Aortic disease	LV thrombus Mechanical aortic valve Aortic stenosis with AVA <0.6 Moderate to severe AR Severe PAD Contraindication to anticoagulation	Severe PAD HIT DIC Contraindications to anticoagulation LA thrombus VSD Moderate to severe AR	Contraindications to anticoagulation Moderate to severe AR Severe PAD
Complications	Stroke Limb ischemia Vascular trauma Balloon rupture Thrombocytopenia Acute kidney injury Bowel ischemia Infection	Device migration Device thrombosis Limb ischemia Vascular trauma Hemolysis Infection Stroke	Air embolism Thromboembolism Device Dislodgement Cardiac tamponade Limb ischemia Vascular trauma Hemolysis Infection Stroke	Bleeding Vascular trauma Limb ischemia Compartment syndrome Acute kidney injury Hemolysis Thromboembolism Air embolism Infection Neurological Injury
Bleeding/hemolysis	+	++	++	++
Vascular complications	+	++	+++	++++

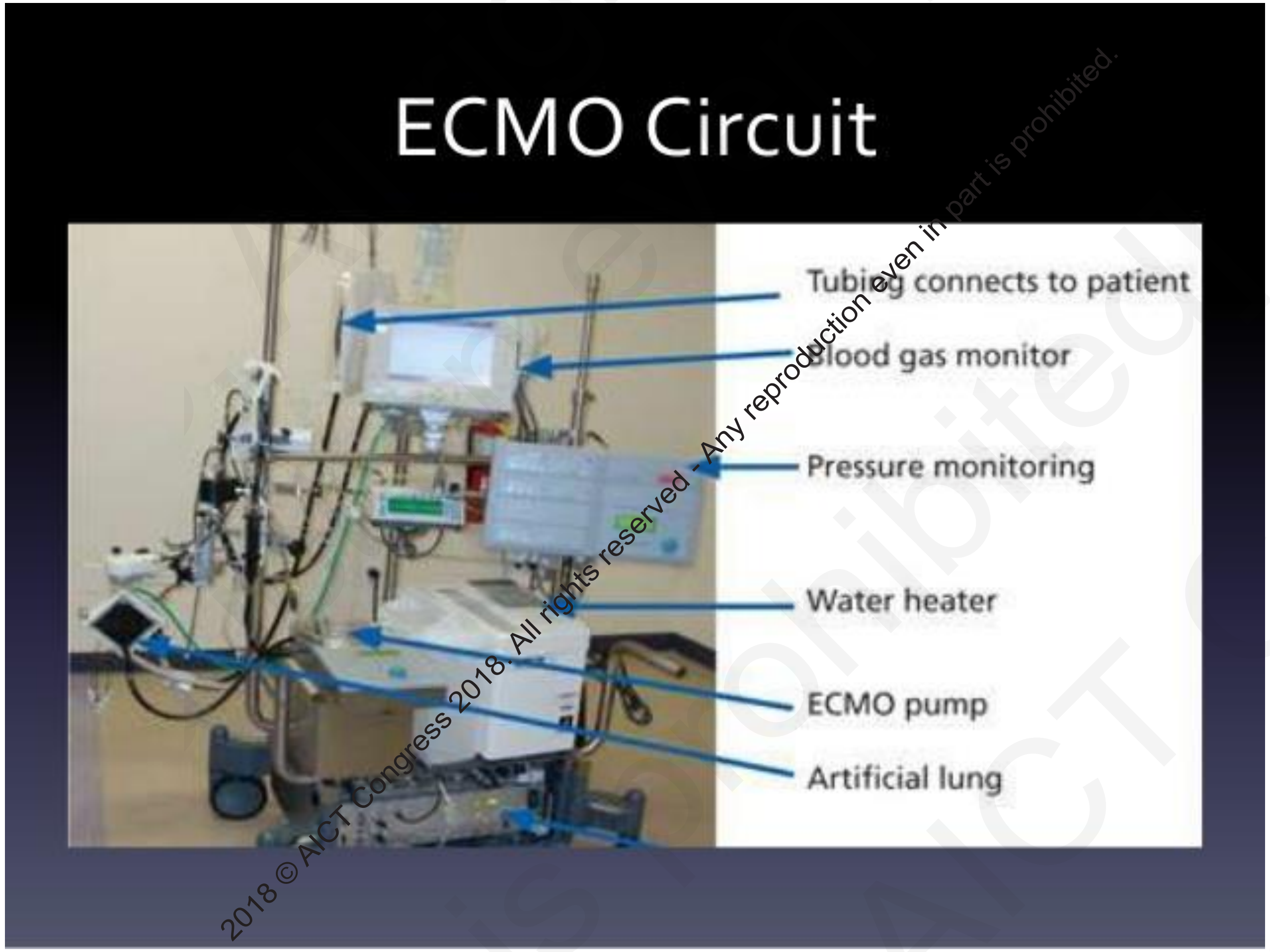
PAD and AR

Stroke/ICH

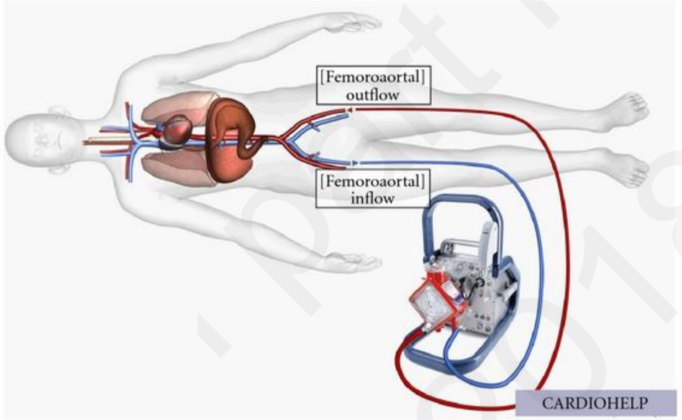
Contraindications and complications must be reviewed prior to MCS device use in all patients and can vary according to device.

AR = aortic regurgitation; AVA = aortic valve area; DIC = disseminated intravascular coagulation; HIT = heparin-induced thrombocytopenia; LA = left atrium; LV = left ventricle; PAD = peripheral arterial disease; VSD = ventricular septal defect; other abbreviations as in Table 4.

Large bore devices: Severe AR, PAD and bleeding tendencies



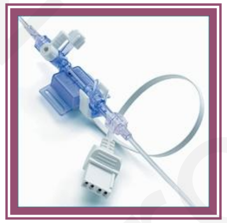
Resource intensive



ECMO Round

- ✓**Cardiologists**
- ✓**Cardiac surgeon**
- ✓**Intensivist**
- ✓**RTs**
- ✓**ECMO bedside nurse**
- ✓**Perfusionist**
- ✓**ECMO specialist**

Checklist

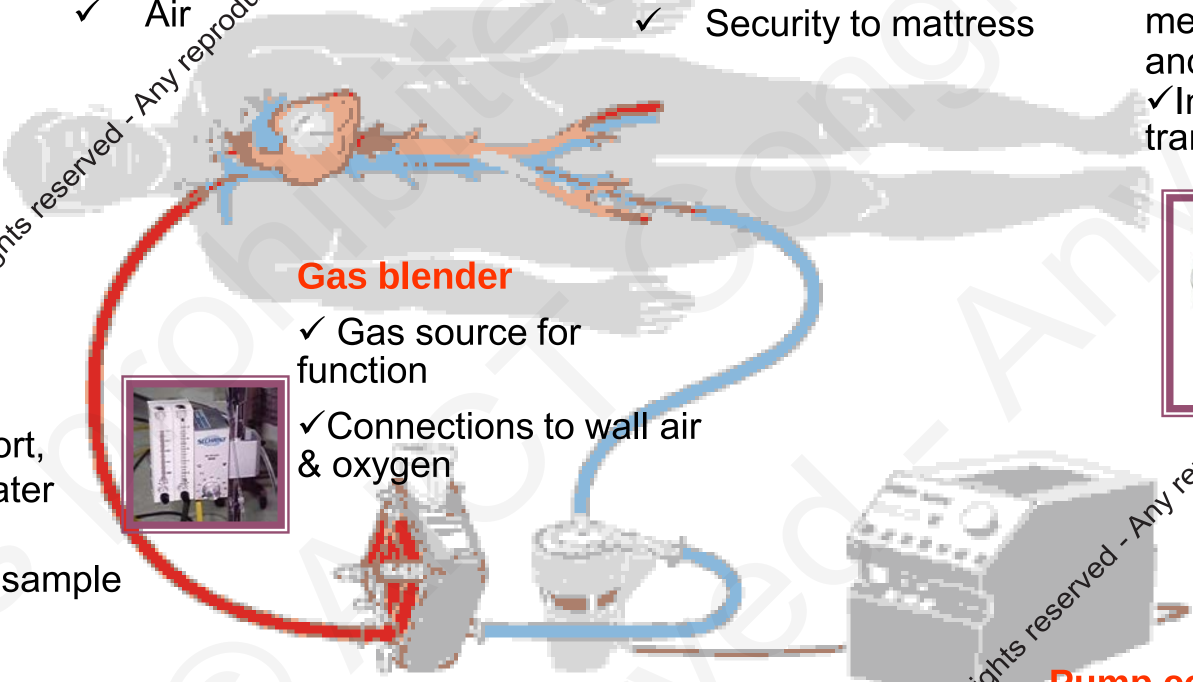


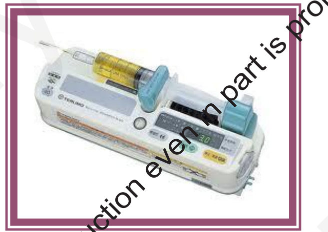
Arterial limb connectors
- ✓ Clots
- ✓ Air
- ✓ Leaks
- ✓ Fibrin strands

Arterial cannula
- ✓ Position
- ✓ Bleeding
- ✓ Clots/fibrin
- ✓ Air

Venous cannula
- ✓ Position
- ✓ Bleeding
- ✓ Clots/fibrin
- ✓ Kinking
- ✓ Air
- ✓ Security to mattress

Pressure Monitor
- ✓ Verify pre/post membrane pressures and TMP
- ✓ Inspect pressure transducer and cables





Oxygenator
- ✓ Air
- ✓ Clots/fibrin
- ✓ Secure gas line connection
- ✓ Open gas vent port,
- ✓ Secure water heater connections
- ✓ Secure pressure sample port connections
- ✓ Integrity

Gas blender
- ✓ Gas source for function
- ✓ Connections to wall air & oxygen

Medications
- ✓ Verify medication, drug dosages & volume infusions

Heater cooler
- ✓ Function
- ✓ Alarms
- ✓ Temp (patient,water)
- ✓ Power supply
- ✓ Integrity

Pump head
- ✓ Air
- ✓ Function
- ✓ Sound
- ✓ Clots/fibrin
- ✓ Integrity

Pump console
- ✓ Proper function
- ✓ Flow rate
- ✓ RPMs
- ✓ Alarms
- ✓ Power source
- ✓ Battery supply

National Heart Centre Singapore
SingHealth

Interhospital ECMO Transport

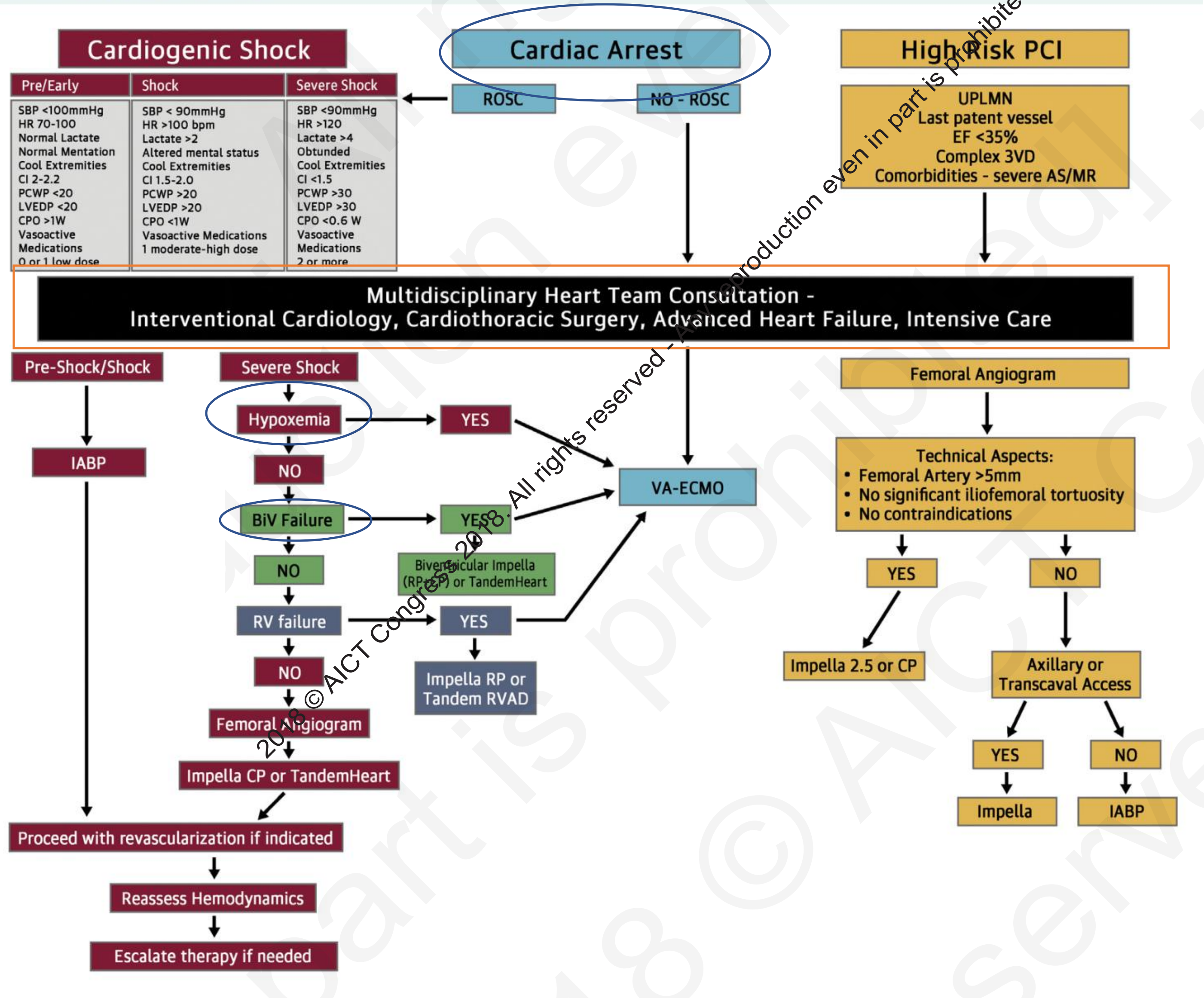
ECMO Transport Cart

Loading of ECMO Components on taxi

ECMO Initiated at Referring Hospital

Patient on ECMO in ambulance

CENTRAL ILLUSTRATION **Algorithm for Percutaneous MCS Device Selection in Patients with Cardiogenic Shock, Cardiac Arrest, and HR-PCI**



Atkinson, T.M. et al. J Am Coll Cardiol Intv. 2016;9(9):871-83.

3VD = 3 vessel coronary artery disease; AS = aortic stenosis; BiV = biventricular; CI = cardiac index; CPO = cardiac power; EF = ejection fraction; HR = heart rate; HR-PCI = high-risk percutaneous coronary intervention; IABP = intra-aortic balloon pump; LVEDP = left ventricular end-diastolic pressure; MCS = mechanical circulatory support; MR = mitral regurgitation; PCI = percutaneous coronary intervention; PCWP = pulmonary capillary wedge pressure; ROSC = return of spontaneous circulation; RVAD = right ventricular assist device; SBP = systolic blood pressure; UPLMN = unprotected left main artery; VA-ECMO = venoarterial extracorporeal

- Early shock→IABP
- Early step up
- Severe shock without hypoxemia or RV failure→Impella
- Cardiac arrest/biven failure→ECMO
- Full revascularization when supported

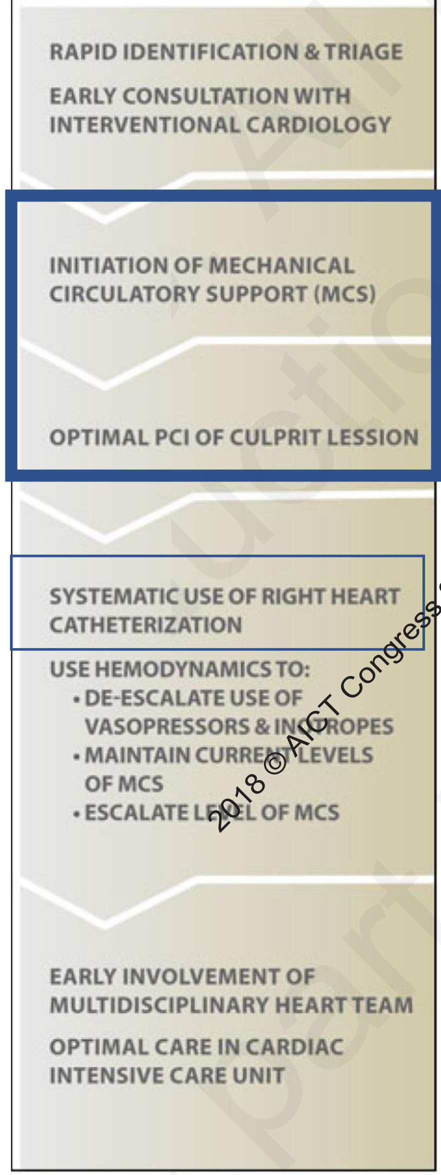
Develop your own center's workflow in consult with surgeons, HF team, ICU, inventionalists

Tips to Build a Cardiogenic Shock Team

Cardiogenic shock mortality has not declined in 30 years, but progress is being made with a shock team approach.

Cardiology Today's Intervention, May/June 2018
William W. O'Neill, MD, FACC, MSCAI; Mir Basir, DO; Ruth Fisher, MBA, CMPE

Figure. Rapid Identification and treatment of AMICS to Improve Survival



Source: William W. O'Neill, MD, FACC, MSCAI; Mir Basir, DO; and Ruth Fisher, MBA, CMPE

Table. Components of an AMICS Team

▶ Yearly use of mechanical circulatory support > 10 cases per year
▶ Systematic use of mechanical circulatory support pre-PCI
▶ Systematic use of Swan-Ganz catheters to obtain invasive hemodynamics
▶ Escalation and de-escalation of mechanical circulatory support and medical therapy based on invasive hemodynamics
▶ Specific location for ICU care with identified "team captain"
▶ Close collaboration with LVAD and transplant team
▶ Collaboration with EMS and ED physicians
▶ Institutional champion

Source: William W. O'Neill, MD, FACC, MSCAI; Mir Basir, DO; and Ruth Fisher, MBA, CMPE.

Table. Performance Goals for a Shock Team

▶ Door-to-support < 90 minutes
▶ Pre-PCI mechanical circulatory support > 90% of care
▶ Use of right heart data in all patients
▶ Provide TIMI III flow to the culprit artery > 90% of patients
▶ Post-PCI cardiac power output > 0.6 watts
▶ Survival to hospital discharge > 80%

Source: William W. O'Neill, MD, FACC, MSCAI; Mir Basir, DO; and Ruth Fisher, M

Asian Context

HR-PCI/pre and mild shock → **Consider IABP→MCS Early**

Severe Cardiogenic Shock → **VA ECMO /Impella**

Cardiac Arrest/E-CPR → **VA-ECMO**

My take for profound cardiogenic shock

- Accept that mortality is going to be high
- Differentiate between pre-shock, shock and severe shock. Early escalation from pharmacology to devices for severe shock
- Careful patient selection with timely initiation of Impella/ECMO. Consider early transfer to a tertiary facility for MCS
- Every device has a learning curve: team work and volume
- ECMO is useful for extreme shock or cardiac arrest but need multi-disclipinary team and is highly resource intensive/expensive
- Cost effectiveness analysis seem to favor Impella over ECMO but the upfront cost for a temporary support device is high
- Impella useful for a center that does not have on site CTS support but not for cardiac arrest/severe hypoxemia and RV failure

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