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DIFFERENCES AMONG VARIES PERCUTANEOUS MECHANICAL CIRCULATORY SUPPORT DEVICES

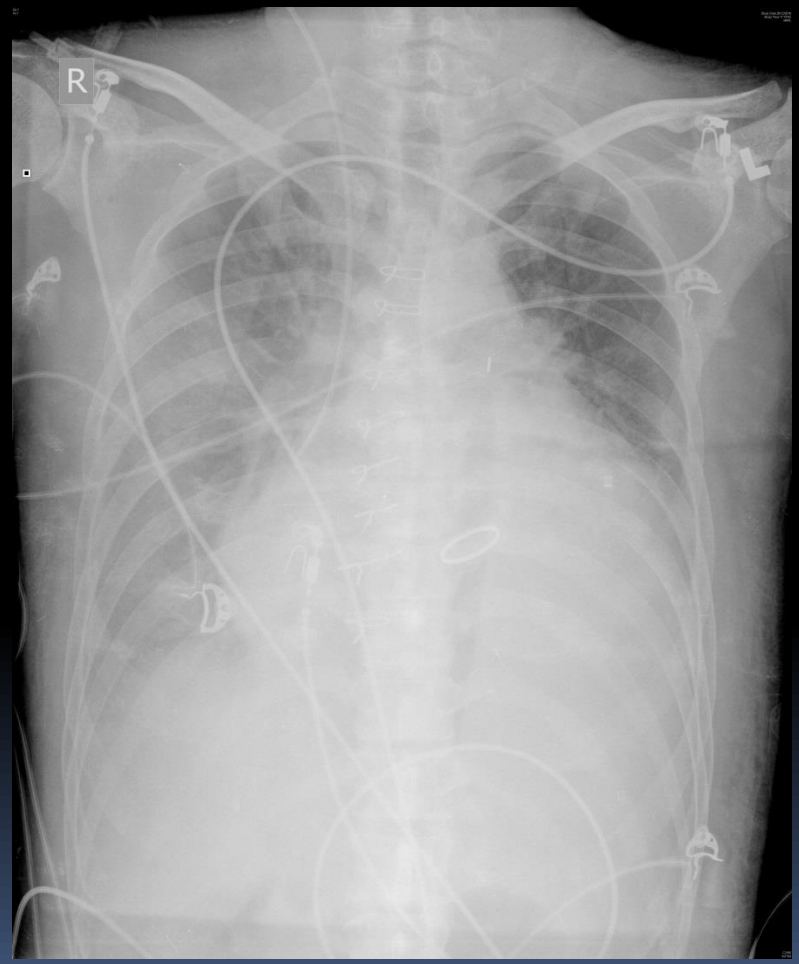
Outline

- Differences in clinical scenario for percutaneous MCS
- Differences of percutaneous MCS devices

Differences in clinical scenario

- Difference in severity
  - Heart Failure ? Cardiogenic shock?
  - Hypotension = shock?
  - Any BP cutoff for shock?
  - Use SBP/MBP for shock?
  - SBP100-140 is safe?
  - How do you know patient is in shock??
- Difference in support needed
  - Myocardial infarction
  - Acute right heart failure
  - Fulminant myocarditis with biventricular failure
  - Refractory cardiac arrest

Heart Failure ? Cardiogenic shock?



Hemodynamic Profiles in Heart Failure

		Congestion at Rest: No	Congestion at Rest: Yes
Low Perfusion at Rest	No	**Warm & Dry** **5%**	**Warm & Wet** **70%**
	Yes	**Cold & Dry** **5%**	**Cold & Wet** **20%**

Signs of congestion

- Orthopnea/PND
- JVD
- Ascites
- Edema
- Rales (not always)

Evidence of low perfusion

- Narrow pulse pressure
- Altered mental status
- Low serum sodium
- Cool extremities
- Hypotension with ACE inhibitor
- Renal insufficiency

Stevenson LW. *Eur J Heart Fail.* 1999;1:251

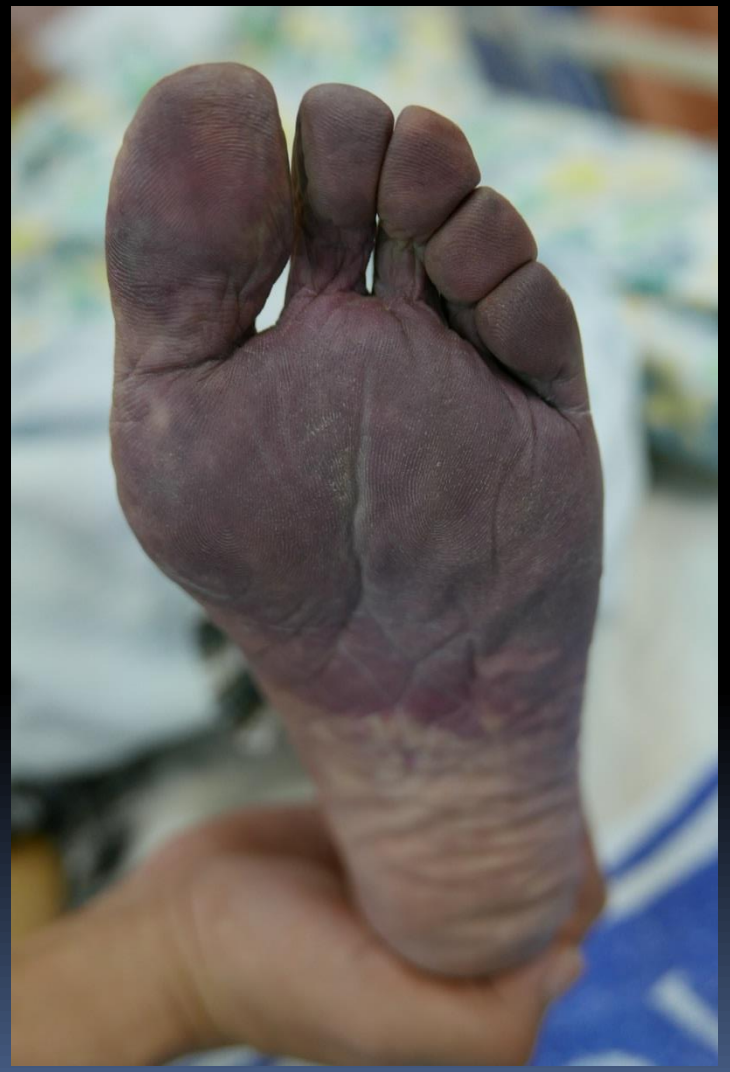
Hypotension = shock?

Today
- BP 80/55 Pulse 76
- BW 64.1 Ht 168cm
- ECG SR rate 73 QRS 95ms
- Came alone
- Walk unaided
- Currently taking lasix 40mg BD from private since 19/6/2017
- No worsening HF symptom
- No chest pain/dizziness
- Good drug compliance
- Clinically compensated

- Zestril 10mg BD
- Carvedilol 3.125mg Daily
- Hytrin 1mg daily
- Aldactone 50mg daily
- Lasix 40mg BD

SBP100-140 is safe?

- Adrenaline 8mg/100ml D5 20ml/hour
- Noradrenaline 8mg/100ml D5 20ml/hour
- BP 110/90 Pulse 110
- Happy??



SCAI Statement for Cardiogenic Shock 2019

SCAI Clinical Expert Consensus Statement on the Classification of Cardiogenic Shock. *Catheter Cardiovasc Interv* 2019;May 19

SCAI Statement for Cardiogenic Shock 2019

Stage	Description	Physical exam/bedside findings	Biochemical markers	Hemodynamics
A At risk	A patient who is not currently experiencing signs or symptoms of CS, but is at risk for its development. These patients may include those with large acute myocardial infarction or prior infarction acute and/or acute on chronic heart failure symptoms.	Normal JVP Lung sounds clear Warm and well perfused • Strong distal pulses • Normal mentation	Normal labs • Normal renal function • Normal lactic acid	Normotensive (SBP≥100 or normal for pt.) If hemodynamics done • cardiac index ≥2.5 • CVP <10 • PA sat ≥65%
B Beginning CS	A patient who has clinical evidence of relative hypotension or tachycardia without hypoperfusion.	Elevated JVP Rales in lung fields Warm and well perfused • Strong distal pulses • Normal mentation	Normal lactate Minimal renal function impairment Elevated BNP	SBP <90 ***OR*** MAP <60 ***OR*** >30 mmHg drop from baseline Pulse ≥100 If hemodynamics done • cardiac index ≥2.2 • PA sat ≥65%
C Classic CS	A patient that manifests with hypoperfusion that requires intervention (inotrope, pressor or mechanical support, including ECMO) beyond volume resuscitation to restore perfusion. These patients typically present with relative hypotension.	***May Include Any of***: Looks unwell Panicked Ashen, mottled, dusky Volume overload Extensive rales Killip class 3 or 4 BiPap or mechanical ventilation Cold, clammy Acute alteration in mental status Urine output <30 mL/h	***May Include Any of***: Lactate ≥2 Creatinine doubling ***OR*** >50% drop in GFR Increased LFTs Elevated BNP	***May Include Any of***: SBP <90 ***OR*** MAP <60 ***OR*** >30 mmHg drop from baseline ***AND*** drugs/device used to maintain BP above these targets Hemodynamics • cardiac index <2.2 • PCWP >15 • RAP/PCWP ≥0.8 • PAPI <1.85 • cardiac power output ≤0.6
D Deteriorating/ doom	A patient that is similar to category C but are getting worse. They have failure to respond to initial interventions.	***Any of stage C***	***Any of Stage C AND***: Deteriorating	***Any of Stage C AND***: Requiring multiple pressors ***OR*** addition of mechanical circulatory support devices to maintain perfusion
E Extremis	A patient that is experiencing cardiac arrest with ongoing CPR and/or ECMO, being supported by multiple interventions.	Near Pulselessness Cardiac collapse Mechanical ventilation Defibrillator used	**"Trying to die"** CPR (A-modifier) pH ≤7.2 Lactate ≥5	No SBP without resuscitation PEA or refractory VT/VF Hypotension despite maximal support

SCAI Clinical Expert Consensus Statement on the Classification of Cardiogenic Shock. *Catheter Cardiovasc Interv* 2019;May 19

Indications for Percutaneous MCS

TABLE 1 Suggested Indications for Percutaneous MCS

Indication	Comments
Complications of AMI	Ischemic mitral regurgitation is particularly well-suited to these devices as the hemodynamic disturbance is usually acute and substantial. Acutely depressed LV function from large AMI during and after primary PCI is an increasing indication for temporary MCS use. Cardiogenic shock from RV infarction can be treated with percutaneous right ventricular support.
Severe heart failure in the setting of nonischemic cardiomyopathy	Examples include severe exacerbations of chronic systolic heart failure as well as acutely reversible cardiomyopathies such as fulminant myocarditis, stress cardiomyopathy, or peripartum cardiomyopathy. In patients presenting in INTERMACS profiles 1 or 2, MCS can be used as a bridge to destination VAD placement or as a bridge to recovery if the ejection fraction rapidly improves (108).
Acute cardiac allograft failure	Primary allograft failure (adult or pediatric) may be due to acute cellular or antibody-mediated rejection, prolonged ischemic time, or inadequate organ preservation.
Post-transplant RV failure	Acute RV failure has several potential causes, including recipient pulmonary hypertension, intraoperative injury/ischemia, and excess volume/blood product resuscitation. MCS support provides time for the donor right ventricle to recover function, often with the assistance of inotropic and pulmonary vasodilator therapy (109).
Patients slow to wean from cardiopulmonary bypass following heart surgery	Although selected patients may be transitioned to a percutaneous system for additional weaning, this is rarely done.
Refractory arrhythmias	Patients can be treated with a percutaneous system that is somewhat independent of the cardiac rhythm. For recurrent, refractory, ventricular arrhythmias, ECMO may be required for biventricular failure.

IMPORTANT AIMS

Augment LV and/or RV cardiac output

Reduce filling pressure of LV (LAP/PCWP) and/or RV (RAP)

+/- additional respiratory support

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

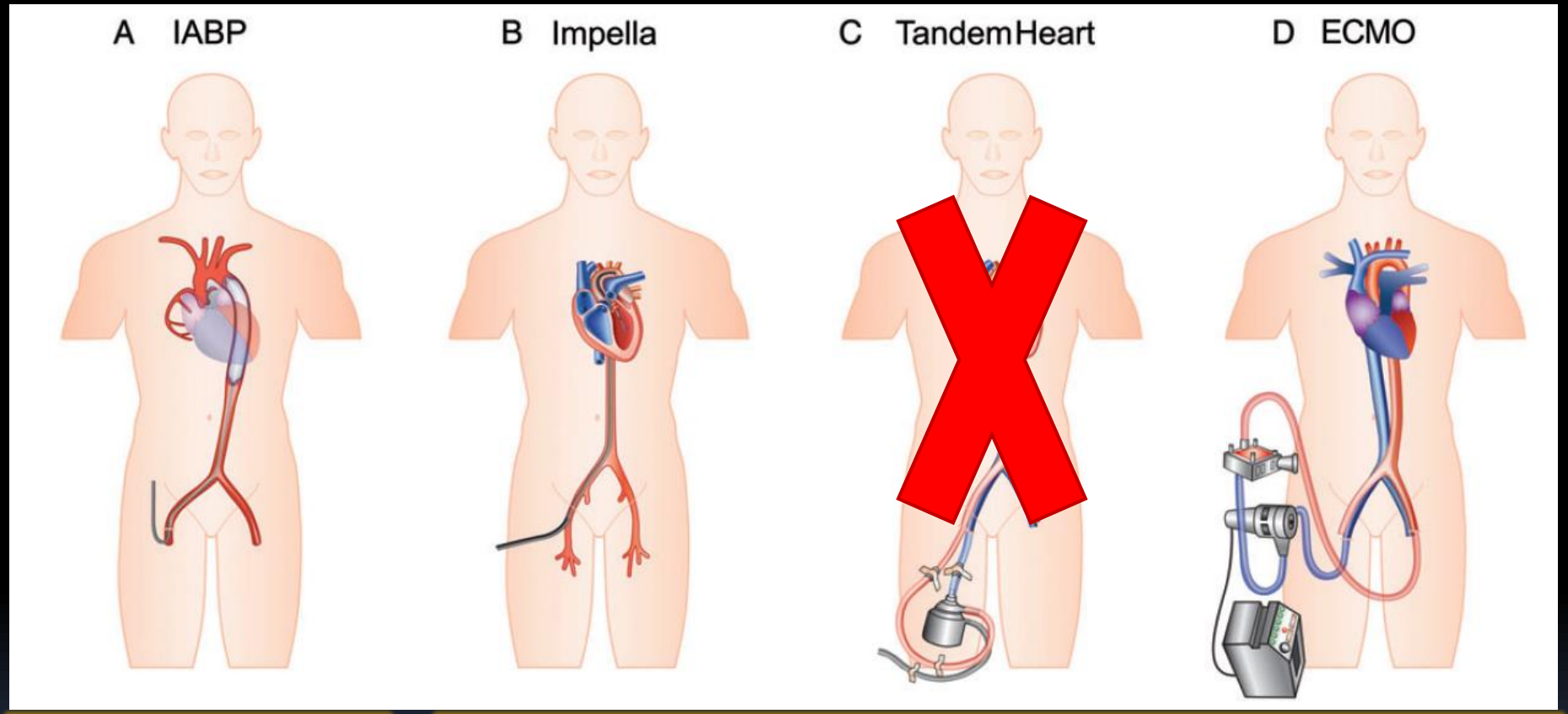
Question 1

- What is the ESC heart failure guideline recommendation for routine use of IABP in acute myocardial infarction complicated with cardiogenic shock?
  A. Class I
  B. Class IIa
  C. Class IIb
  D. Class III

Question 2

- Veno-arterial Extracorporeal Membrane Oxygenation (VA-ECMO) can provide the following support:
  A. circulatory support alone
  B. respiratory support alone
  C. both circulatory and respiratory support
  D. none of the above

Differences in Percutaneous MCS Left Ventricular Support



Pulsatile

Non-pulsatile

Axial Flow

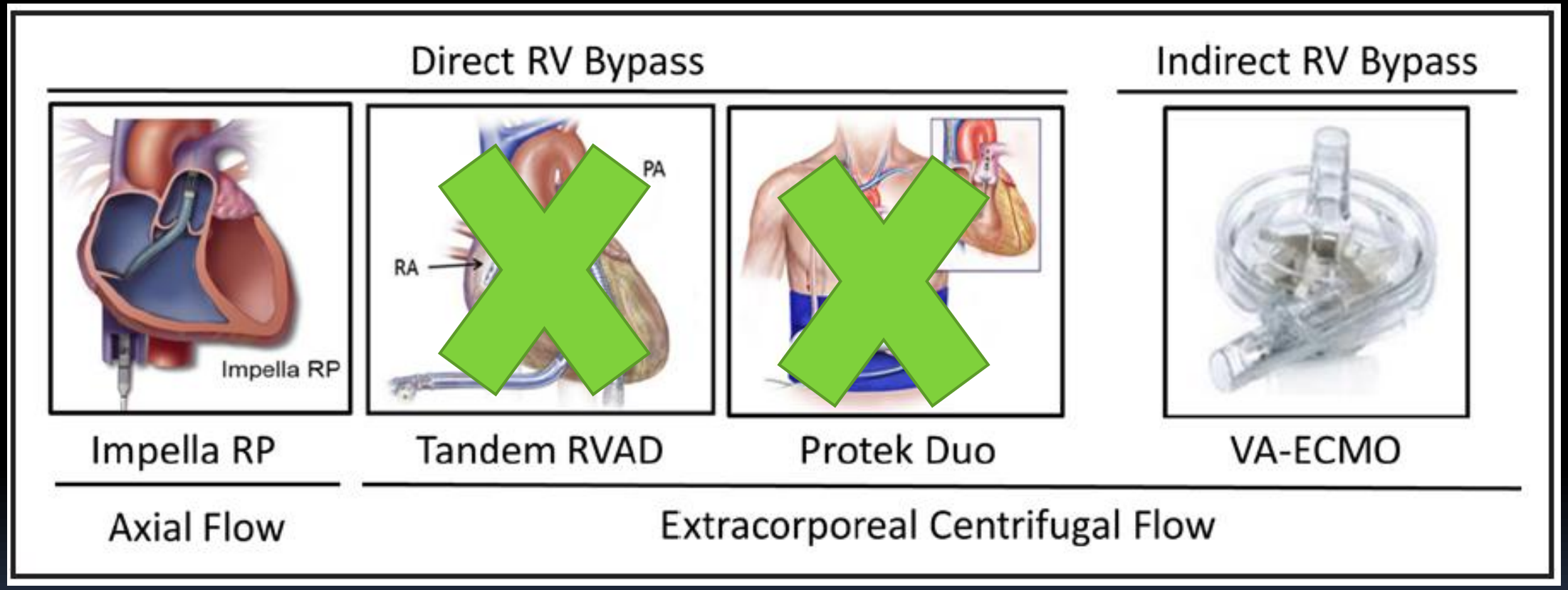
Centrifugal Flow

No Respiratory Support

Resp. Support

European Heart Journal (2014) 35, 156–167

Differences in Percutaneous MCS Right Ventricular Support



Axial Flow	Centrifugal Flow	
No Respiratory Support		Respiratory Support

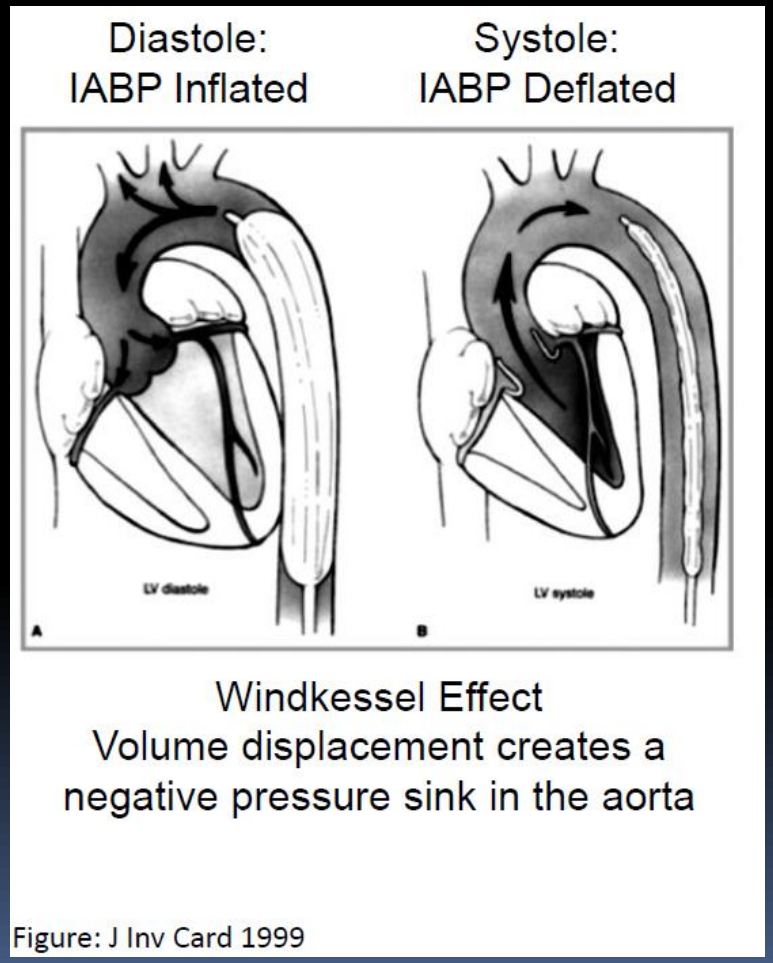
Circulation. 2017;136:314–326.

Question 3

- Which of the following percutaneous mechanical circulatory support devices provide the LEAST cardiac output augmentation/support?
  A. IABP
  B. VA-ECMO
  C. Impella CP
  D. Impella 5.0

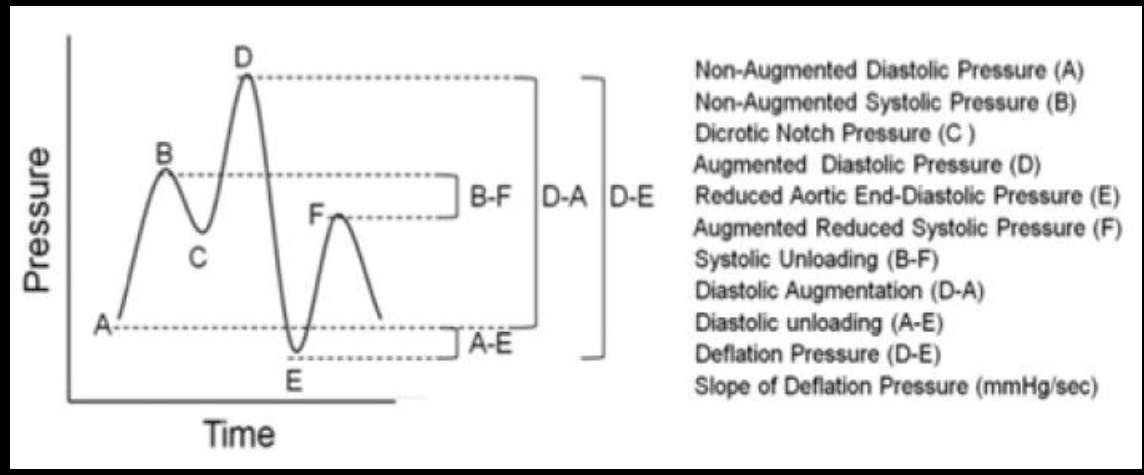
IABP

LV output – Mild increase
LAP/PCWP – Decrease
Right side support – passive
Respiratory support – passive



Windkessel Effect
Volume displacement creates a negative pressure sink in the aorta

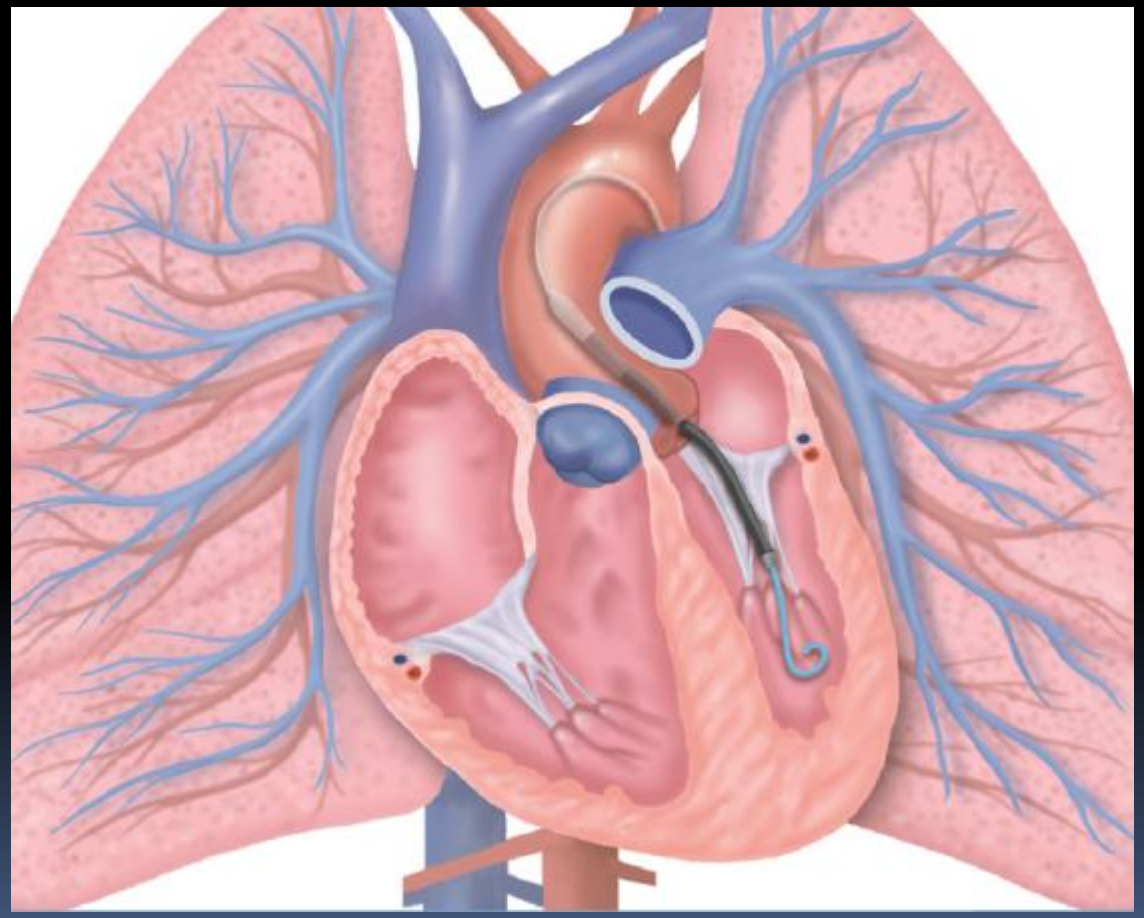
Figure: J Inv Card 1999



- Augment Aortic Diastolic Pressure
- Reduce LV afterload
- Improve coronary perfusion (increase myocardial supply demand ratio)

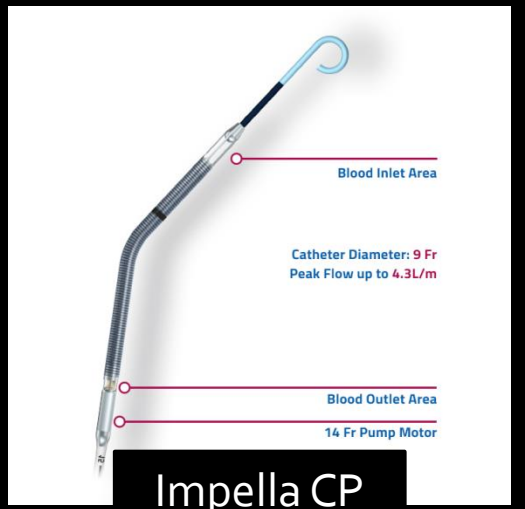
Impella

LV output – Increase
LAP/PCWP – Decrease
Right side support – Need additional Impella RP/ECMO
Respiratory support – passive

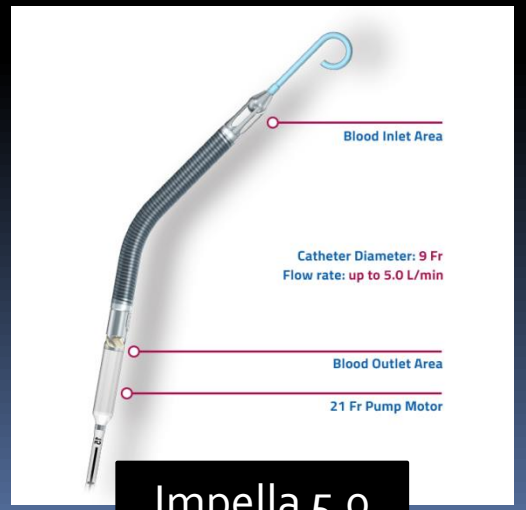


Burkhoff, D. et al. J Am Coll Cardiol. 2015; 66(23):2663–74

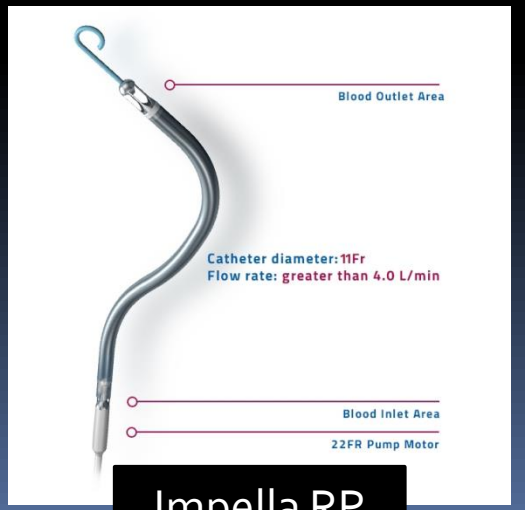
Impella 2.5



Impella CP

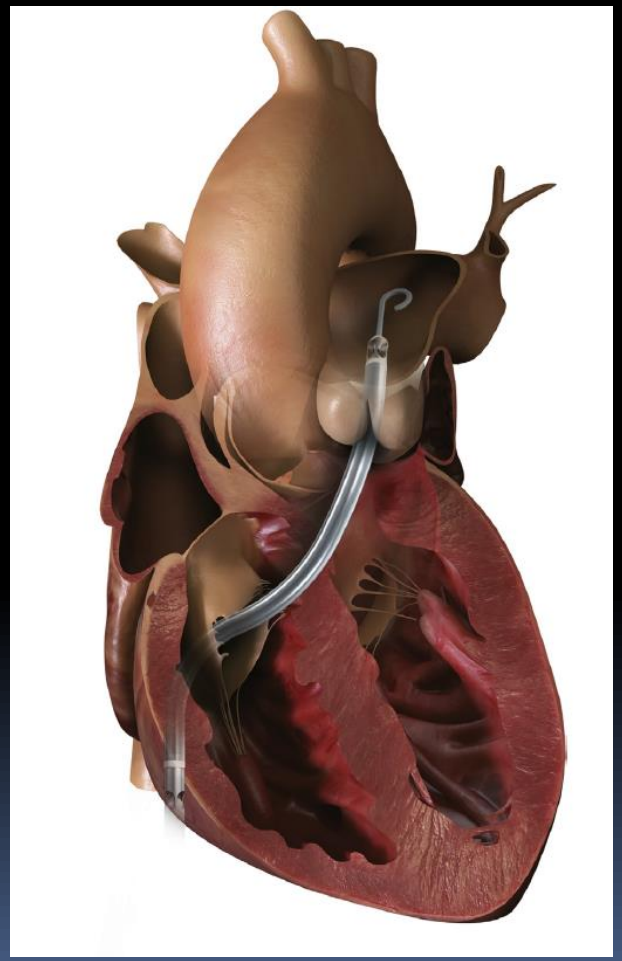


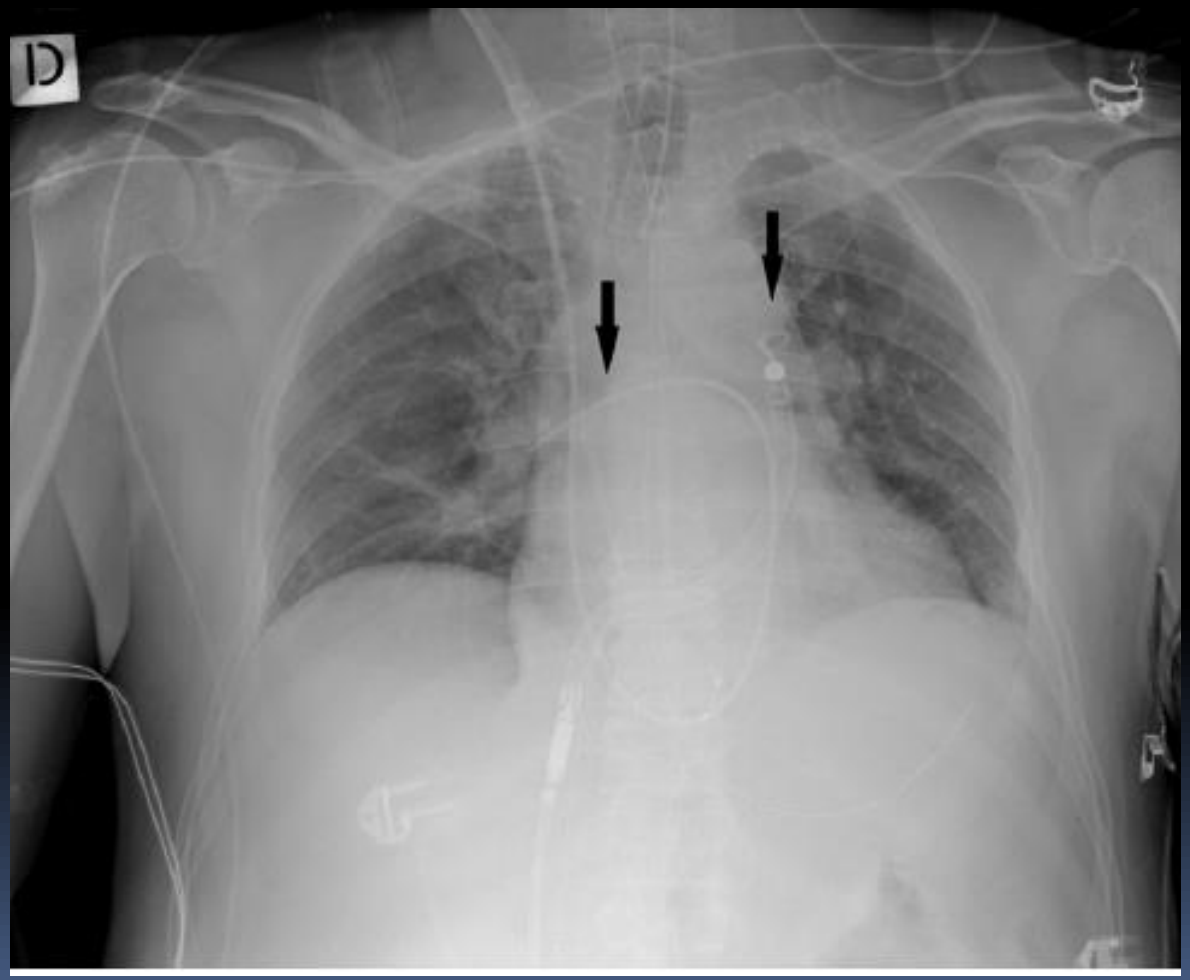
Impella 5.0



Impella RP

Impella RP

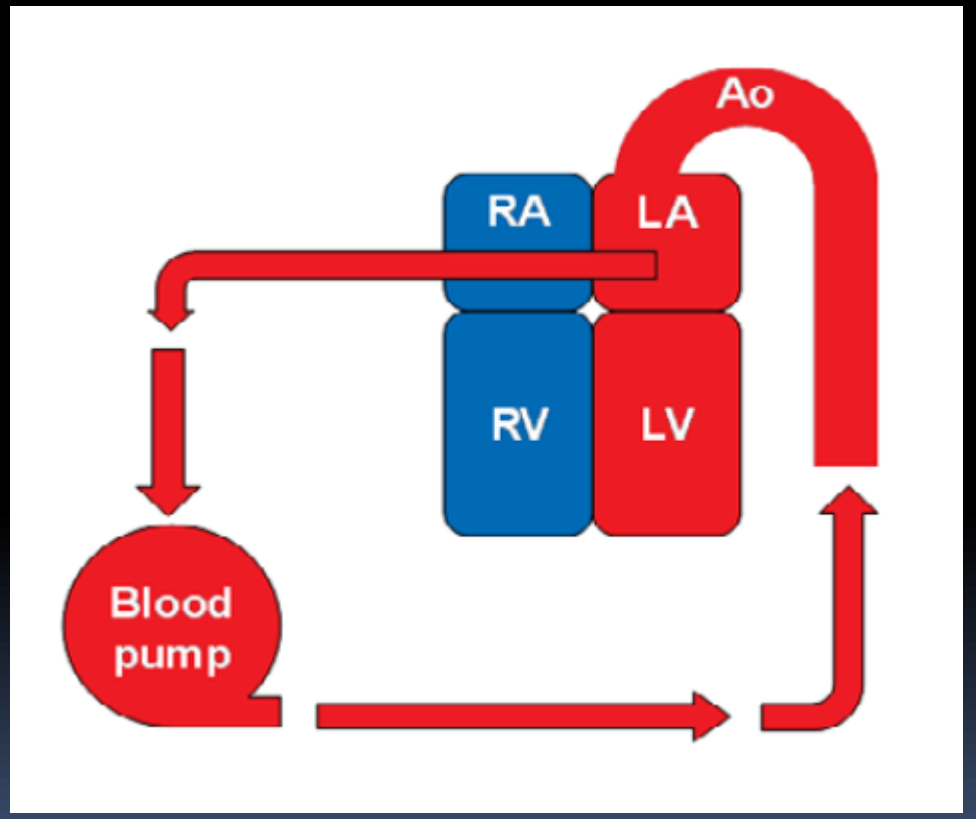




Journal of Cardiothoracic and Vascular Anesthesia 32(2018) 2339–2343

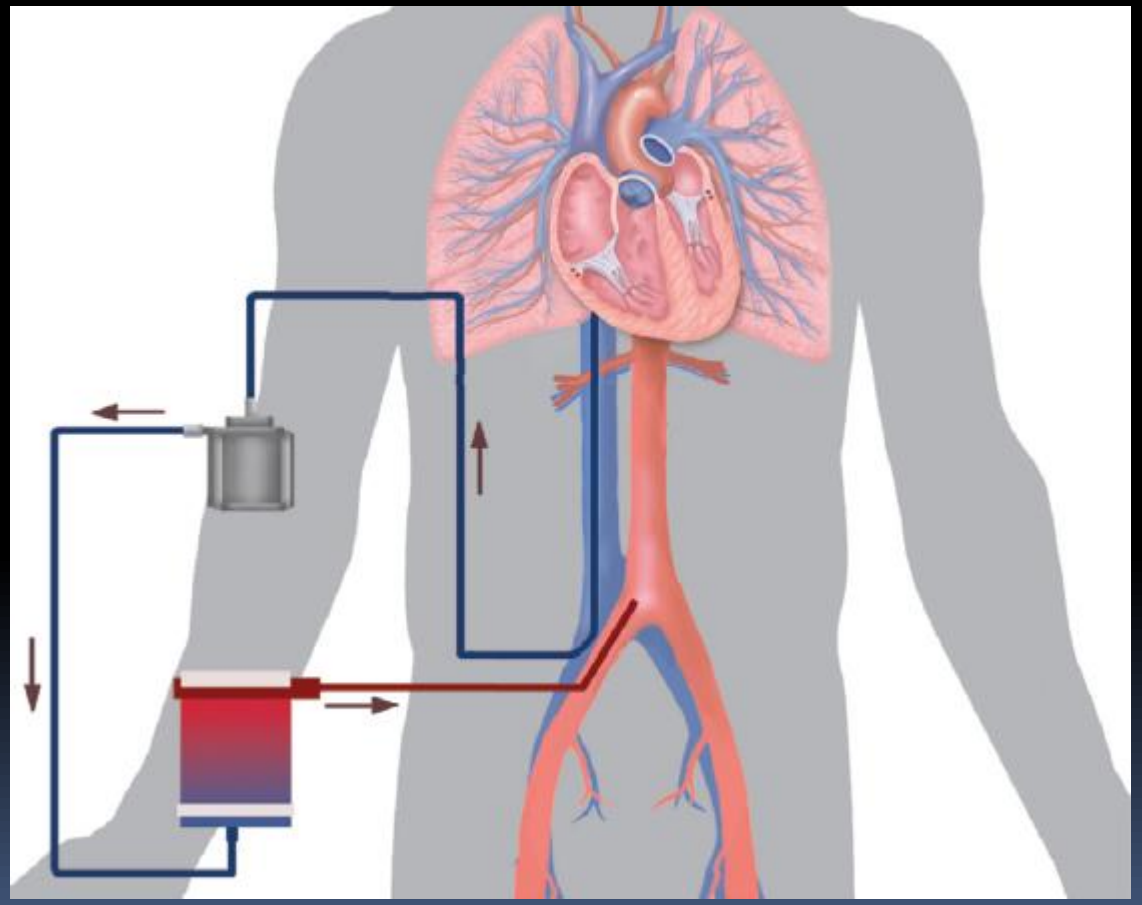
Tandem Heart

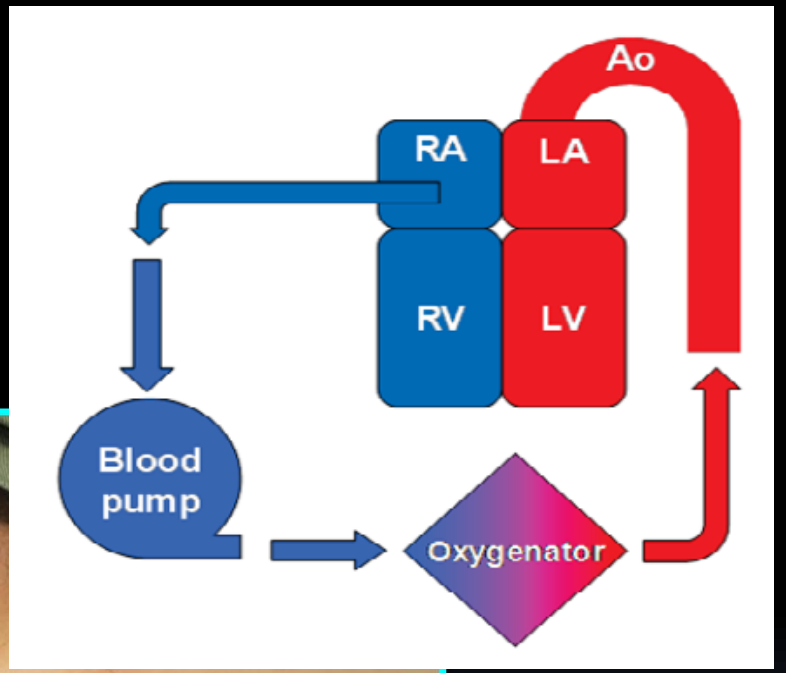
LV output – Reduced; total systemic flow increase
LAP/PCWP – Decrease
Right side support – passive
Respiratory support – passive

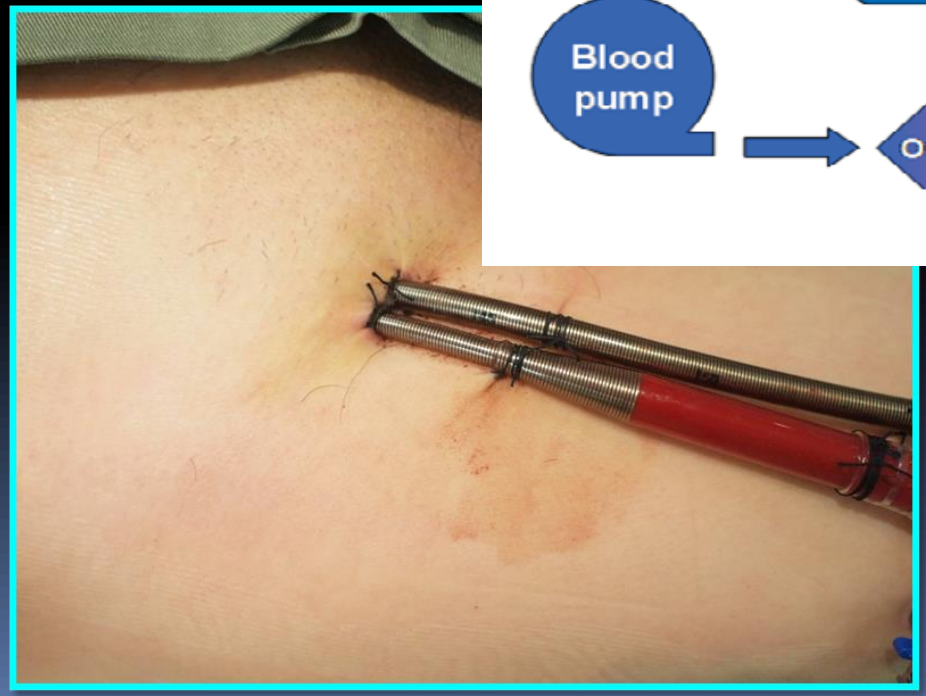


VA-ECMO

LV output – Reduced, total systemic flow increased
LAP/PCWP – Increase/unchange
Right side support – Yes
Respiratory support – Yes



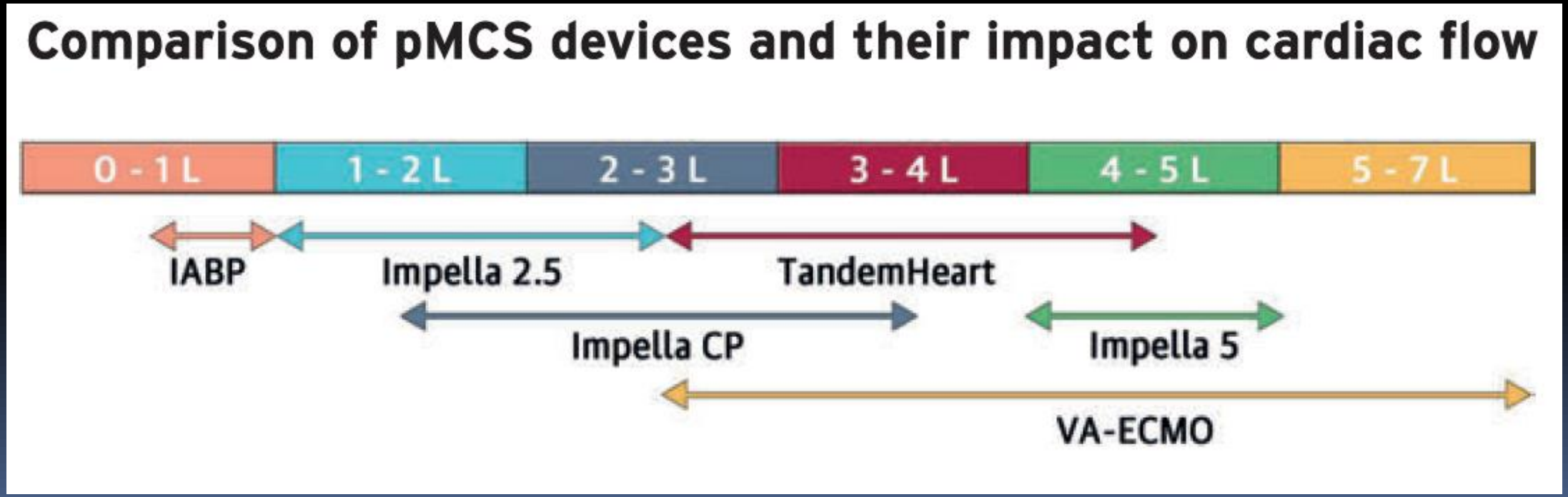




Burkhoff, D. et al. J Am Coll Cardiol. 2015; 66(23):2663–74

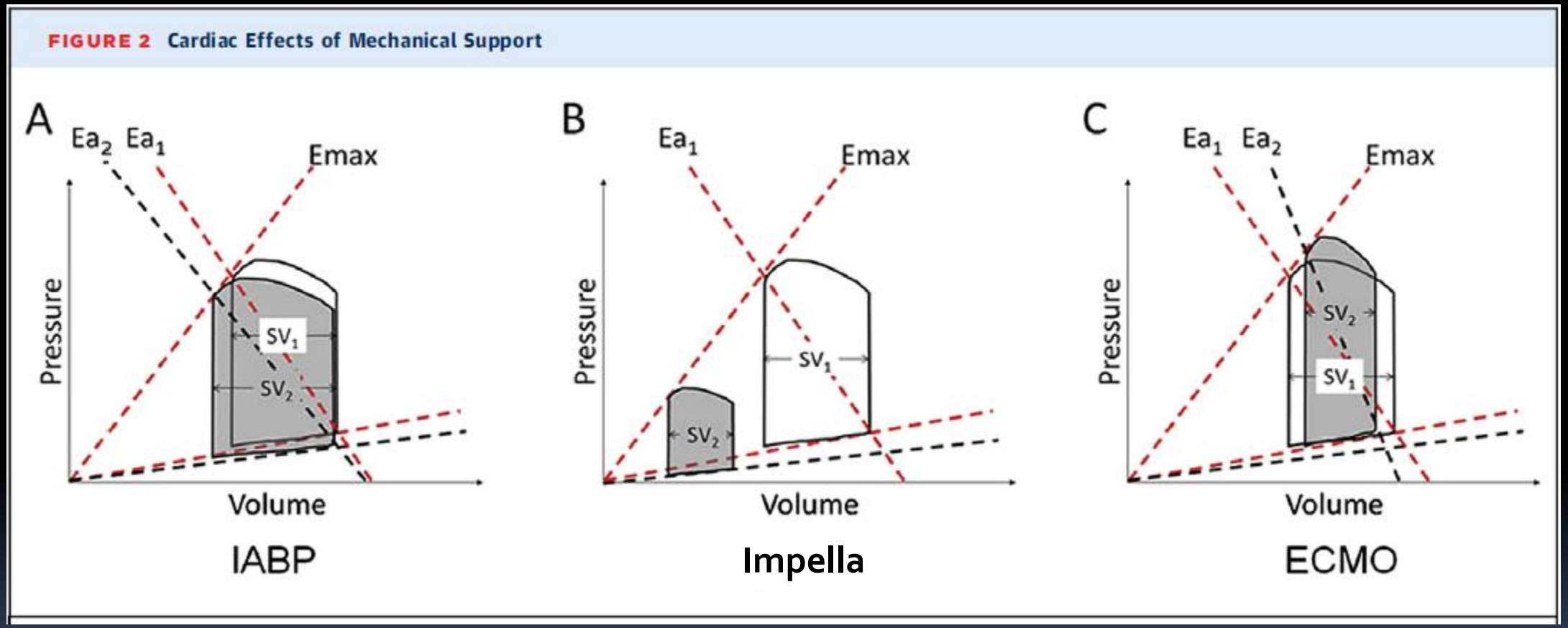
Differences in percutaneous MCS

	IABP	VA-ECMO	Impella
Cost	~ 5-8K	~ 40-70K	~ 260K
Experience in Hong Kong	20 years	5-10 years	~3-5 years
Service availability	Every center	Most centers	Some centers



JACC Cardiovasc Interv. 2016 May 9;9(9):871-83

Differences in percutaneous MCS



J Am Coll Cardiol. 2015 May 19;65(19):2140-1.

Differences in percutaneous MCS

Table 3 Proposed haemodynamic effects of the mechanical circulatory support devices

	IABP	ECMO	TandemHeart	Impella
Afterload	Reduced	Increased	Increased	Neutral
LV stroke volume	Slight increase	Reduced	Reduced	Reduced
Coronary perfusion	Slight increase	Unknown	Unknown	Unknown
LV pre-load	Slightly reduced	Reduced	Reduced	Slightly reduced
PCW pressure	Slightly reduced	Reduced	Reduced	Slightly reduced
Peripheral tissue perfusion	No significant increase	Improved	Improved	Improved

European Heart Journal (2014) 35, 156–167

Differences in percutaneous MCS

Table 2 Comparison of devices

	IABP	ECMO	TandemHeart	Impella 2.5	Impella 5.0
Pump mechanism	Pneumatic	Centrifugal	Centrifugal	Axial flow	Axial flow
Cannula size	7.9 Fr	18–21 Fr inflow;15–22 Fr outflow	21 Fr inflow; 15–17 Fr outflow	13 Fr	22 Fr
Insertion technique	Descending aorta via the femoral artery	Inflow cannula into the right atrium via the femoral vein, outflow cannula into the descending aorta via the femoral artery	21 Fr inflow cannula into left atrium via femoral vein and transseptal puncture and 15–17 Fr outflow cannula into the femoral artery	12 Fr catheter placed retrogradely across the aortic valve via the femoral artery	21 Fr catheter placed retrogradely across the aortic valve via a surgical cutdown of the femoral artery
Haemodynamic support	0.5 – 1.0 L min^{-1}	>4.5 L min^{-1}	4 L min^{-1}	2.5 L min^{-1}	5.0 L min^{-1}
Implantation time	+	++	+++	++	++++
Risk of limb ischaemia	+	+++	+++	++	++
Anticoagulation	+	+++	+++	+	+
Haemolysis	+	++	++	++	++
Post-implantation management complexity	+	+++	++++	++	++
Optional active cooling in post-cardiopulmonary resuscitation patients	No	Yes	(Yes)	No	No

European Heart Journal (2014) 35, 156–167

Contraindications and Complications

TABLE 5 MCS Device 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	+	++	+++	++++

JACC Cardiovasc Interv. 2016 May 9;9(9):871-83

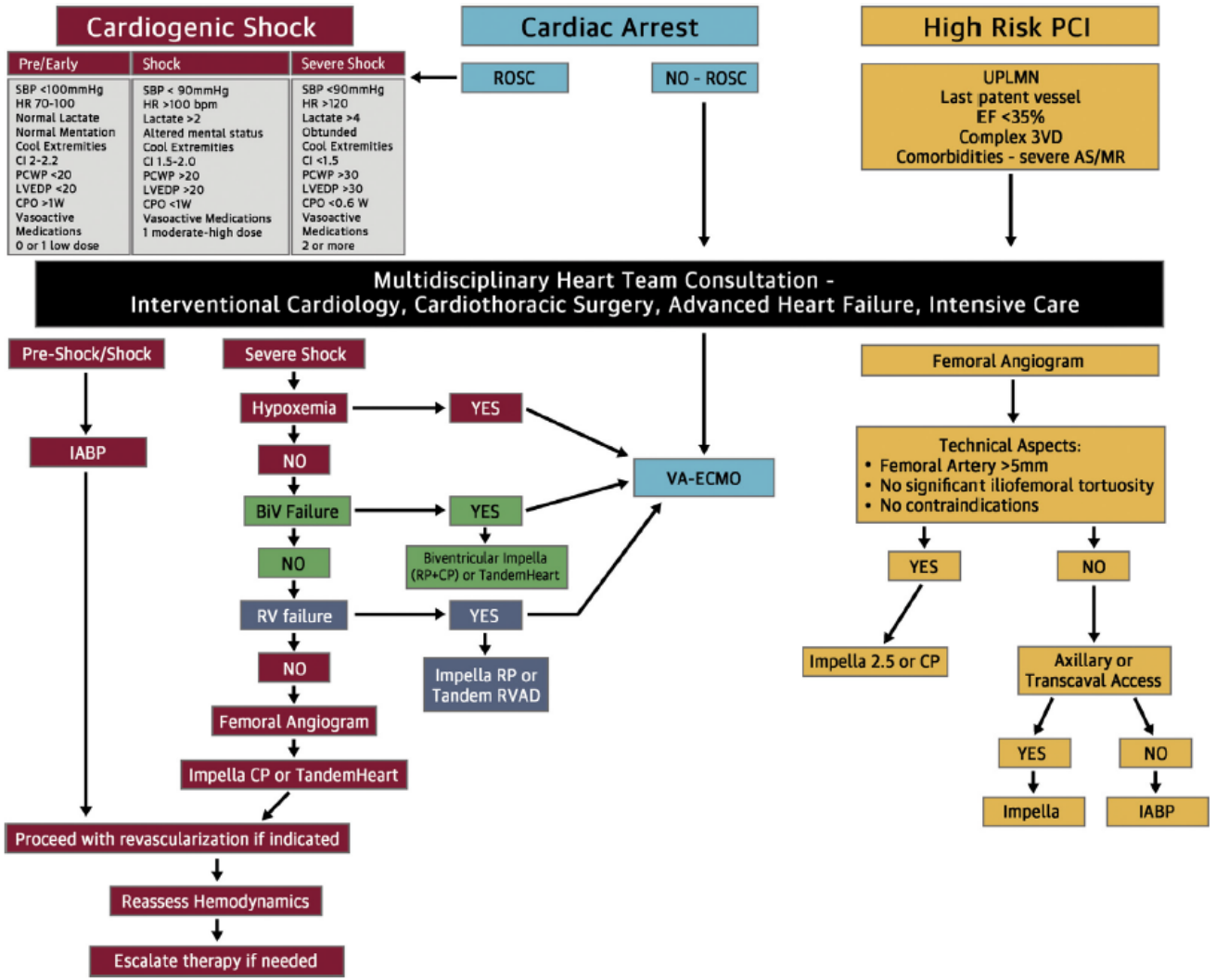
Question 4

- Which of the following is NOT an appropriate consideration for use of percutaneous mechanical circulatory support device?
  A. Massive pulmonary embolism with unstable hemodynamics despite maximal medical treatment
  B. Severe viral pneumonia with ARDS and stable hemodynamics
  C. Acute myocardial infarction complicated with cardiogenic shock
  D. High risk percutaneous coronary intervention

Clinical Application

Case sharing

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.

JACC Cardiovasc Interv. 2016 May 9;9(9):871-83

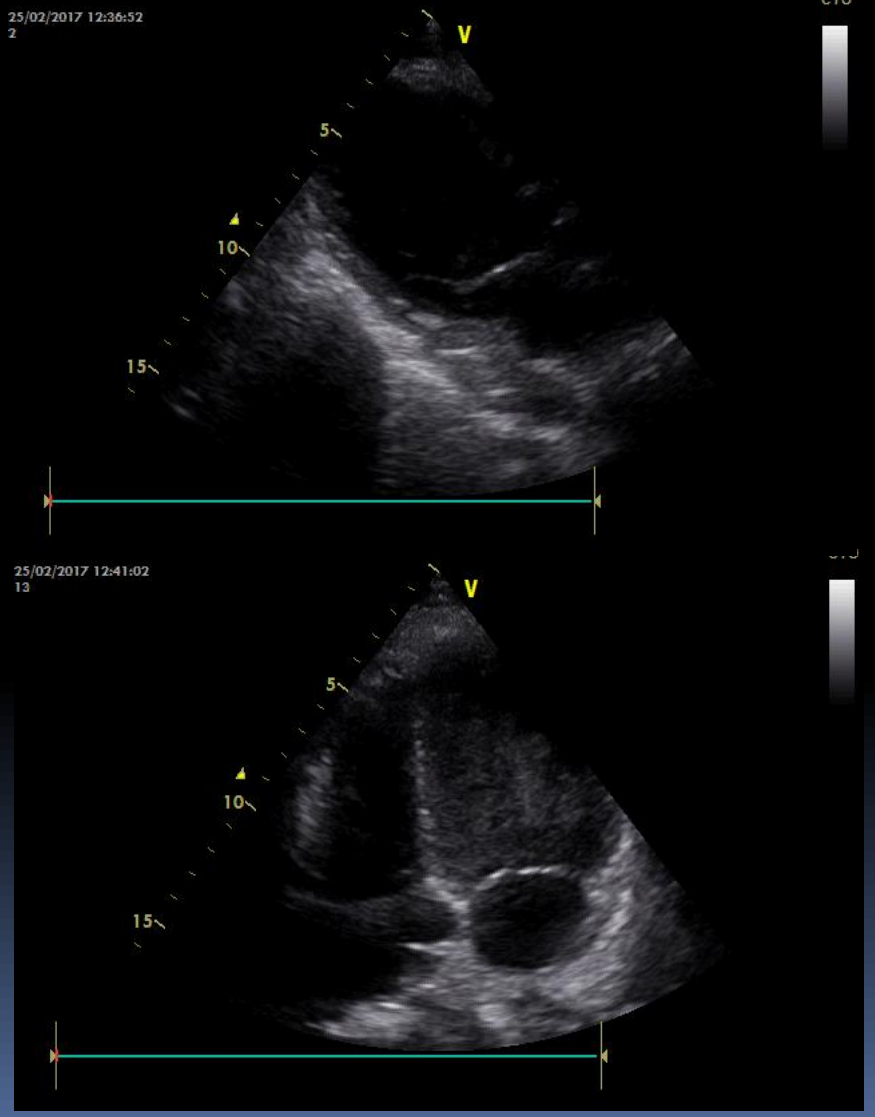
Case 1
ECMO E-CPR → LVAD(CentriMag) → Transplant

Massive Anterior STEMI 25/10/2016
Primary PCI to LM/LAD
Refractory VT/VF
VA-ECMO as ECPR

港聞

50歲工程師心臟功能不足15%　急需換心續命　列輪候名單首位

撰文： 朱韻斐　發佈日期：2017-04-20 15:31　最後更新日期：2017-04-20 21:20



Heart Transplant 8/5/2017

ECPR and Survival to Discharge Time is the Key

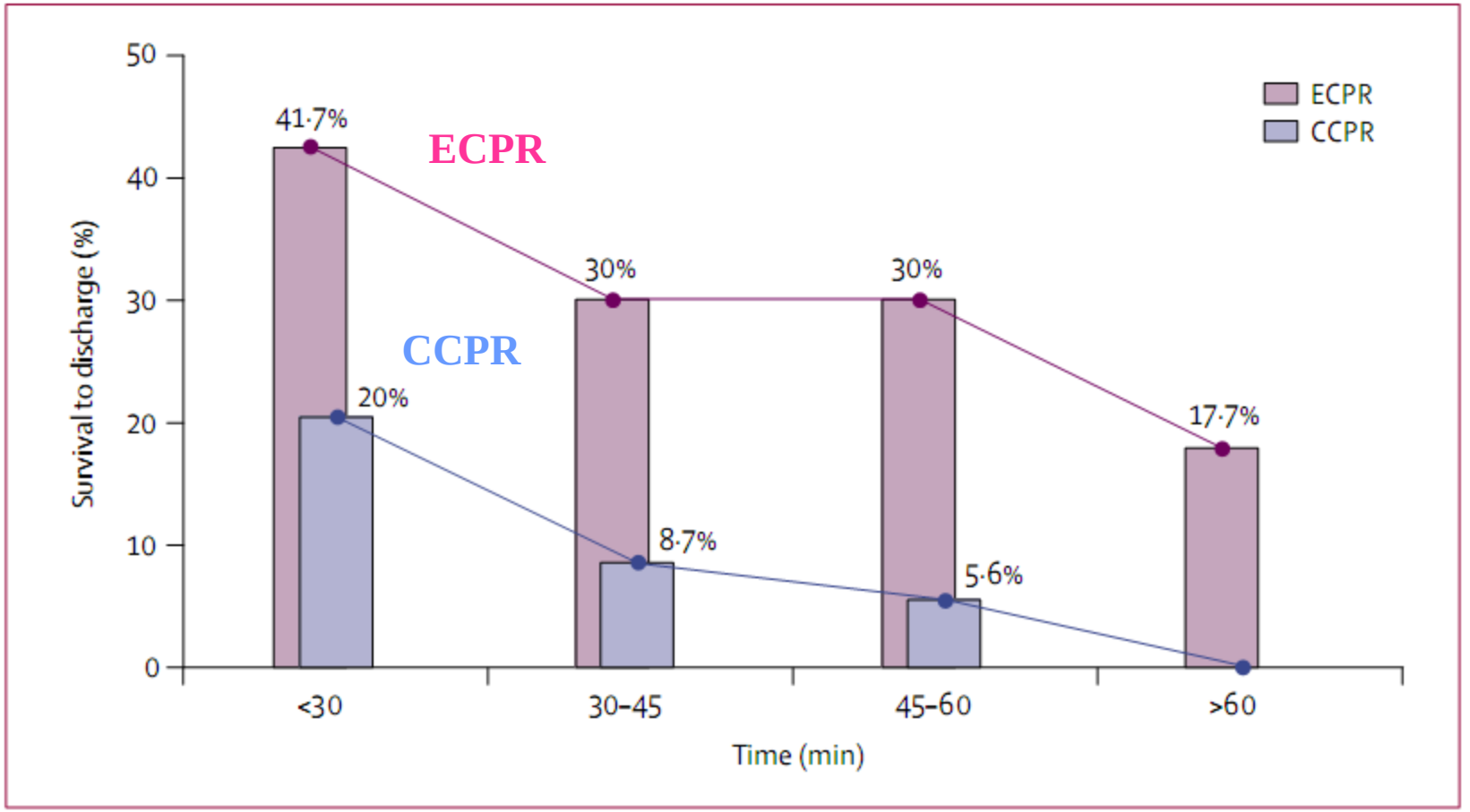


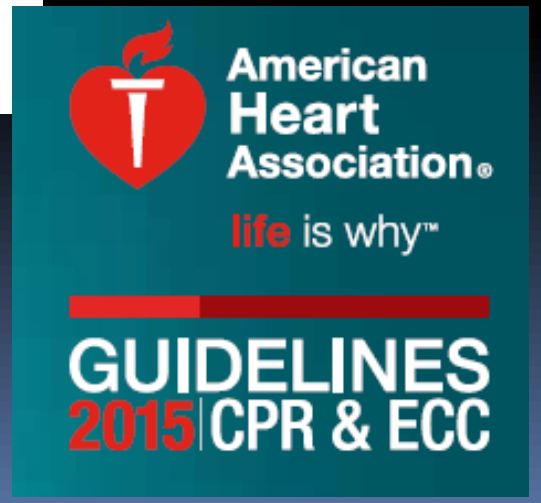
Figure 1: Relation between CPR duration and the survival rate to discharge

Lancet 2008

Extracorporeal Techniques and Invasive Perfusion Devices

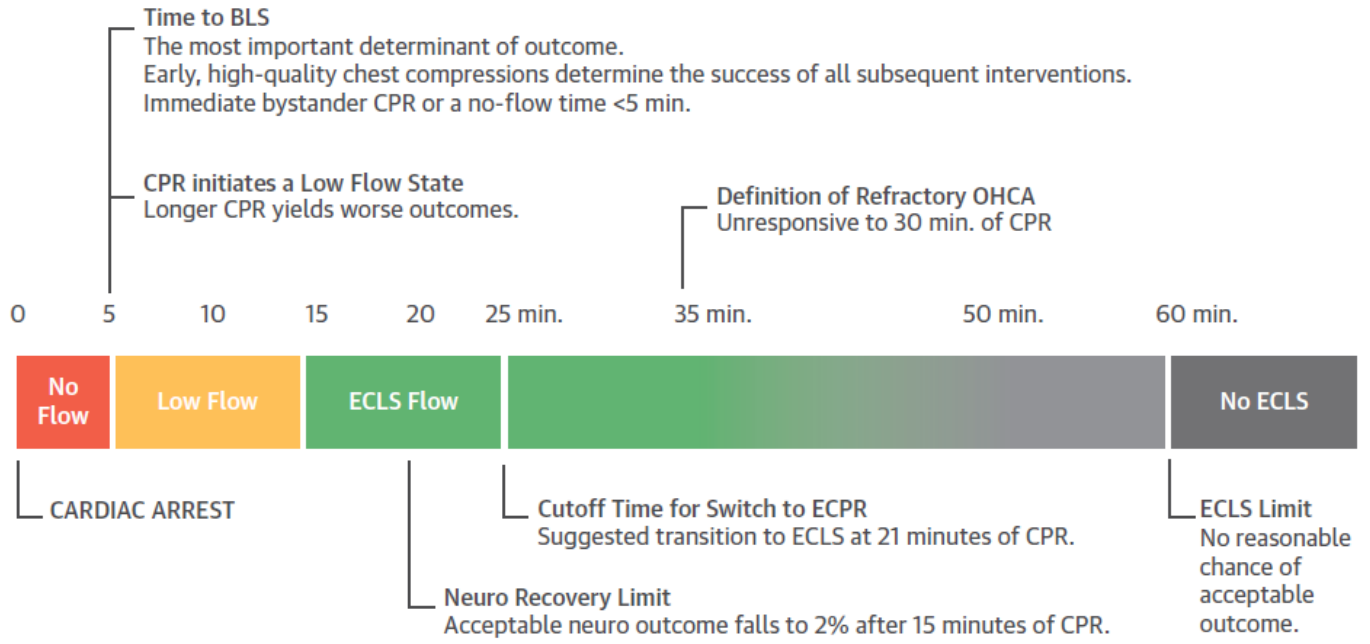
2015 (Updated): ECPR may be considered an alternative to conventional CPR for select patients who have a cardiac arrest and for whom the suspected etiology of the cardiac arrest is potentially reversible.

2010 (Old): There was insufficient evidence to recommend the routine use of ECPR for patients in cardiac arrest. However, in settings where ECPR is readily available, it may be considered when the time without blood flow is brief and the condition leading to the cardiac arrest is reversible (eg, accidental hypothermia, drug intoxication) or amenable to heart transplantation (eg, myocarditis) or revascularization (eg, acute myocardial infarction).



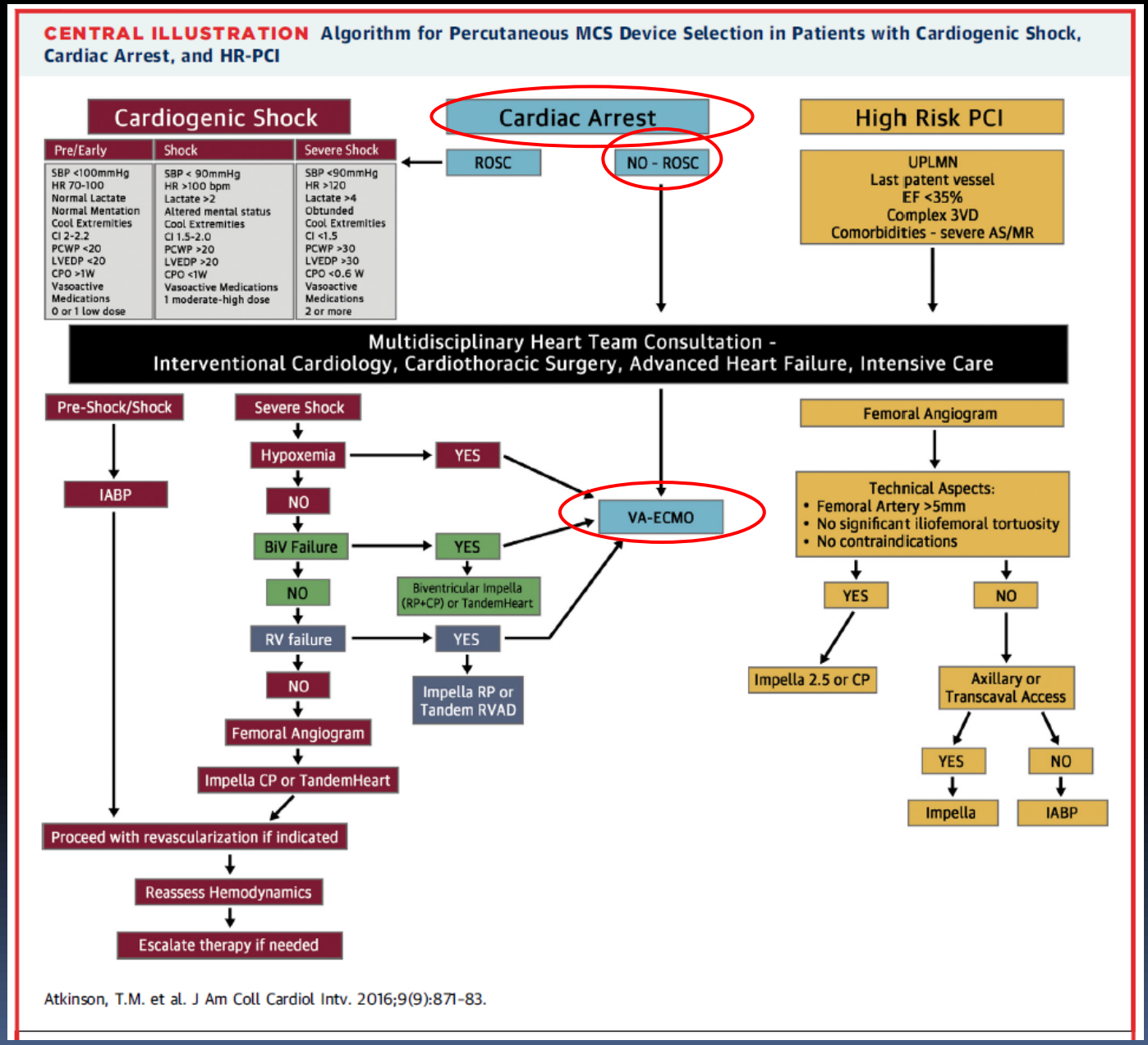
VA-ECMO for ECPR

FIGURE 5 ECPR Time for Patient Selection



The interval from the arrest to the beginning of cardiopulmonary resuscitation (CPR) should be considered a no-flow period **(far left)**, whereas time on CPR is a low-flow period with suboptimal circulation. The probability of survival with good neurological outcome declines rapidly with each minute of conventional CPR. When extracorporeal CPR (ECPR) is delayed until refractory cardiac arrest, CPR, survival is extremely poor **(far right)**. BLS = basic life support; ECLS = extracorporeal life support; OHCA = out-of-hospital cardiac arrest.

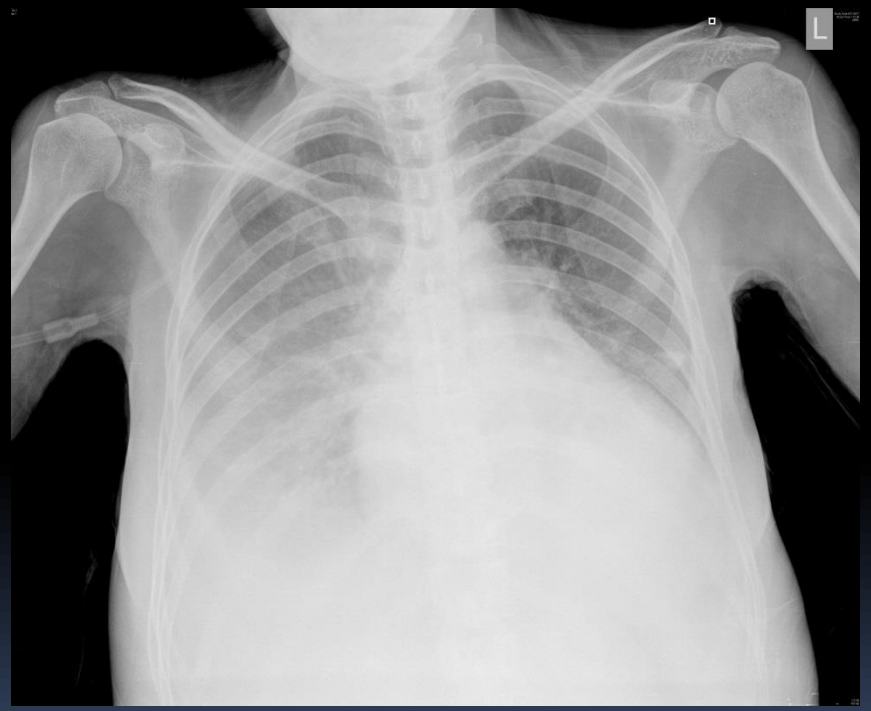
J Am Coll Cardiol. 2019 Feb 19;73(6):698-716.



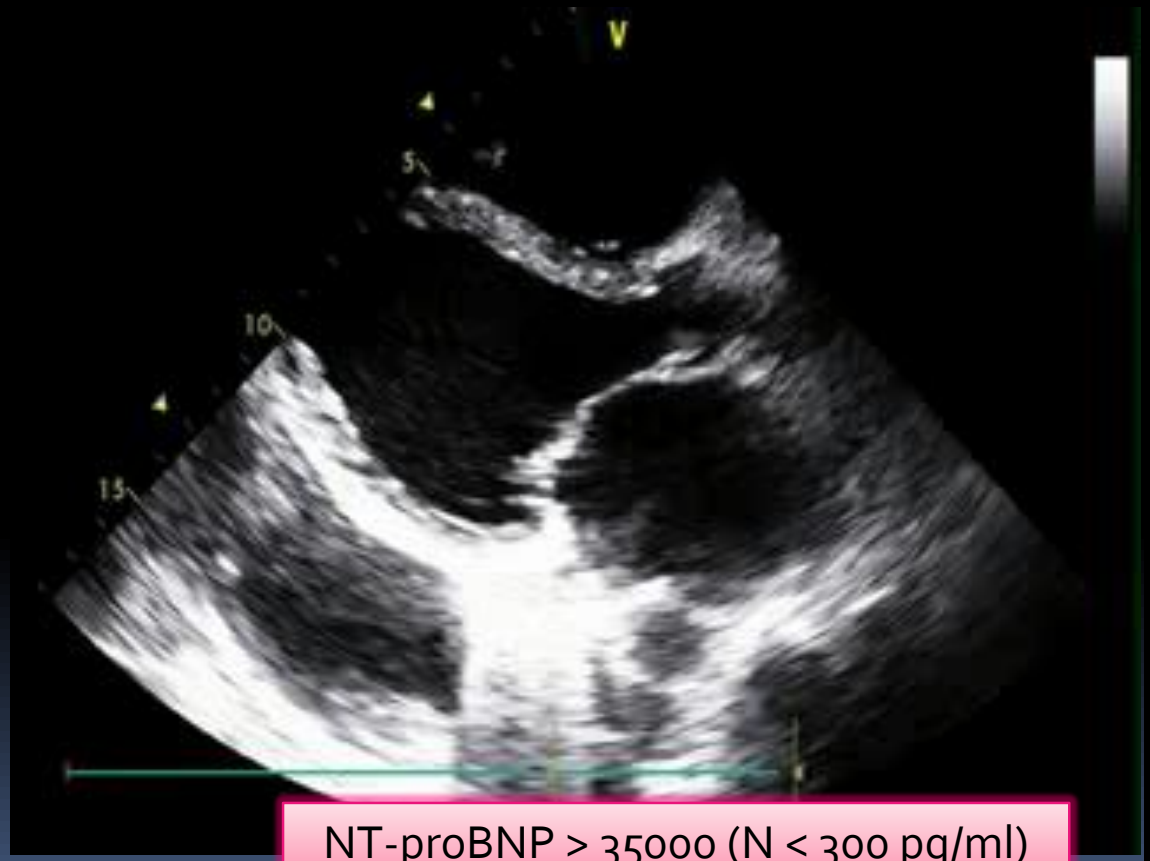
JACC Cardiovasc Interv. 2016 May 9;9(9):871-83

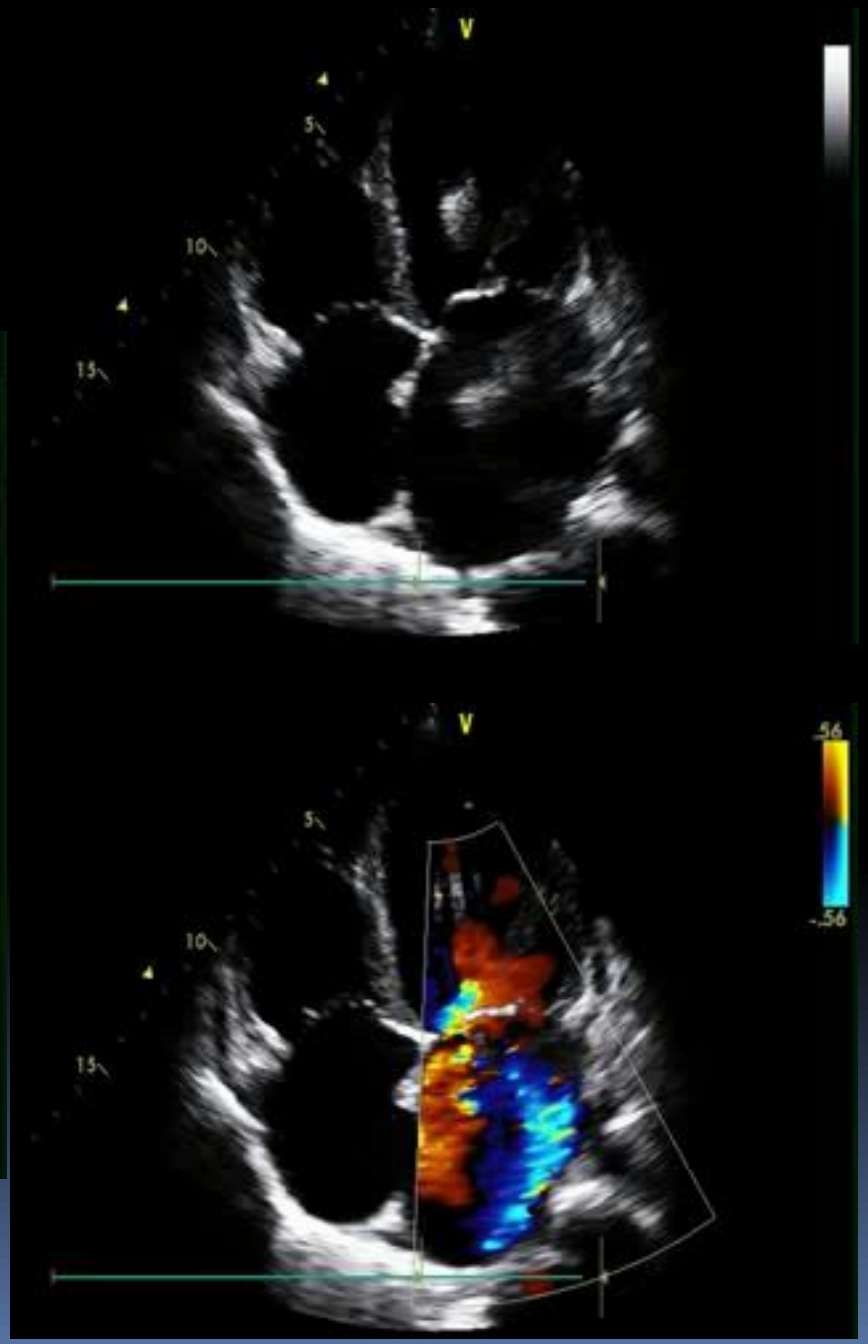
Case 2

- F/47 with history of dilated LV with LVEF 36%, severe MR, mod TR
- ADHF 10/2017 increase 30 lbs, orthopnoea
- Cr 99 → 174 umol/L
- Bili 56 → 82 umol/L
- Lactic acid 14.7 mmol/L (N < 2.2)



Case 2



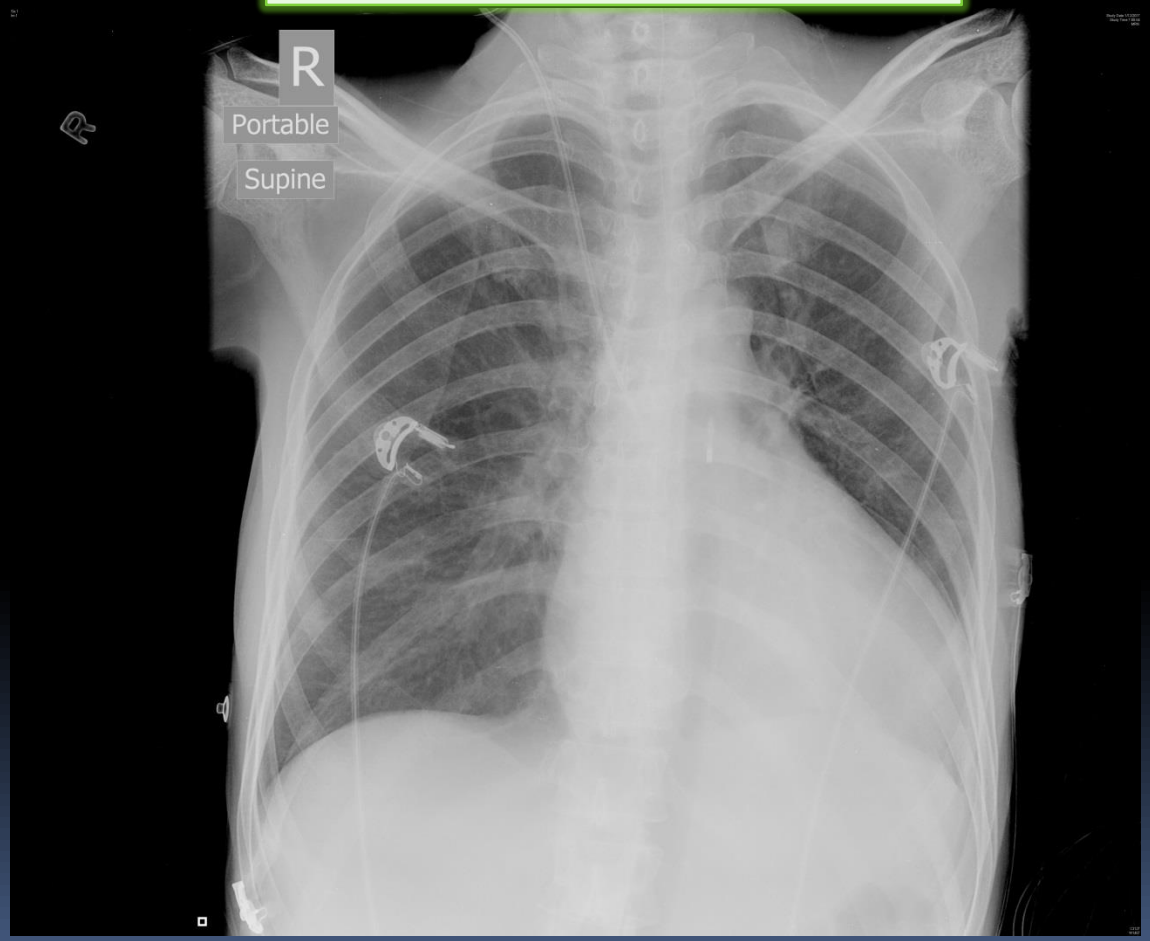


NT-proBNP > 35000 (N < 300 pg/ml)

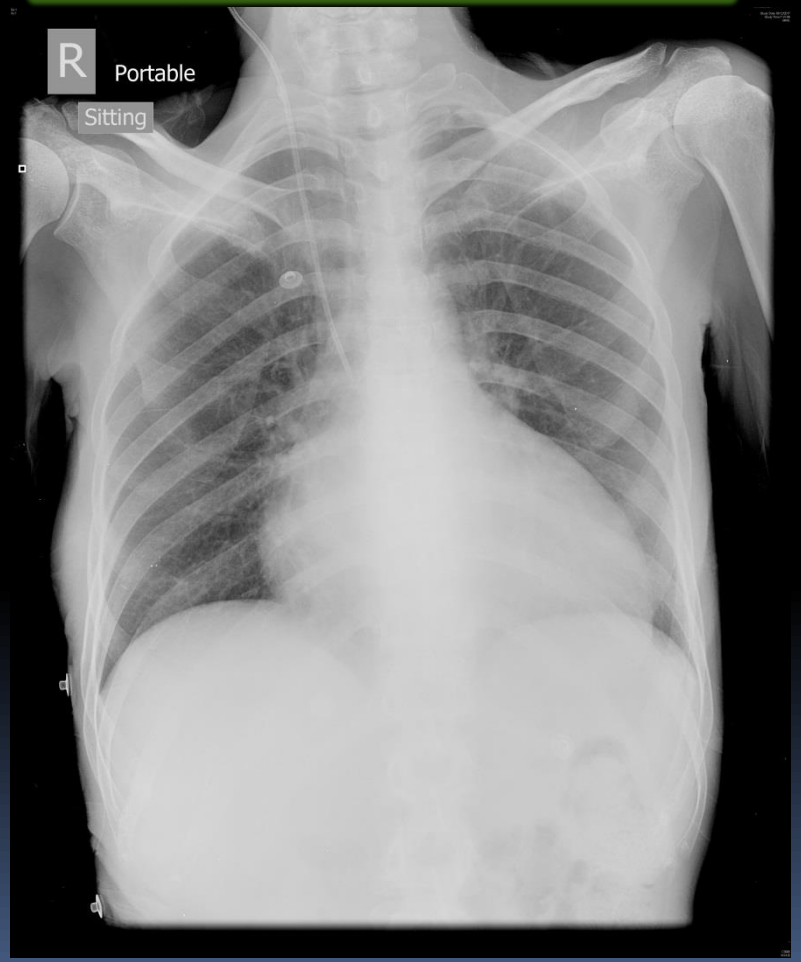
On dopamine 2:1 @ 6ml/hour

Case 2

Central Line + IABP
Congestion improved

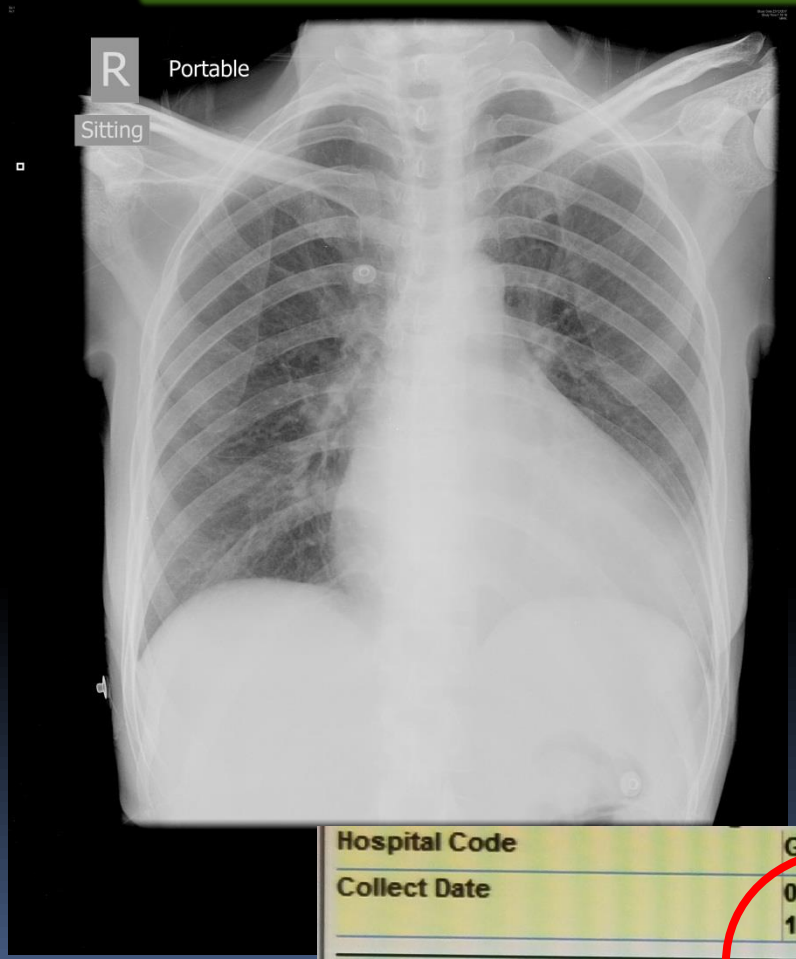


IABP wean off

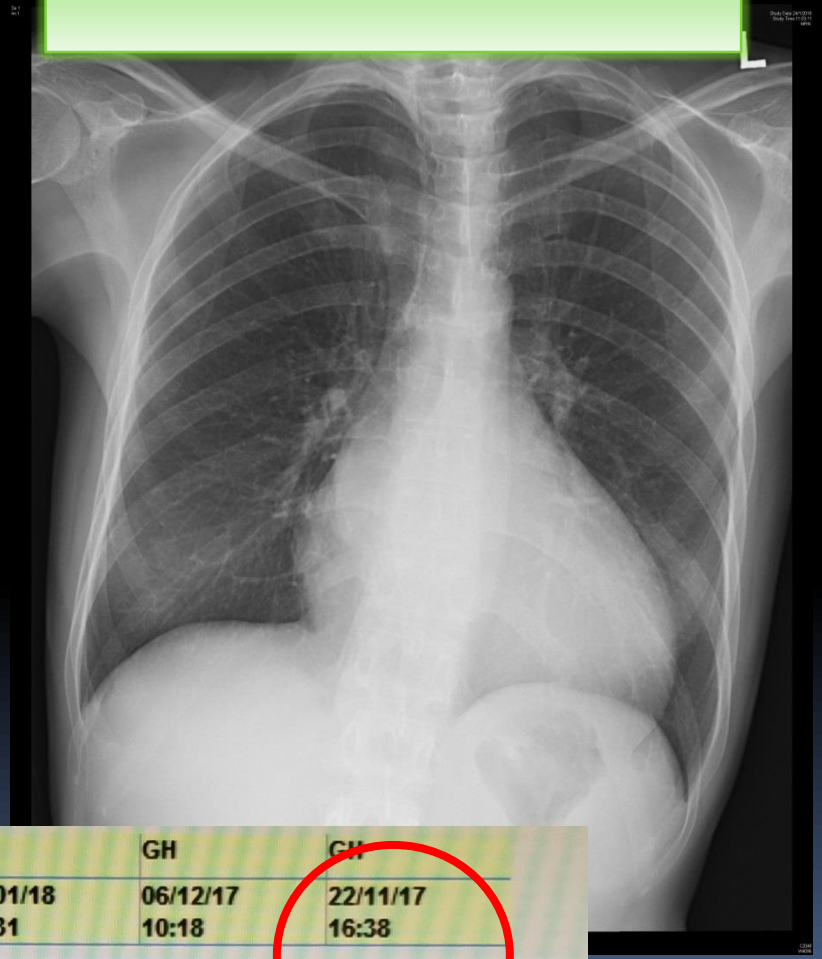


Case 2

Inotrope wean off



Uptitrated HF medical therapy



Hospital Code	GH	GH	GH	GH
Collect Date	06/04/18 10:46	12/01/18 12:31	06/12/17 10:18	22/11/17 16:38
NT-proBNP, Whole Blood, POCT	407	2020	2190	>35000
Report Image			---	---

ELSEVIER

The Journal of Heart and Lung Transplantation

http://www.jhltonline.org

Clinical and hemodynamic effects of intra-aortic balloon pump therapy in chronic heart failure patients with cardiogenic shock

CrossMark

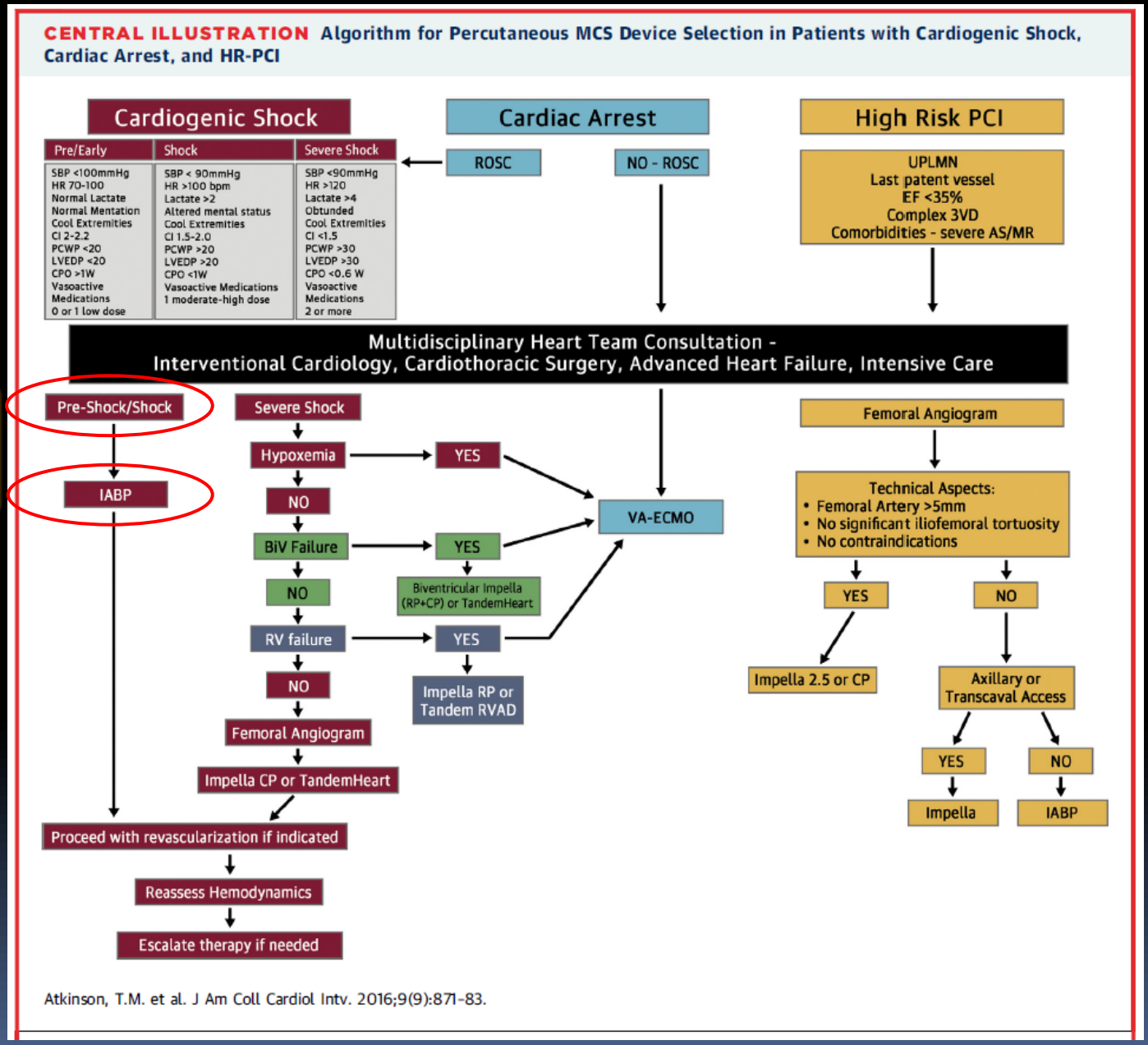
132 chronic heart failure patient with decompensation and cardiogenic shock

Overall 30-day survival 84.1%

78.0% of patients were successfully bridged to heart replacement therapy or discharge without need for escalation of device support

IABP is a reasonable ***first-line device*** for chronic heart failure patients with cardiogenic shock.

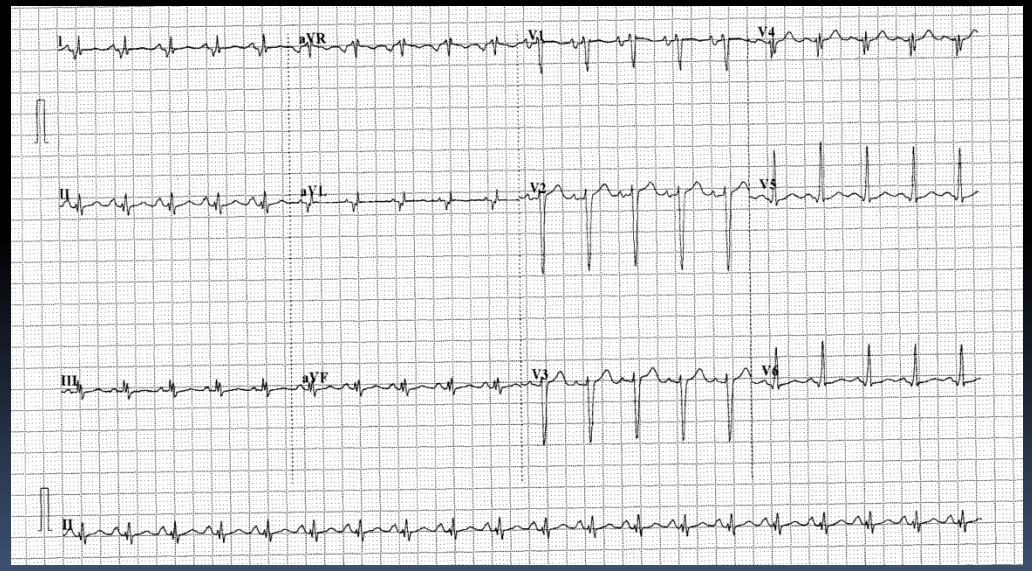
Especially chronic heart failure

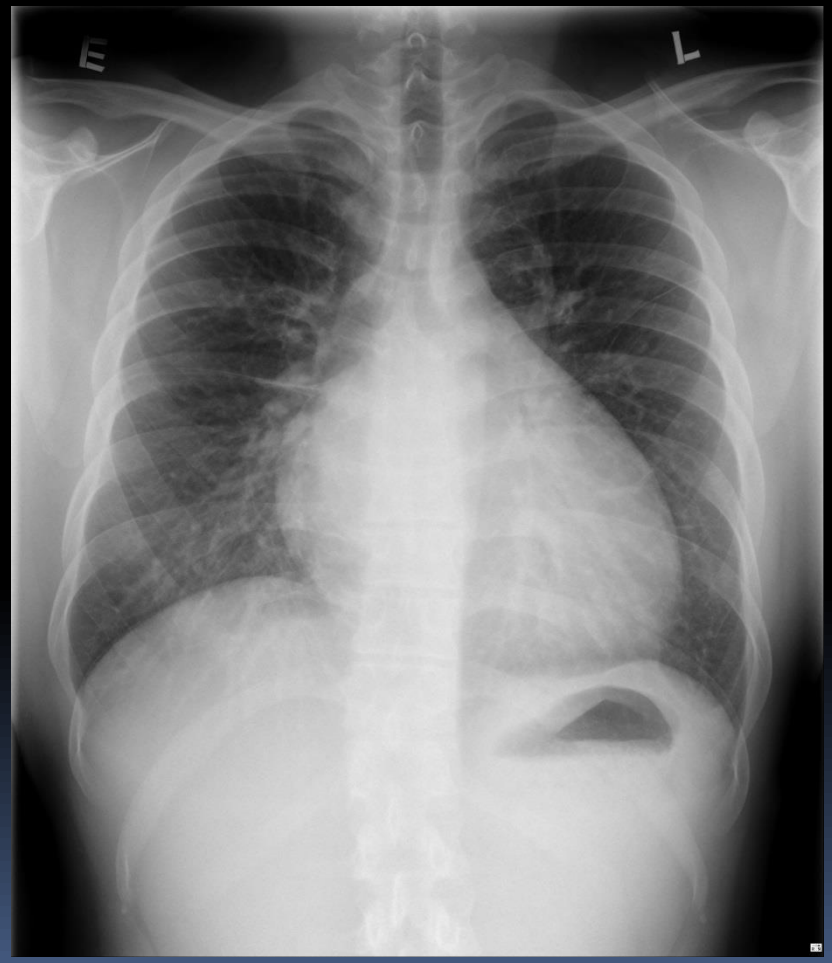


JACC Cardiovasc Interv. 2016 May 9;9(9):871-83

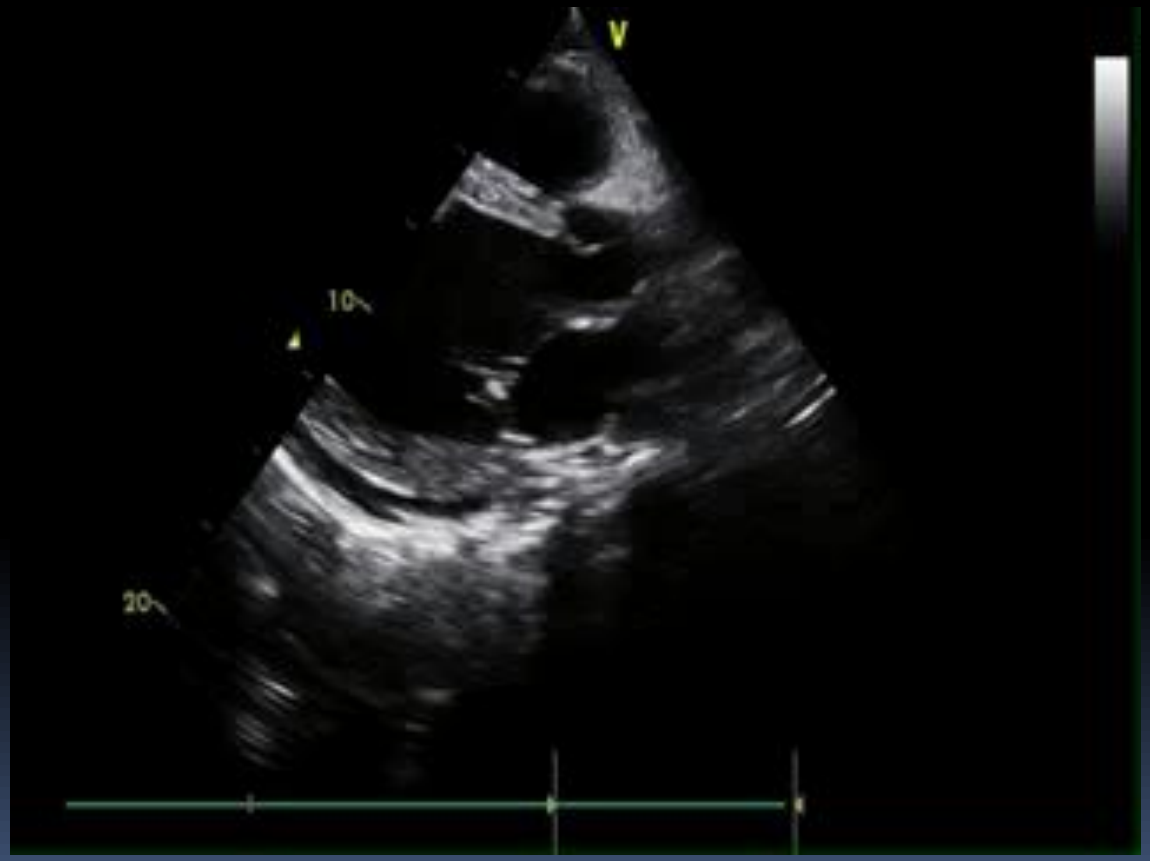
Case 3

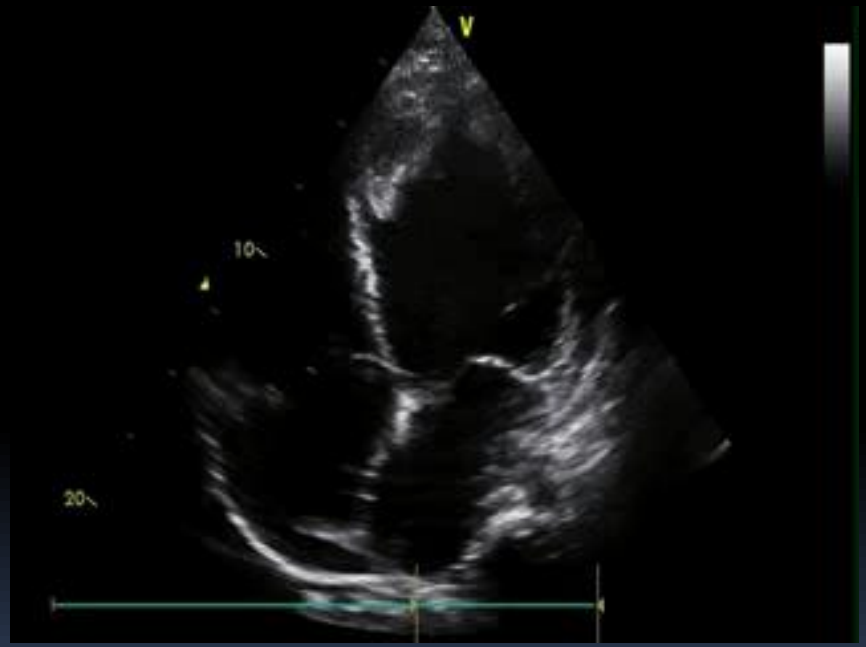
- M/20 Good past health
- Cough, Dyspnoea 24/11/2016
- hsTrop I 11421 ng/L (N < 34.2)



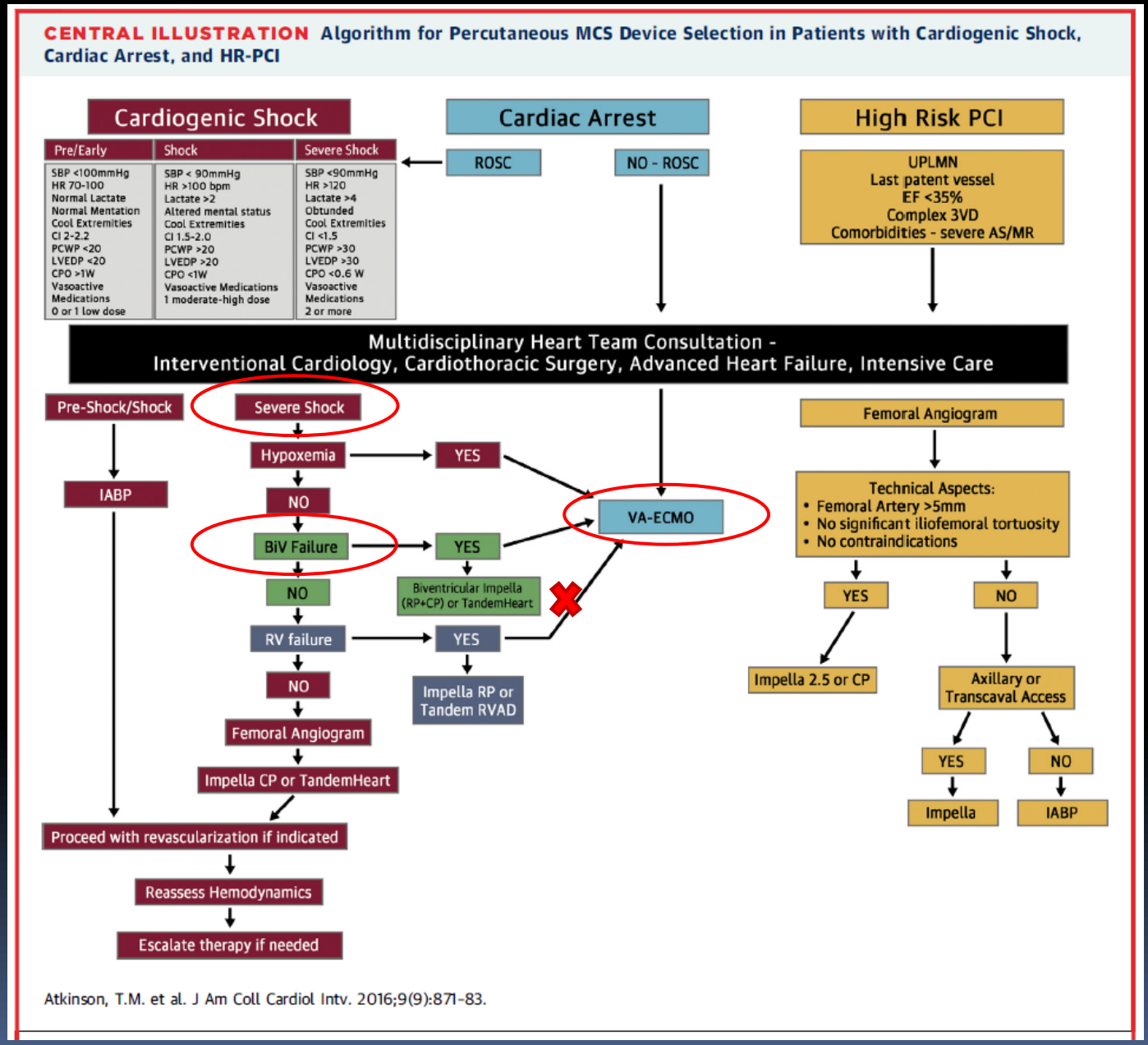


Case 3





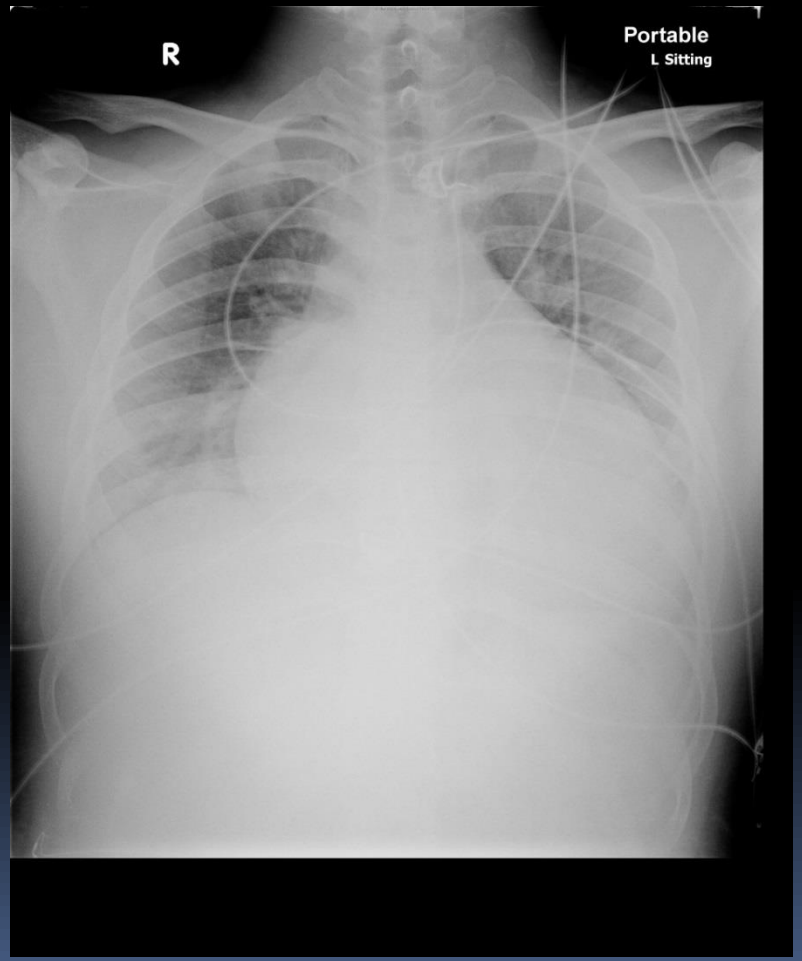
Coronary Angiogram Normal

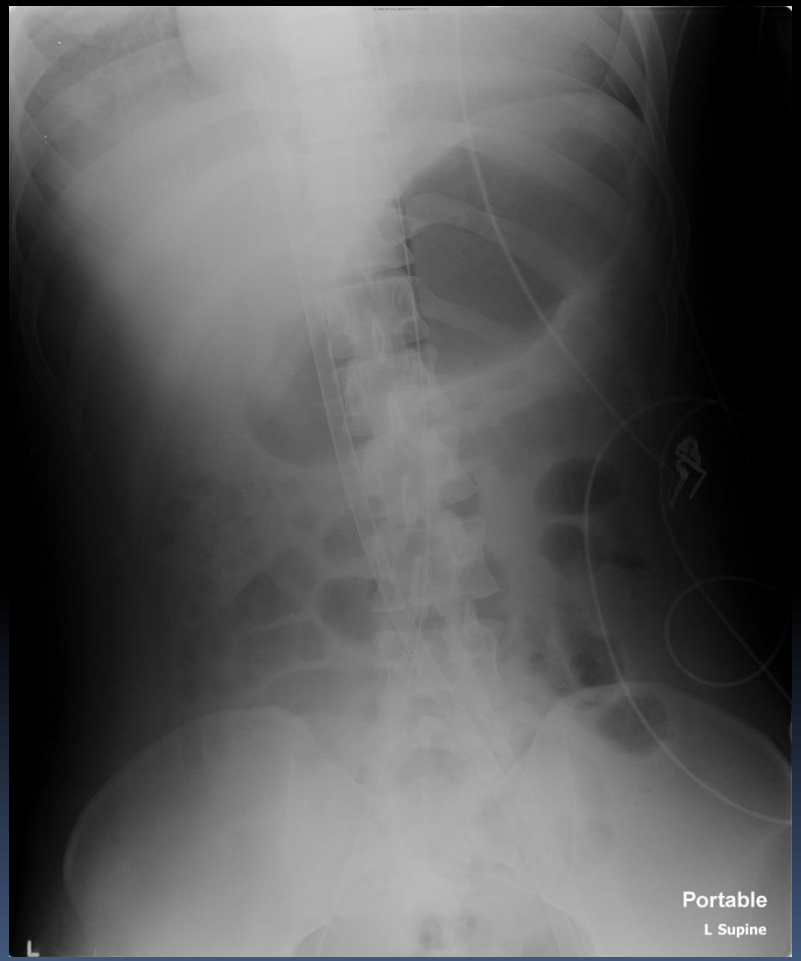


Atkinson, T.M. et al. J Am Coll Cardiol Intv. 2016;9(9):871-83.

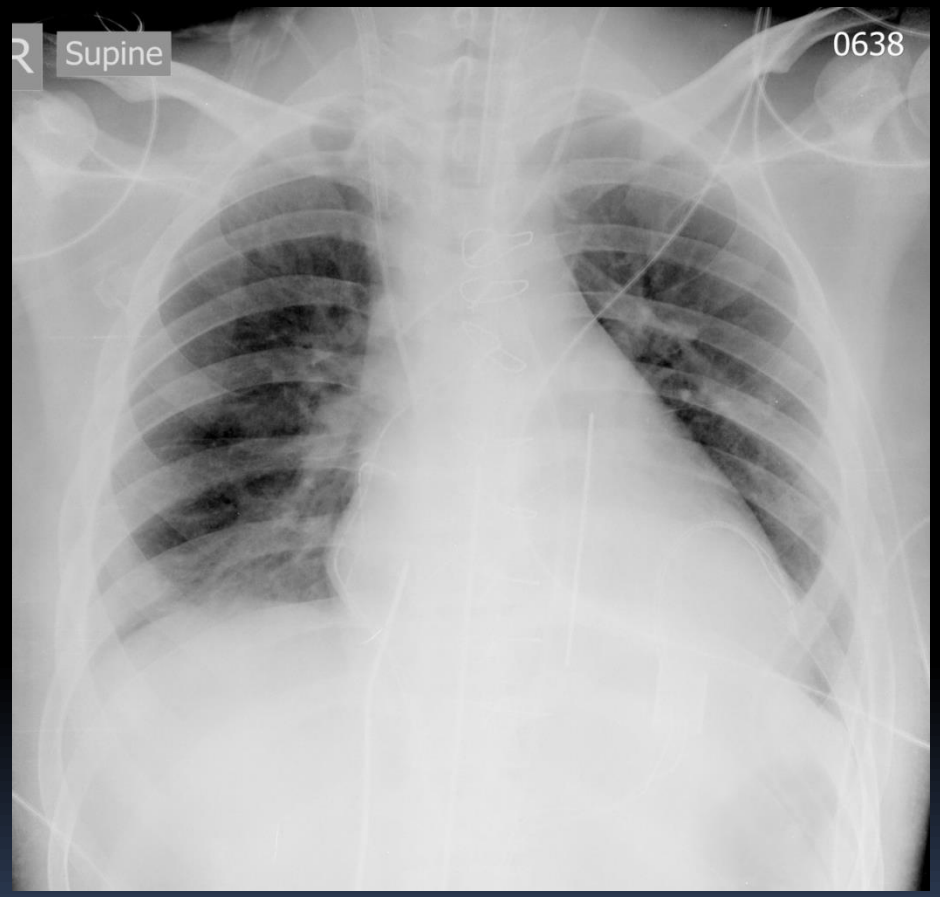
JACC Cardiovasc Interv. 2016 May 9;9(9):871-83

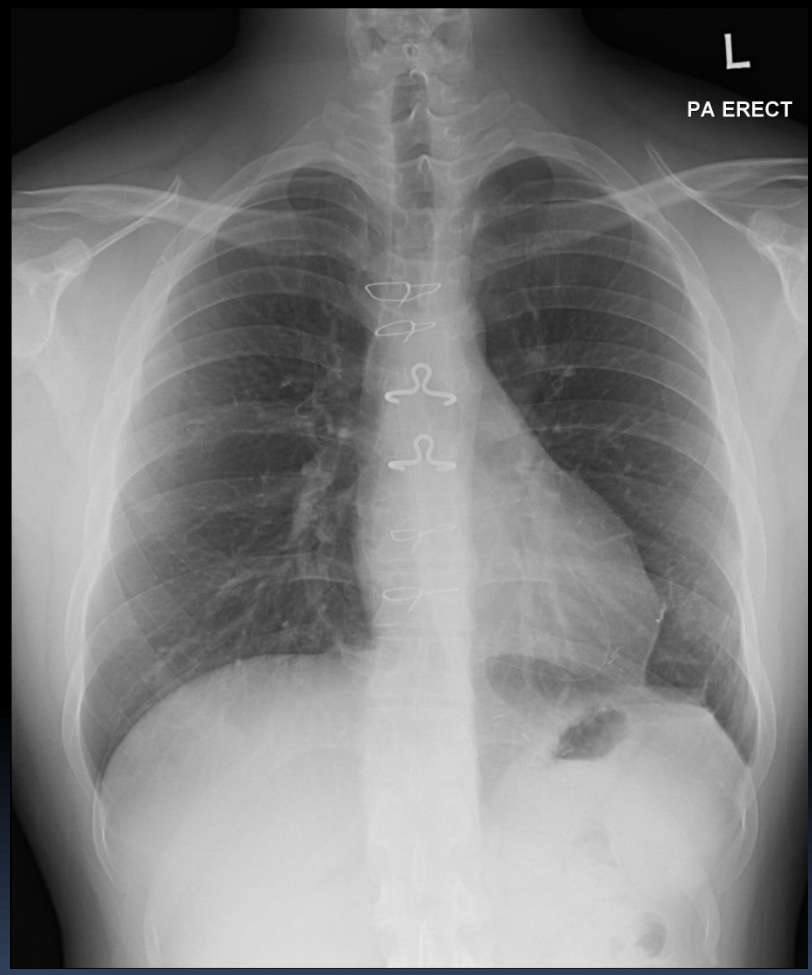
Case 3





Case 3





Biventricular VAD (CentriMag) since 21/12/2016

Heart Transplant 1/3/2017

Are they useful?

Current Evidence

ESC 2016 Guideline - IABP

Recommendations regarding management of patients with cardiogenic shock

Recommendations	Class [a]	Level [b]	Ref [c]
In all patients with suspected cardiogenic shock, immediate ECG and echocardiography are recommended.	I	C	
All patients with cardiogenic shock should be rapidly transferred to a tertiary care center which has a 24/7 service of cardiac catheterization, and a dedicated ICU/CCU with availability of short-term mechanical circulatory support.	I	C	
In patients with cardiogenic shock complicating ACS an immediate coronary angiography is recommended (within 2 hours from hospital admission) with an intent to perform coronary revascularization.	I	C	
Continous ECG and blood pressure monitoring are recommended.	I	C	
Invasive monitoring with an arterial line is recommended.	I	C	
Fluid challenge (saline or Ringer's lactate, >200 ml/15–30 min) is recommended as the first-line treatment if there is no sign of overt fluid overload.	I	C	
Intravenous inotropic agents (dobutamine) may be considered to increase cardiac output.	IIb	C	
Vasopressors (norepinephrine preferable over dopamine) may be considered if there is a need to maintain SBP in the presence of persistent hypoperfusion.	IIb	B	558
IABP is not routinely recommended in cardiogenic shock.	III	B	585, 586
Short-term mechanical circulatory support may be considered in refractory cardiogenic shock depending on patient age, comorbidities and neurological function.	IIb	C	

IABP SHOCK II Trial

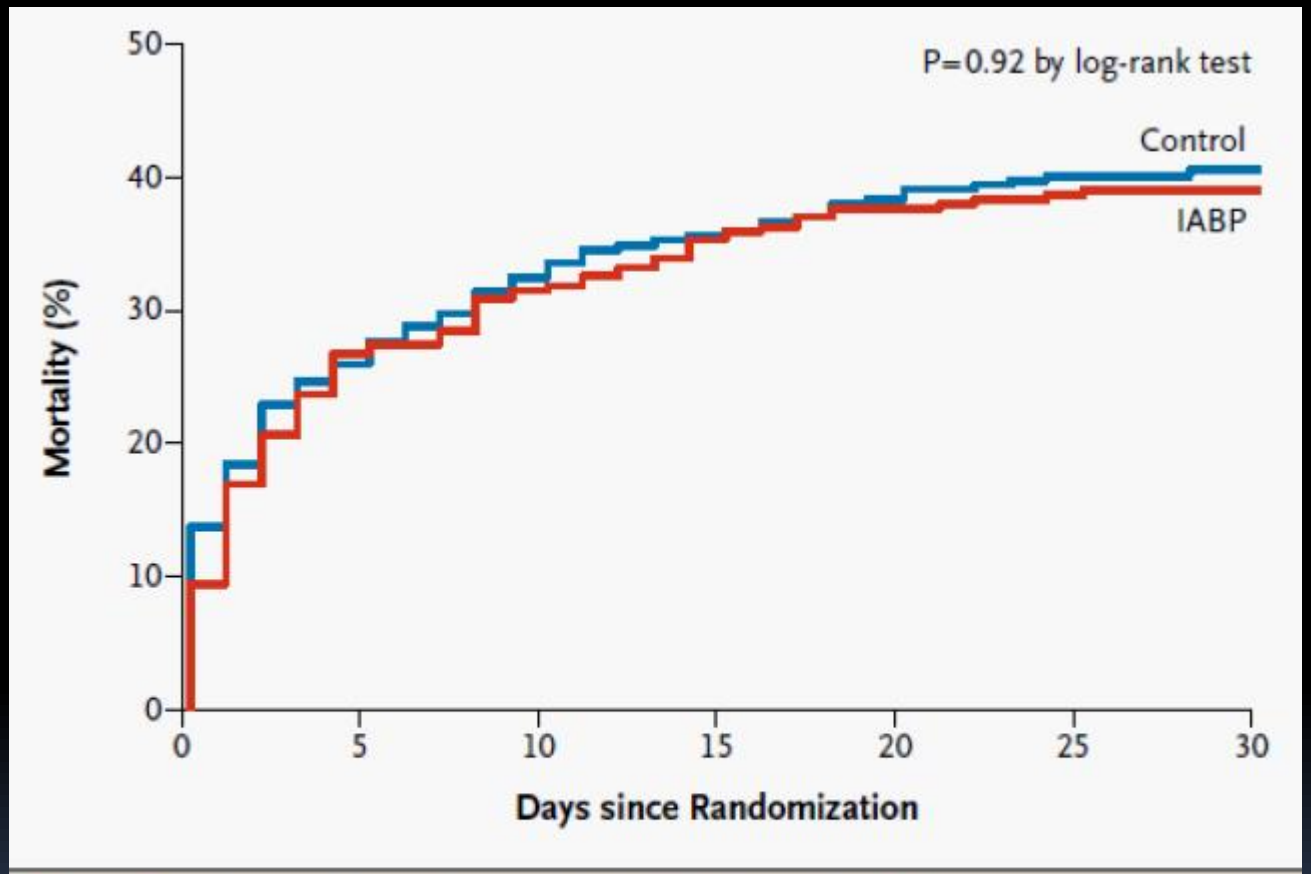
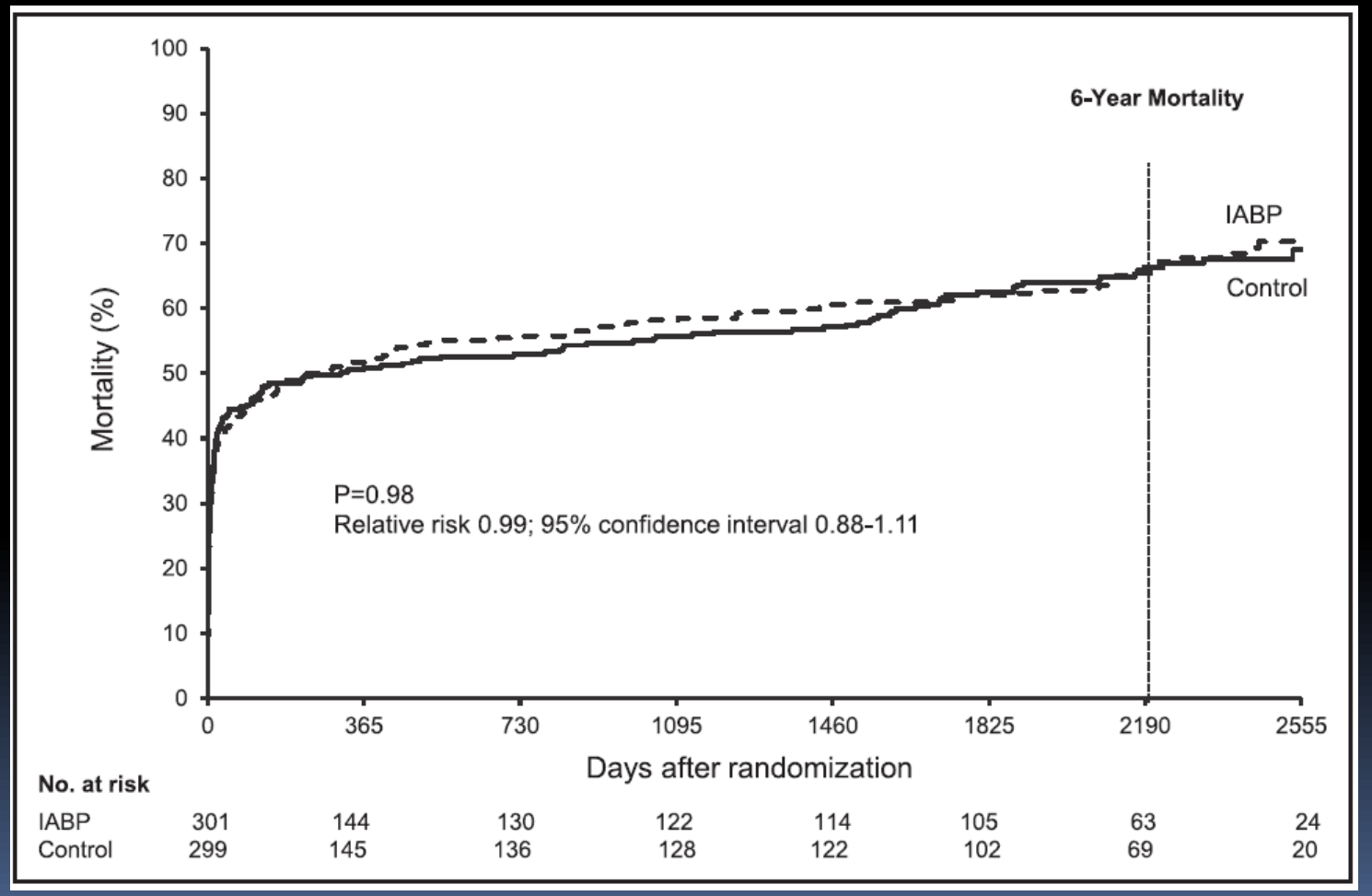


Figure 1. Time-to-Event Curves for the Primary End Point.

Time-to-event curves are shown through 30 days after randomization for the primary end point of all-cause mortality. Event rates represent Kaplan–Meier estimates.

N Engl J Med. 2012 Oct 4;367(14):1287-96

IABP Shock II Trial 6 Year FU



Circulation. 2019;139:395–403.

IABP –safe procedure

Table 3. Clinical Outcomes.

Outcome	IABP (N=300)	Control (N=298)	P Value	Relative Risk with IABP (95% CI)
	number (percent)			
Primary end point: all-cause mortality at 30 days	119 (39.7)	123 (41.3)	0.69	0.96 (0.79–1.17)
Reinfarction in hospital	9 (3.0)	4 (1.3)	0.16	2.24 (0.70–7.18)
Stent thrombosis in hospital	4 (1.3)	3 (1.0)	0.71	1.32 (0.30–5.87)
Stroke in hospital	2 (0.7)	5 (1.7)	0.28	0.40 (0.08–2.03)
Ischemic	2 (0.7)	4 (1.3)	0.45	0.49 (0.09–2.71)
Hemorrhagic	0	1 (0.3)	0.50	—
Peripheral ischemic complications requiring intervention in hospital	13 (4.3)	10 (3.4)	0.53	1.29 (0.58–2.90)
Bleeding in hospital*				
Life-threatening or severe	10 (3.3)	13 (4.4)	0.51	0.76 (0.34–1.72)
Moderate	52 (17.3)	49 (16.4)	0.77	1.05 (0.74–1.50)
Sepsis in hospital	47 (15.7)	61 (20.5)	0.15	0.77 (0.54–1.08)

No significant increase in complications

N Engl J Med. 2012 Oct 4;367(14):1287-96

IABP Evidences

TABLE 7 Contemporary Trials With IABP

Trial/First Author (Ref. #)	Indication	Definition	N	Control or No IABP Survival	Prophylactic or IABP Survival	Routine Use
IABP-SHOCK-II (3)	AMI and CS	SBP <90 mm Hg for >30 min or vasoactive medications needed to maintain SBP >90, pulmonary edema, end-organ dysfunction (AMS, cool extremities, UOP <30 ml/h, lactate >2)	600	41.3%	39.7%	No difference in survival
TACTICs (59)	AMI and CS	s/p fibrinolysis	57	67% at 30 days Killip III/IV: 20% at 6 months	73% at 30 days Killip III/IV: 61% at 6 months	No significant difference except in Killip III/IV patients who received IABP
Waksman et al. (58)	AMI and CS	s/p fibrinolysis	45	19%	46%	In-hospital survival improved with IABP use in patients s/p fibrinolysis
NRMI (81)	AMI and CS	Observational study: IABP compared to no IABP among patients given fibrinolysis or primary angioplasty	IABP = 7,268 No IABP = 15,912	Lytics: 67% in-hospital mortality PTCA: 42% in-hospital mortality	Lytics: 49% in-hospital mortality PTCA: 47% in-hospital mortality	IABP provided substantial benefit in patients with AMI and CS who received fibrinolysis
CRISP-AMI (5)	Anterior MI with planned PCI	Prophylactic IABP	337	No difference in survival	No difference in survival	No reduction in infarct size
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

JACC Cardiovasc Interv. 2016 May 9;9(9):871-83

ESC 2016 Guideline - IABP

Recommendations regarding management of patients with cardiogenic shock

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All patients with cardiogenic shock should be rapidly transferred to a tertiary care center which has a 24/7 service of cardiac catheterization, and a dedicated ICU/CCU with availability of short-term mechanical circulatory support.	I	C	
In patients with cardiogenic shock complicating ACS an immediate coronary angiography is recommended (within 2 hours from hospital admission) with an intent to perform coronary revascularization.	I	C	
Continous ECG and blood pressure monitoring are recommended.	I	C	
Invasive monitoring with an arterial line is recommended.	I	C	
Fluid challenge (saline or Ringer's lactate, >200 ml/15–30 min) is recommended as the first-line treatment if there is no sign of overt fluid overload.	I	C	
Intravenous inotropic agents (dobutamine) may be considered to increase cardiac output.	IIb	C	
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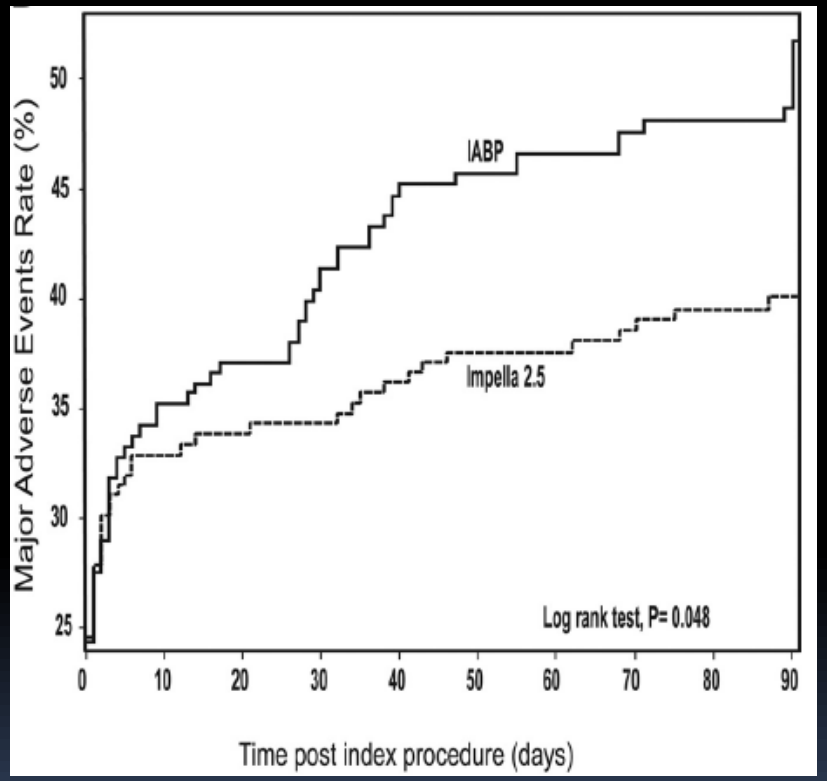
IABP is not routinely recommended in cardiogenic shock.	III	B	585, 586
Short-term mechanical circulatory support may be considered in refractory cardiogenic shock depending on patient age, comorbidities and neurological function.	IIb	C	

Impella – HR PCI - Protect II study

Table 3. Combined In- and Out-of-Hospital Hierarchical Outcomes for the Intent-to-Treat Population

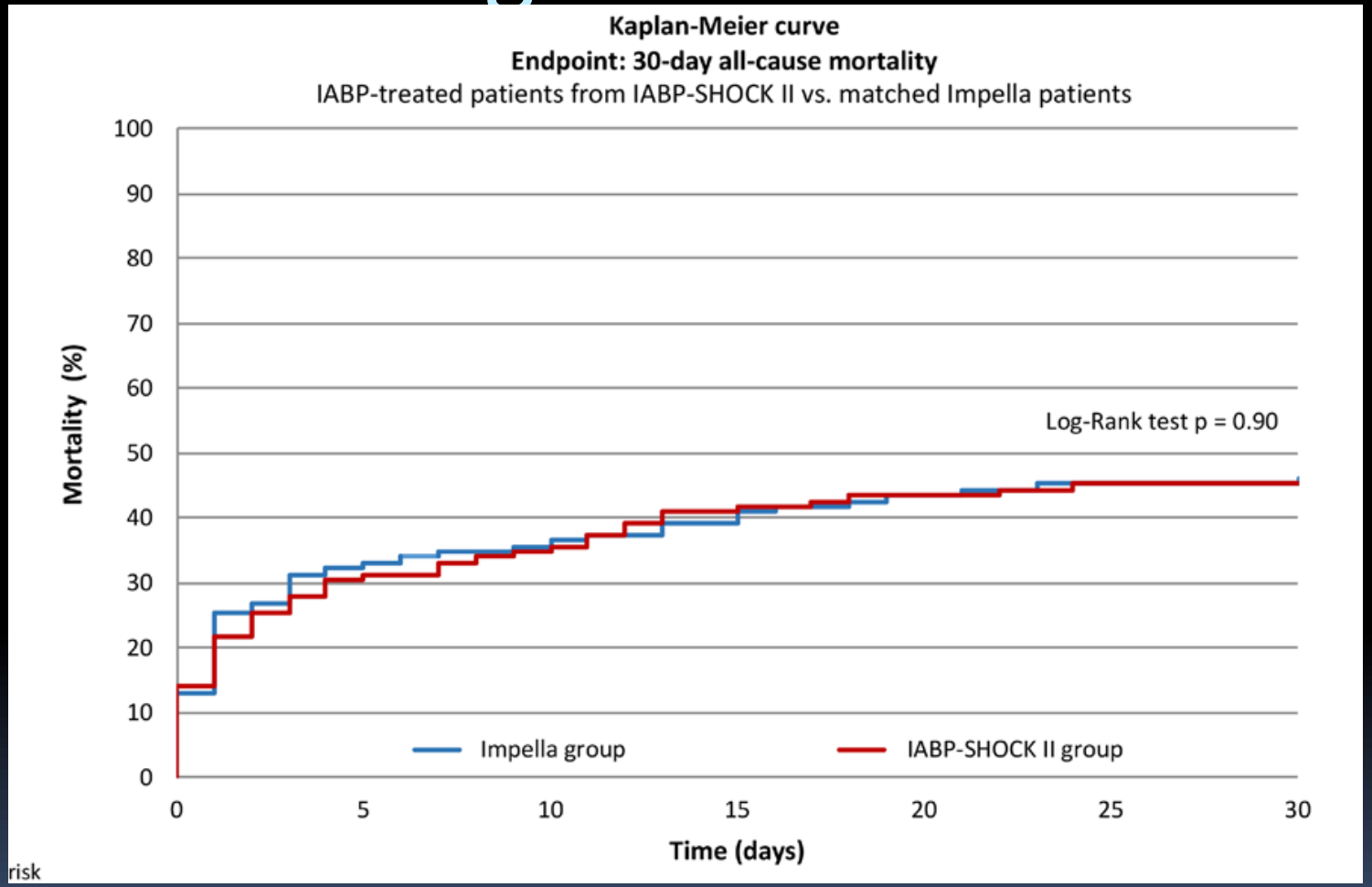
	30 Days			90 Days		
	IABP (n=222)	Impella 2.5 (n=225)	*P*	IABP (n=219)	Impella 2.5 (n=224)	*P*
Composite of major adverse events	40.1	35.1	0.277	49.3	40.6	0.066
Death	5.9	7.6	0.473	8.7	12.1	0.244
Stroke/TIA	1.8	0.0	0.043	2.7	0.9	0.144
Myocardial Infarction	10.4	13.8	0.268	14.2	12.1	0.512
Repeat revascularization	4.1	1.3	0.075	7.8	3.6	0.056
Need for cardiac or vascular operation*	1.4	0.9	0.642	1.8	1.3	0.681
Acute renal dysfunction	4.5	4.0	0.792	4.6	4.0	0.776
Cardiopulmonary resuscitation/ventricular arrhythmia†	3.2	2.2	0.543	4.1	2.2	0.259
Aortic valve damage/increase in aortic insufficiency	0.0	0.0	. . .	0.0	0.0	. . .
Severe hypotension requiring treatment	8.6	4.9	0.121	5.5	4.0	0.469
Angiographic failure	0.5	0.4	0.992	0.0	0.4	0.322



No difference in mortality
Impella with less major adverse event

Circulation. 2012 Oct 2;126(14):1717-27.

IABP vs Impella matched cohort study AMI with cardiogenic shock



No difference in Mortality

Circulation. 2019;139:1249–1258.

IABP vs Impella matched cohort study AMI with cardiogenic shock

	Impella vs IABP-SHOCK II Trial Patients			Impella vs IABP-Treated Patients From the IABP-SHOCK II Trial		
	Impella Group (n=237)	Control (n=237)	*P* Value	Impella Group (n=115)	Control (n=115)	*P* Value
30-day all-cause mortality	115 (48.5)	110 (46.4)	0.64	53 (46.1)	52 (45.2)	0.90
Reinfarction in hospital	7 (3.5)	6 (2.5)	0.56	4 (4.0)	4 (3.5)	0.71
Stent thrombosis in hospital	1 (0.6)	3 (1.3)	0.32	0 (0.0)	2 (1.7)	0.22
Stroke in hospital	6 (3.5)	6 (2.5)	0.76	2 (2.3)	1 (0.9)	0.56
Peripheral ischemic complications requiring intervention in hospital	23 (9.8)	9 (3.8)	0.01	11 (9.6)	4 (3.5)	0.05
Moderate bleeding in hospital	48 (20.3)	40 (16.9)	0.32	22 (19.1)	24 (20.9)	0.72
Life-threatening or severe bleeding in hospital	20 (8.5)	7 (3.0)	<0.01	12 (10.4)	2 (1.7)	<0.01
Sepsis in hospital	73 (35.3)	46 (19.4)	<0.01	39 (38.2)	20 (17.4)	<0.01

Impella more bleeding
Impella more sepsis

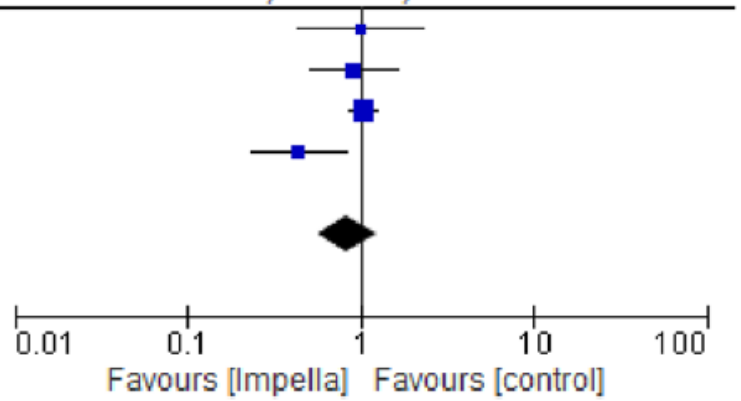
Circulation. 2019;139:1249–1258.

Impella vs IABP meta-analysis

Study or Subgroup	Impella Events	Impella Total	Control Events	Control Total	Weight	Risk Ratio M-H, Random, 95% CI	Year
ISAR-SHOCK	6	13	6	13	14.7%	1.00 [0.44, 2.29]	2008
IMPRESS in Severe Shock	11	24	12	24	22.3%	0.92 [0.51, 1.66]	2017
Schrage 2018	115	237	110	237	42.4%	1.05 [0.86, 1.26]	2018
Karatolios 2018	7	20	16	20	20.6%	0.44 [0.23, 0.83]	2018
Total (95% CI)		**294**		**294**	**100.0%**	**0.84 [0.57, 1.24]**	
Total events	139		144				

Heterogeneity: $Tau^2 = 0.08$; $Chi^2 = 6.66$, $df = 3$ ($P = 0.08$); $I^2 = 55\%$

Test for overall effect: $Z = 0.87$ ($P = 0.38$)

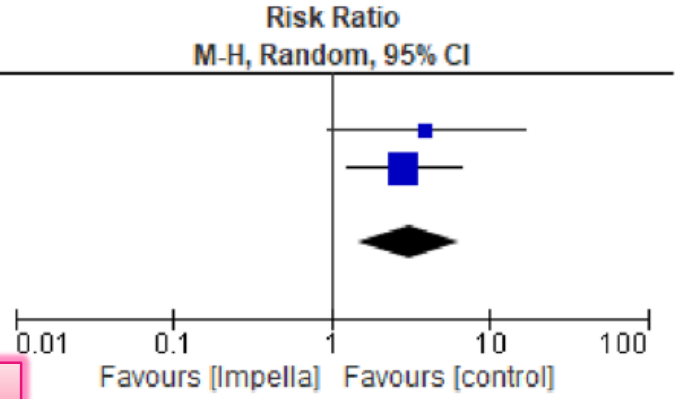


No difference in Mortality

Impella vs IABP meta-analysis

Study or Subgroup	Impella Events	Impella Total	Control Events	Control Total	Weight	Risk Ratio M-H, Random, 95% CI	Year
ISAR-SHOCK	0	13	0	13		Not estimable	2008
IMPRESS in Severe Shock	8	24	2	24	25.4%	4.00 [0.95, 16.92]	2017
Schrage 2018	20	237	7	237	74.6%	2.86 [1.23, 6.63]	2018
Total (95% CI)		**274**		**274**	**100.0%**	**3.11 [1.50, 6.44]**	
Total events	28		9				

Heterogeneity: Tau² = 0.00; Chi² = 0.16, df = 1 (P = 0.69); I² = 0%
Test for overall effect: Z = 3.06 (P = 0.002)

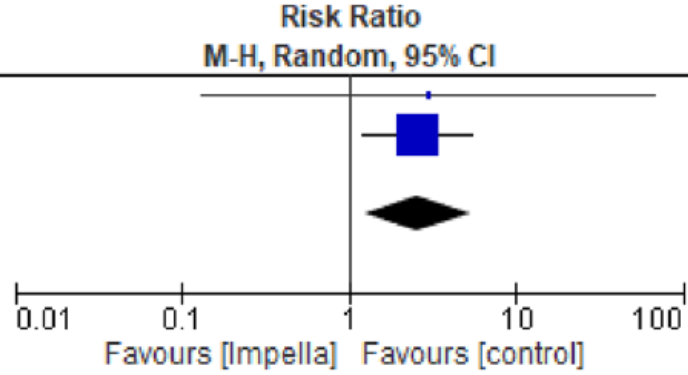


Impella more bleeding

Fig. 3 Forest plot showing risk estimates for short-term major bleeding

Study or Subgroup	Impella Events	Impella Total	Control Events	Control Total	Weight	Risk Ratio M-H, Random, 95% CI	Year
ISAR-SHOCK	1	13	0	13	5.5%	3.00 [0.13, 67.51]	2008
Schrage 2018	23	237	9	237	94.5%	2.56 [1.21, 5.41]	2018
Total (95% CI)		**250**		**250**	**100.0%**	**2.58 [1.24, 5.34]**	
Total events	24		9				

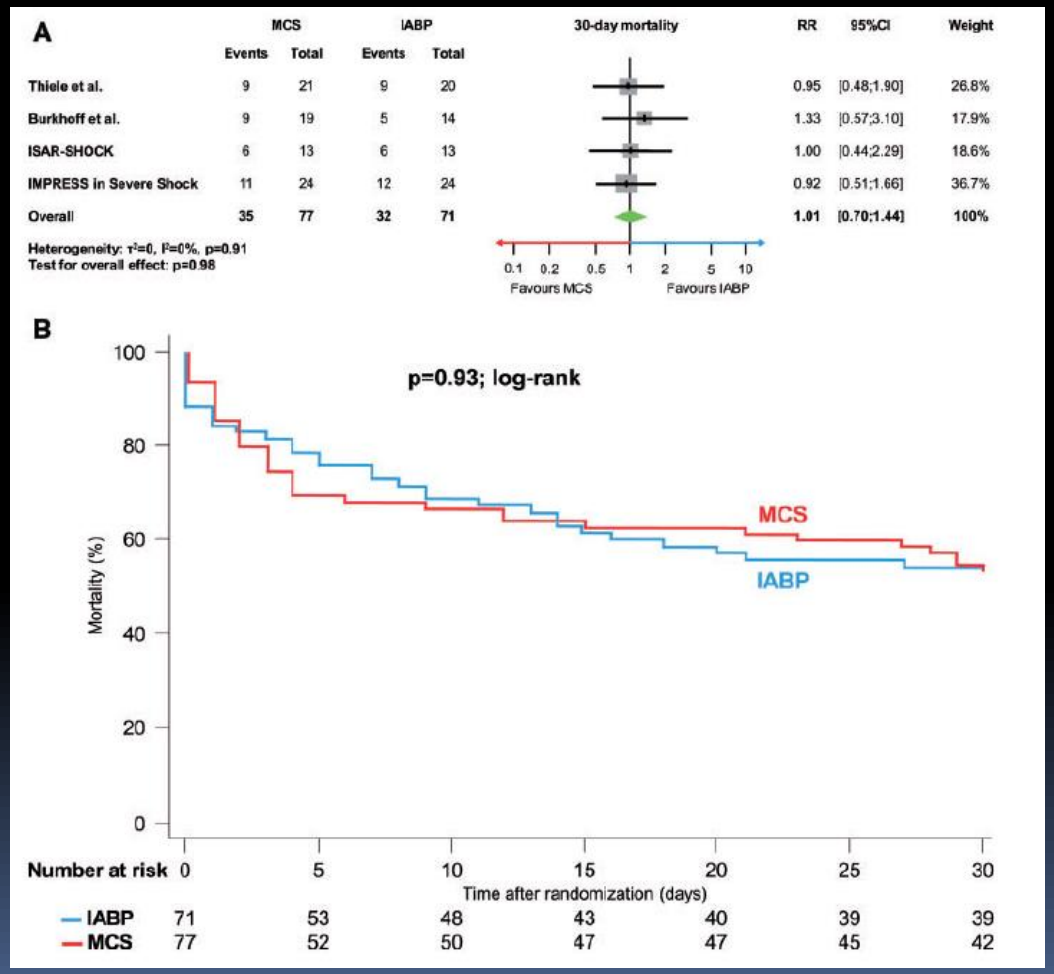
Heterogeneity: Tau² = 0.00; Chi² = 0.01, df = 1 (P = 0.92); I² = 0%
Test for overall effect: Z = 2.55 (P = 0.01)

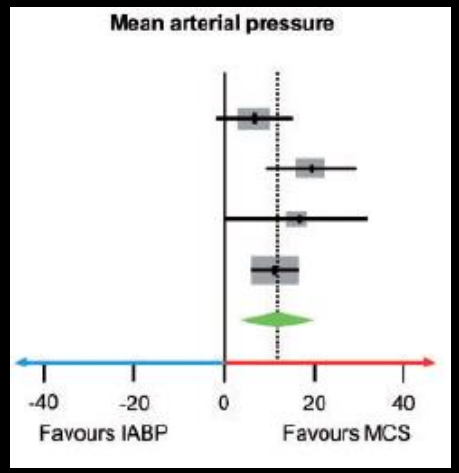


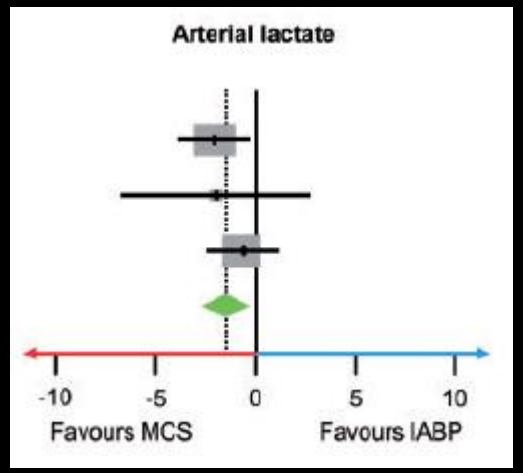
Impella more peripheral ischemic complications

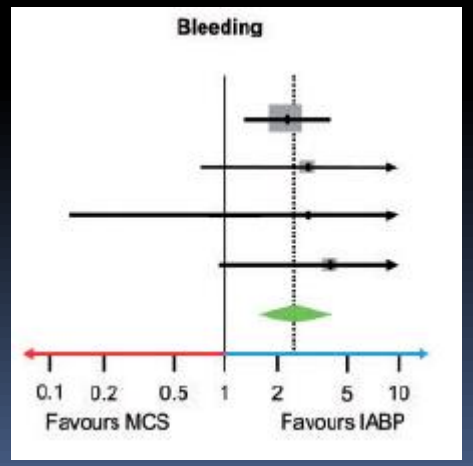
Fig. 4 Forest plot show

Impella/Tandem Heart vs IABP Meta-analysis



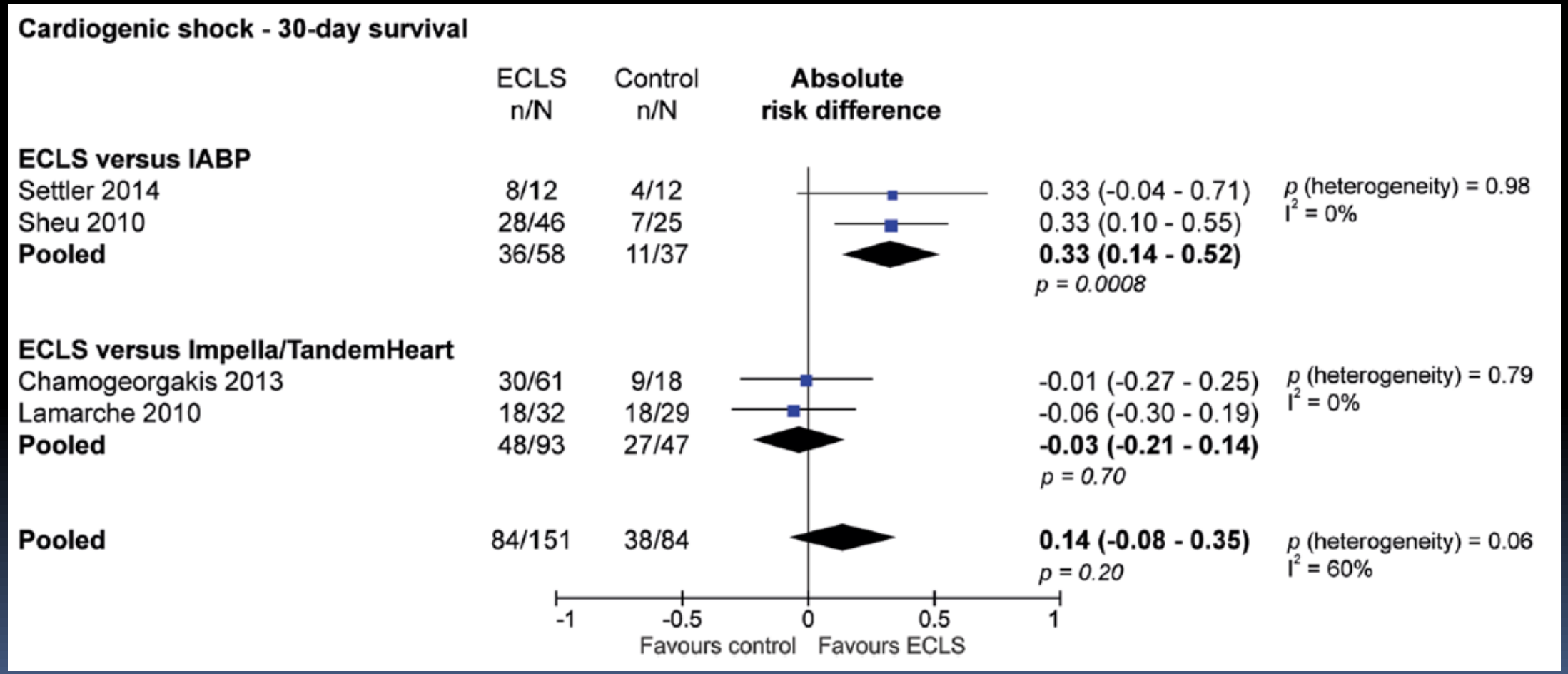






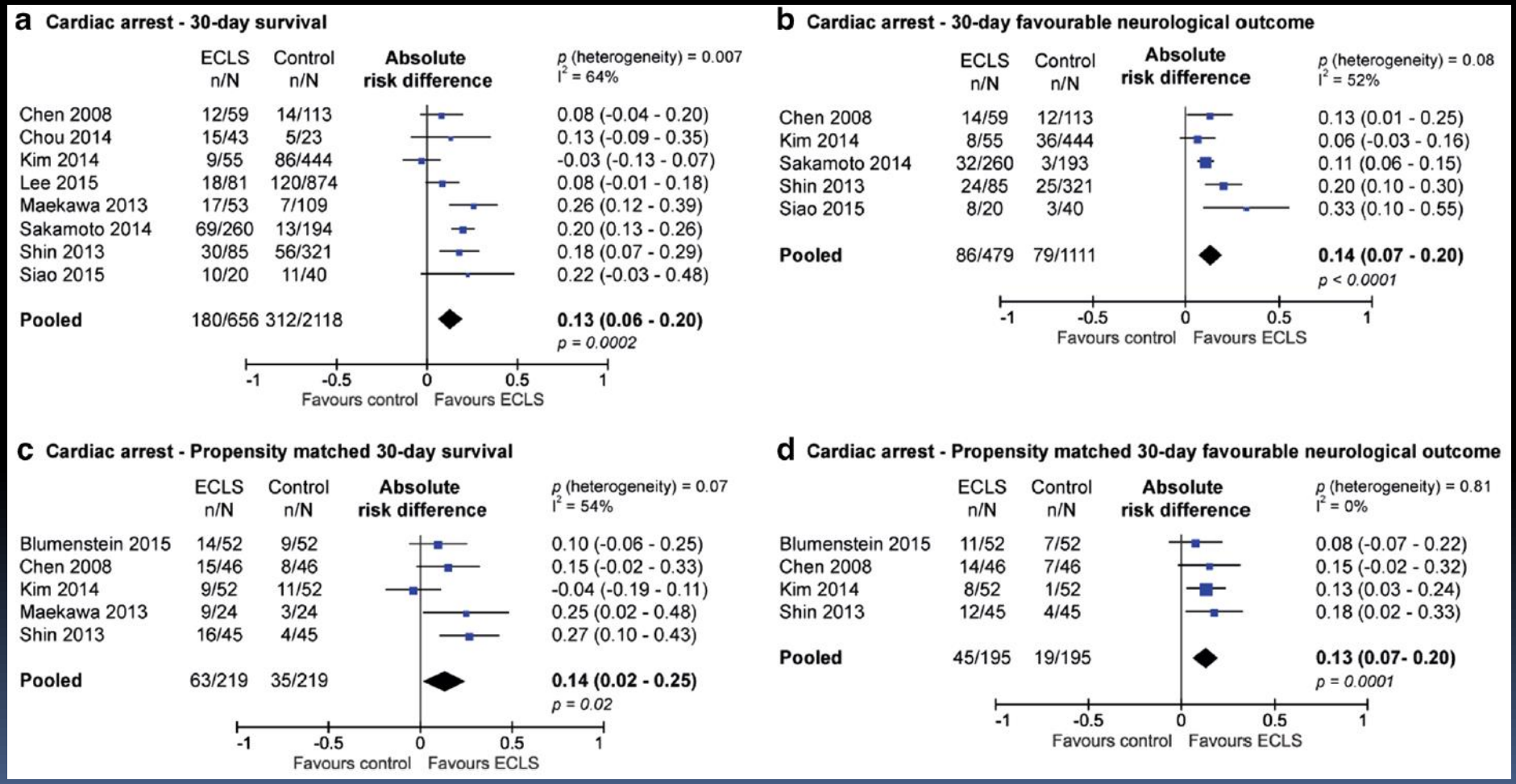
Eur Heart J. 2017 Dec 14;38(47):3523-3531.

ECMO vs IABP or Impella/Tandem Heart



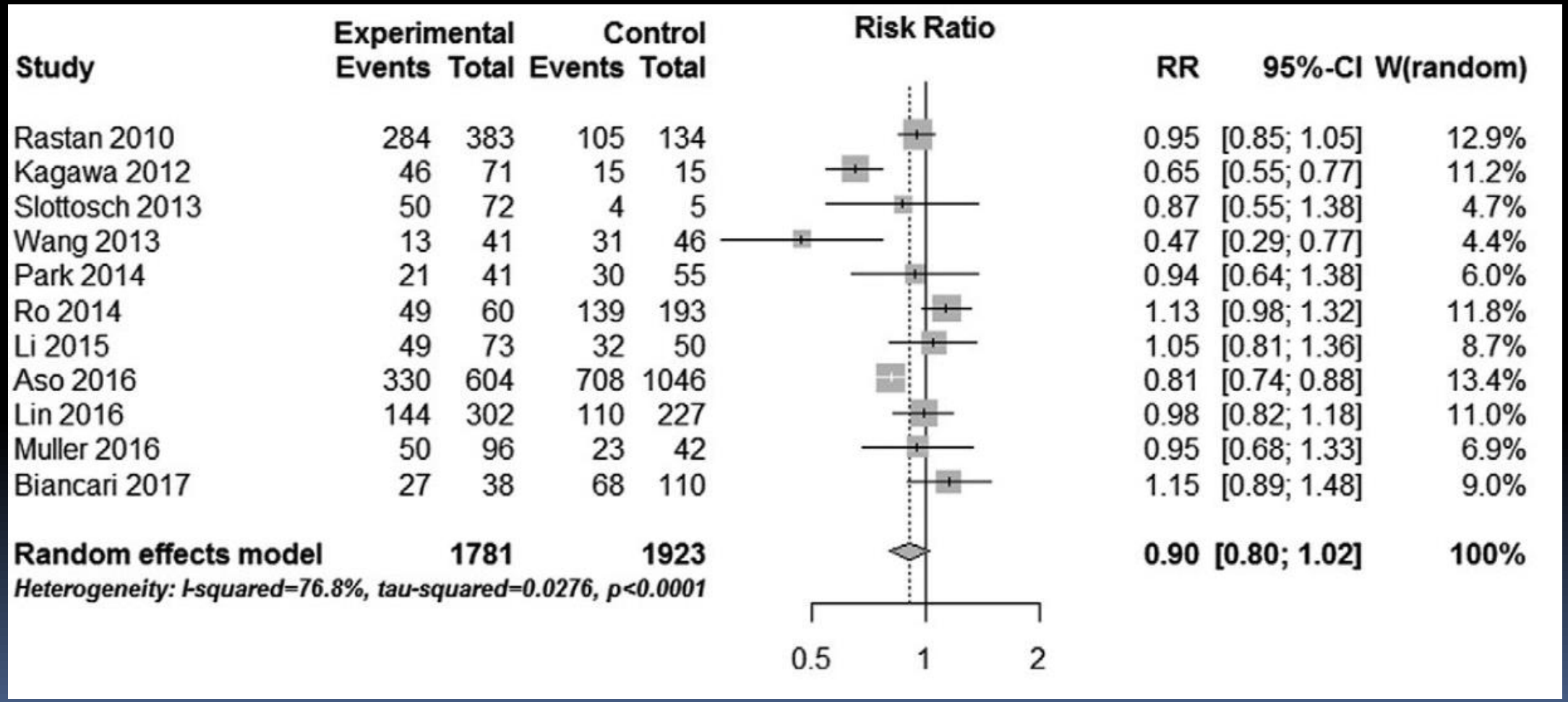
Intensive Care Med (2016) 42:1922–1934

ECPR vs CPR Meta-analysis



Intensive Care Med (2016) 42:1922–1934

ECMO + IABP vs ECMO meta-analysis

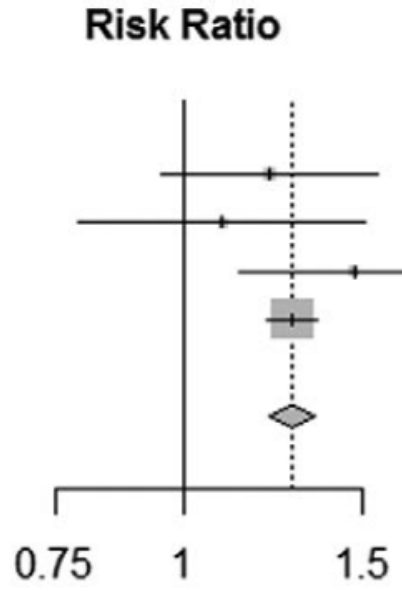


Artif Organs. 2018 Nov 28. doi: 10.1111/aor.13397. [Epub ahead of print]

ECMO + IABP vs ECMO meta-analysis

Study	Experimental Events	Experimental Total	Control Events	Control Total	RR	95%-CI	W(random)
Doll 2004	93	144	40	75	1.21	[0.95; 1.55]	4.7%
Park 2014	26	41	32	55	1.09	[0.79; 1.51]	2.7%
Ro 2014	37	60	81	193	1.47	[1.13; 1.90]	4.2%
Aso 2016	505	604	685	1046	1.28	[1.21; 1.35]	88.4%
Random effects model		**849**		**1369**	**1.28**	**[1.21; 1.35]**	**100%**

Heterogeneity: I-squared=0%, tau-squared=0, p=0.5263



Artif Organs. 2018 Nov 28. doi: 10.1111/aor.13397. [Epub ahead of print]

Conclusion
Different properties and evidence

- Cardiac arrest
  - VA-ECMO as ECPR
- AMI Cardiogenic shock
  - PCI done → Consider Impella/VA-ECMO (especially with cardiac arrest)
  - Lytic → IABP first → escalate if needed
- Decompensated chronic heart failure
  - IABP first line → escalate if needed
- RV failure
  - VA-ECMO
  - *May consider Impella RP*

THANK YOU!