Hemodynamic Support for CHIP

CHIP: Updated Insight

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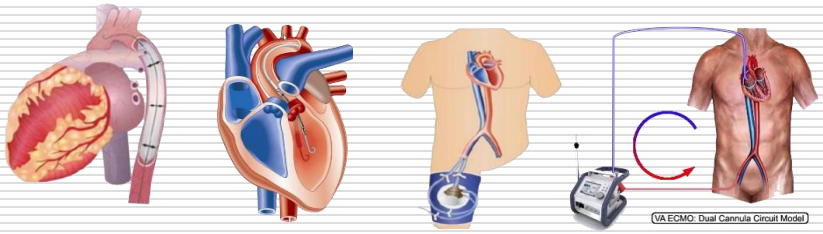
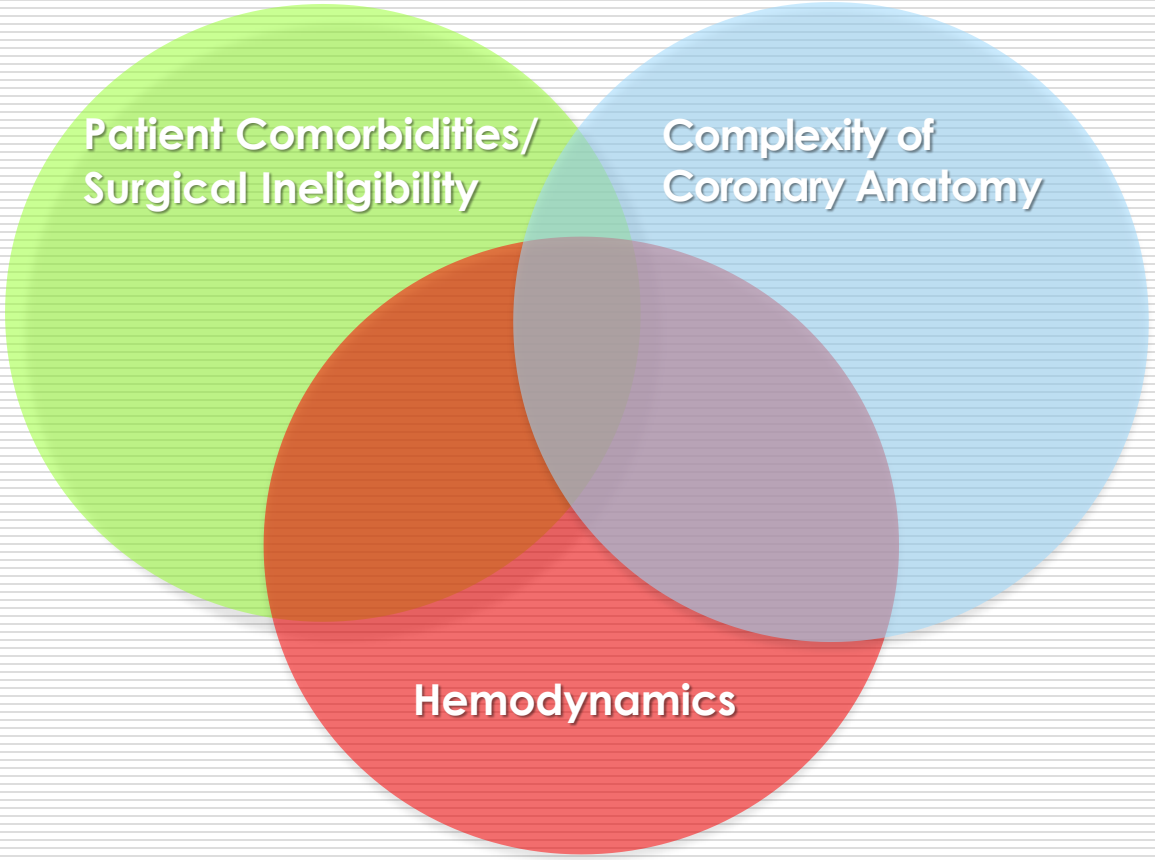


CHIP (Complex, Higher-risk, and Indicated Patients)

1. Acute Coronary Syndrome
2. Prior CABG
3. Heart failure
4. Atrial fibrillation
5. Advanced age
6. Diabetes
7. Renal failure
8. COPD
9. Peripheral vascular disease

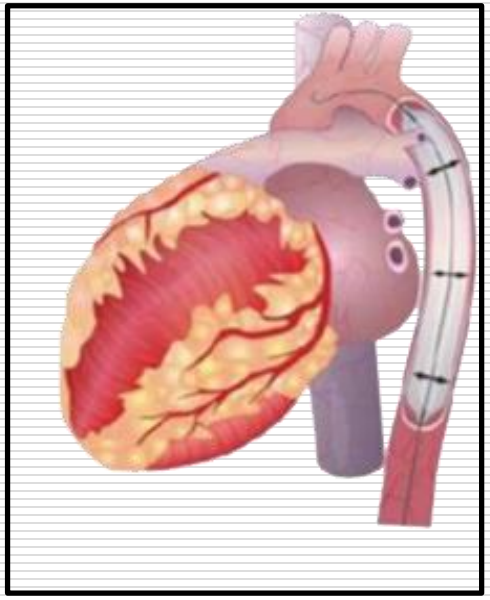


1. CTO
2. Bifurcation
3. Left Main
4. SVG
5. Thrombus
6. Calcification
7. Ostial lesions
8. Multi-vessel disease
9. Small vessel
10. Diffuse disease

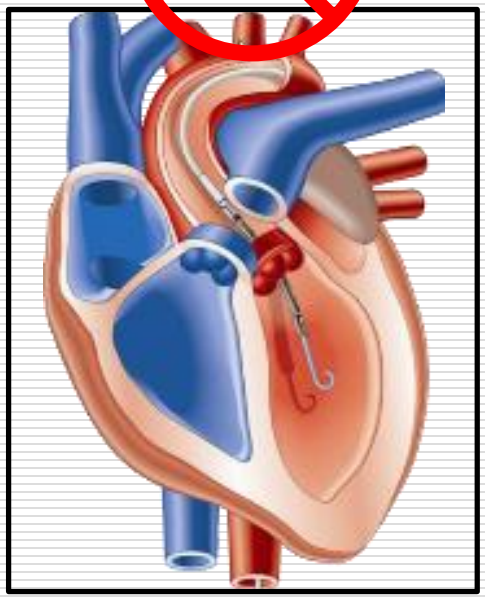
1. Low ejection fraction
2. High filling pressures

LV Percutaneous Hemodynamic Support Devices

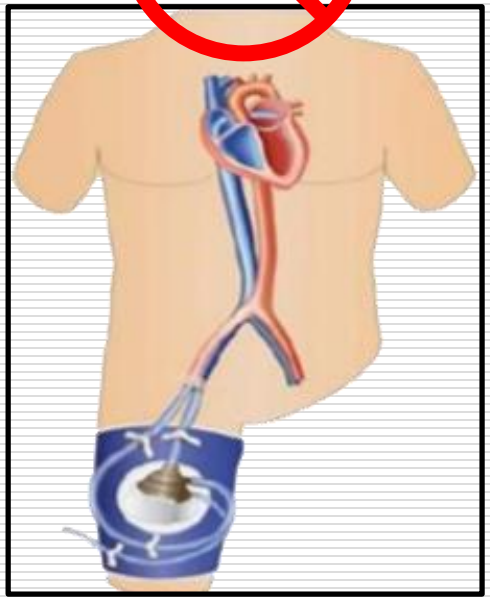
IAPB



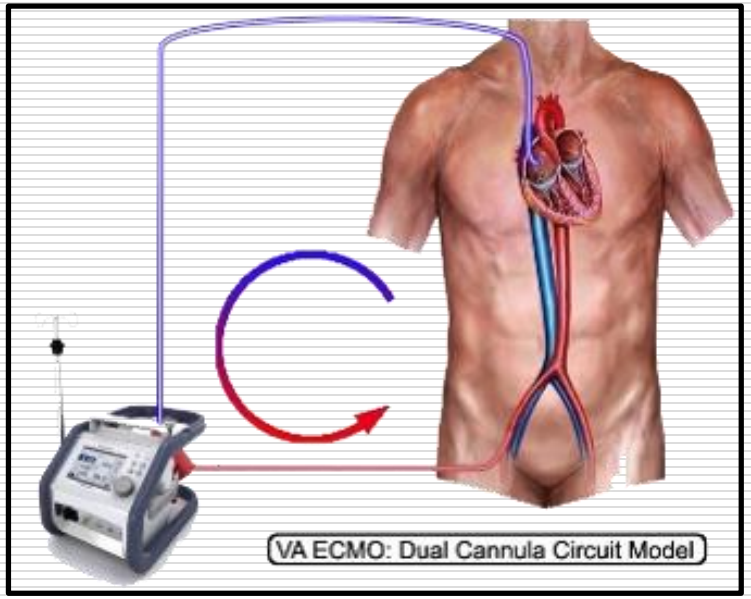
Impella



Tandem Heart

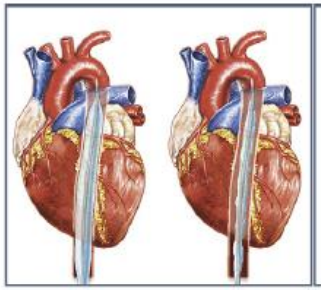
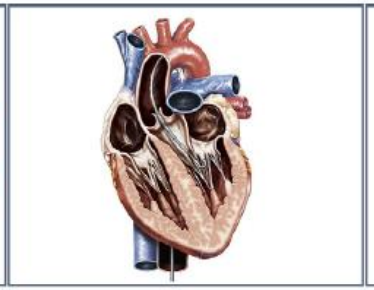


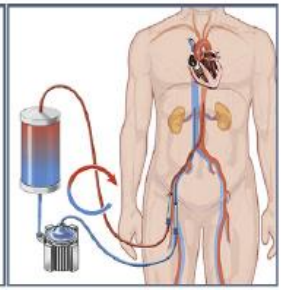
VA ECMO



Curr Treat Options Cardio Med 2016;18:6-19

Comparison of MCS Devices

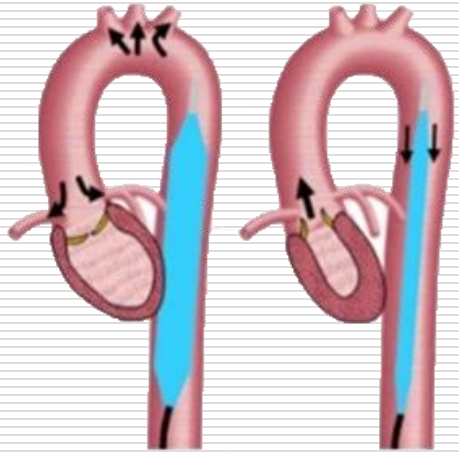



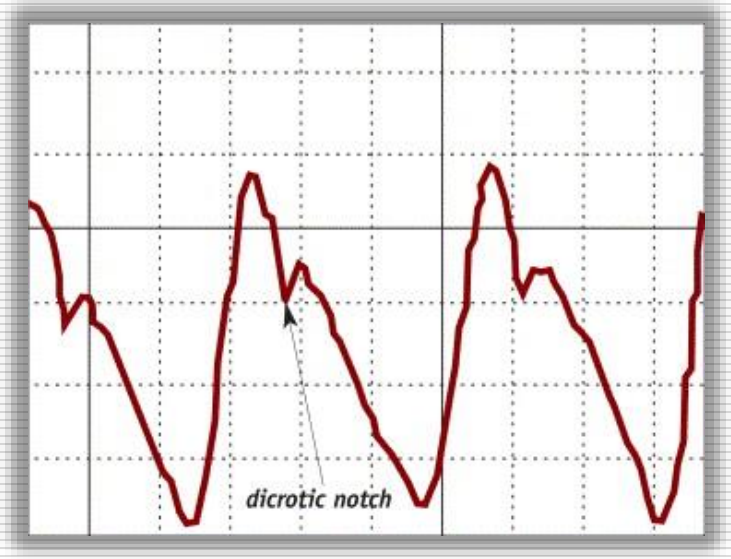


	IABP	IMPELLA	TANDEMHEART	VA-ECMO
Cardiac Flow	0.3-0.5 L/ min	1-5L/ min (Impella 2.5, Impella CP, Impella 5)	2.5-5 L/ min	3-7 L-min
Mechanism	Aorta	LV → AO	LA → AO	RA → AO
Maximum implant days	Weeks	7 days	14 days	Weeks
Sheath size	7-8 Fr	13-14 Fr Impella 5.0 - 21 Fr	15-17 Fr Arterial 21 Fr Venous	14-16 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	↓	↓↓	↔↓	↔

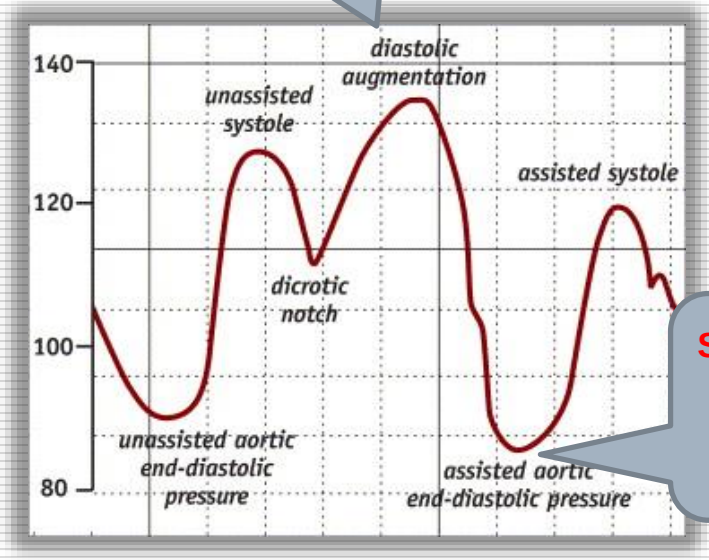
J Am Coll Cardiol Intv 2016;9:871-883

IAPB





Diastolic augmentation which augments coronary and cerebral perfusion



Systolic unloading which reduces LV afterload and augments LV SV

- **Available at nearly all PCI sites**
- **Relatively easy to be inserted (even at bedside)**
- **Most effective in early stages of shock**
- **Counterpulsation needs pulsation**

Intraaortic Balloon Support for Myocardial Infarction with Cardiogenic Shock (IAPB-SHOCK 2 Trial)

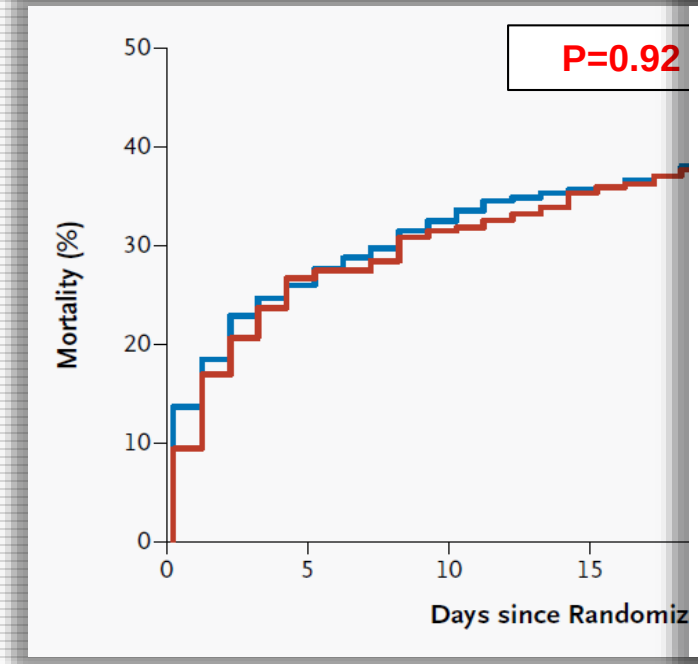
600 Patients with cardiogenic shock complication acute MI.
All patients were expected to undergo early revascularization

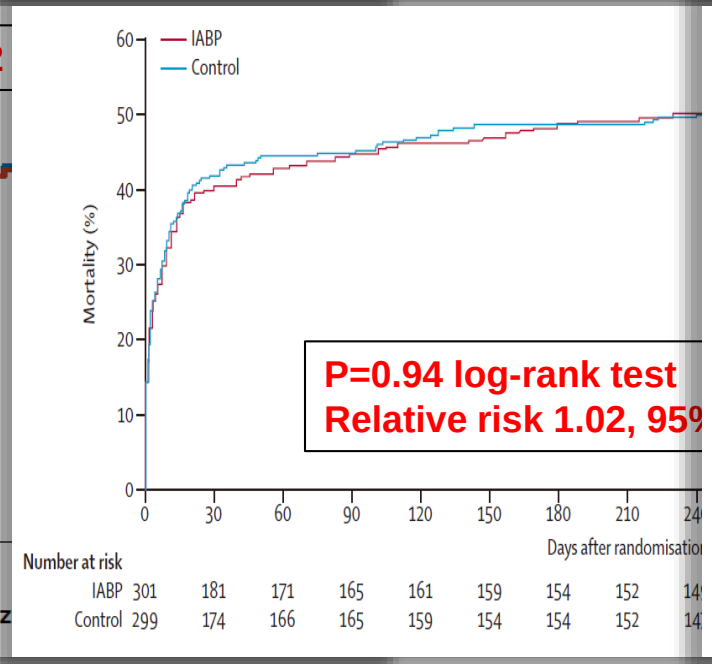
1 → IAPB, n= 301 (300)

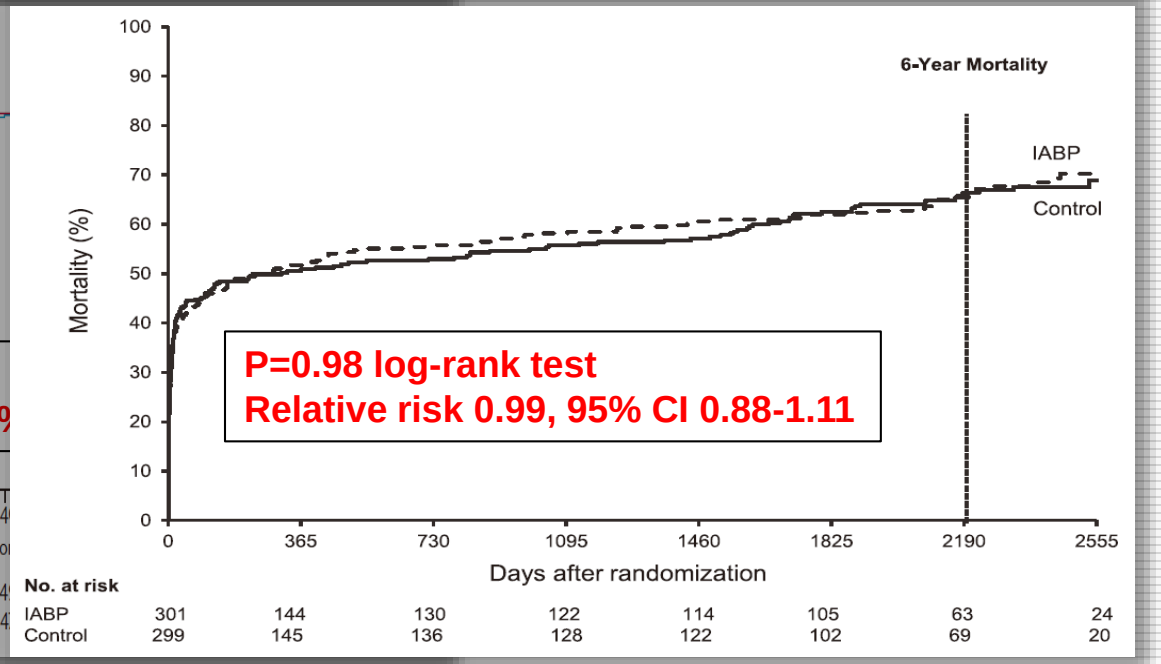
1 → Control, n=299 (298)

- Primary efficacy endpoint : 30-day all-cause mortality
- Safety assessment: major bleeding, peripheral ischemic complications, sepsis, and stroke

Primary efficacy endpoint (30-day a | **12-month all-cause m** | **6-year all-cause mortality**



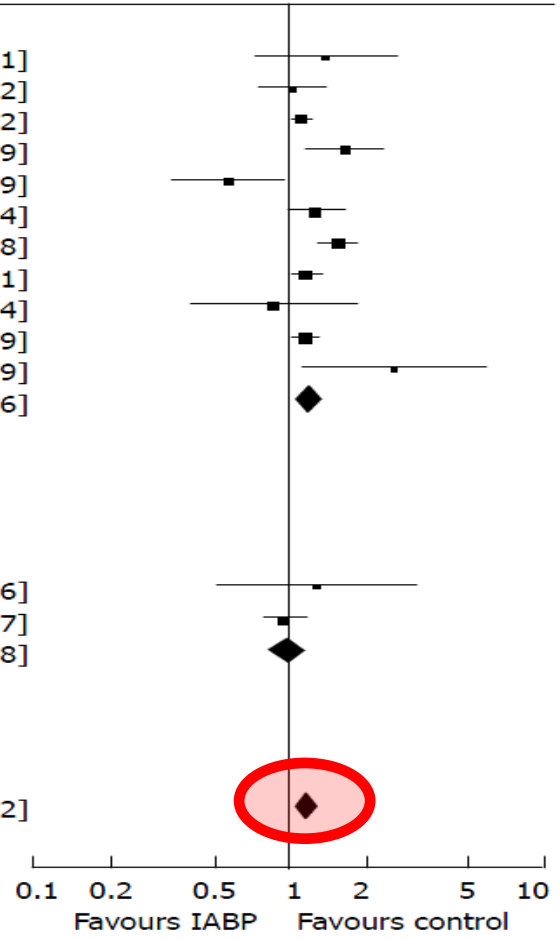




New Engl J Med 2012;367:1287-1296, Lancet 2013; 382:1638-1645, Circulation 2019;139:395-403.

Meta-Analysis on the Risk of In-hospital Mortality Between IABP vs. Medical Therapy in AMICS

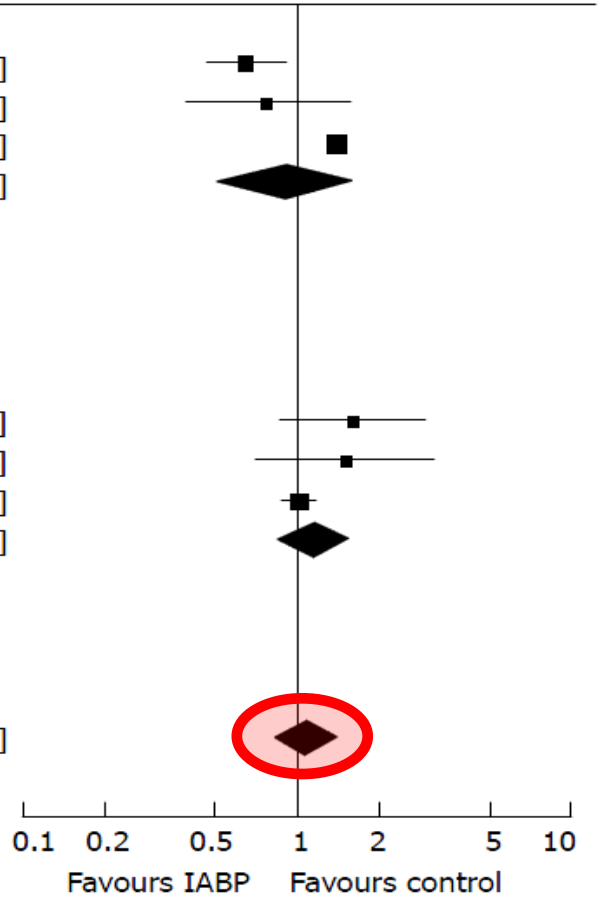
Subgroup/study	IABP Events	IABP Total	Control Events	Control Total	Weight	Risk ratio M-H, Random, 95%CI
Observational studies						
Anderson, 1997 (GUSTO-I)	13	21	7	16	2.3%	1.41 [0.74, 2.71]
Sanborn, 2000 (SHOCK Registry)	120	304	30	79	7.0%	1.04 [0.76, 1.42]
Barron, 2001 (NRMI-2)	956	2035	401	955	15.9%	1.12 [1.02, 1.22]
Vis, 2007 (AMC CS)	93	199	26	93	5.9%	1.67 [1.17, 2.39]
Gu, 2010	13	43	25	48	3.3%	0.58 [0.34, 0.99]
Stub, 2011	108	251	54	159	8.7%	1.27 [0.98, 1.64]
Zeymer, 2011 (EHS-PCI Registry)	92	162	177	491	11.8%	1.58 [1.32, 1.88]
Zeymer, 2013 (ALKK-PCI Registry)	212	487	534	1426	14.4%	1.16 [1.03, 1.31]
Dziewierz, 2014 (EUROTRANSFER Registry)	10	30	8	21	1.8%	0.88 [0.42, 1.84]
Kim, 2015 (KAMIR)	242	425	387	789	15.0%	1.16 [1.04, 1.29]
Suzuki, 2015	31	84	5	35	1.4%	2.58 [1.10, 6.09]
Subtotal (95%CI)		4041		4112	87.5%	1.21 [1.08, 1.36]
Total events	1890		1654			
Heterogeneity: Tau^2 = 0.02, χ^2 = 27.18, df = 10 (P = 0.002); I^2 = 63%						
Test for overall effect: Z = 3.36 (P = 0.0008)						
RCTs						
Prondinsky, 2010 (IABP-SHOCK Ⅰ)	7	19	6	21	1.3%	1.29 [0.53, 3.16]
Thiele, 2012 (IABP-SHOCK Ⅱ)	119	300	123	298	11.2%	0.96 [0.79, 1.17]
Subtotal (95%CI)		319		319	12.5%	0.97 [0.81, 1.18]
Total events	126		129			
Heterogeneity: Tau^2 = 0.00, χ^2 = 0.39, df = 1 (P = 0.53); I^2 = 0%						
Test for overall effect: Z = 0.27 (P = 0.78)						
Total (95%CI)		4360		4431	100.00%	1.18 [1.06, 1.32]
Total events	2016		1783			
Heterogeneity: Tau^2 = 0.02, χ^2 = 31.29, df = 12 (P = 0.002); I^2 = 62%						
Test for overall effect: Z = 3.12 (P = 0.002)						
Test for subgroup differences: χ^2 = 3.83, df = 1 (P = 0.05), I^2 = 73.9%						



World J Cardiol 2016;8:98-111

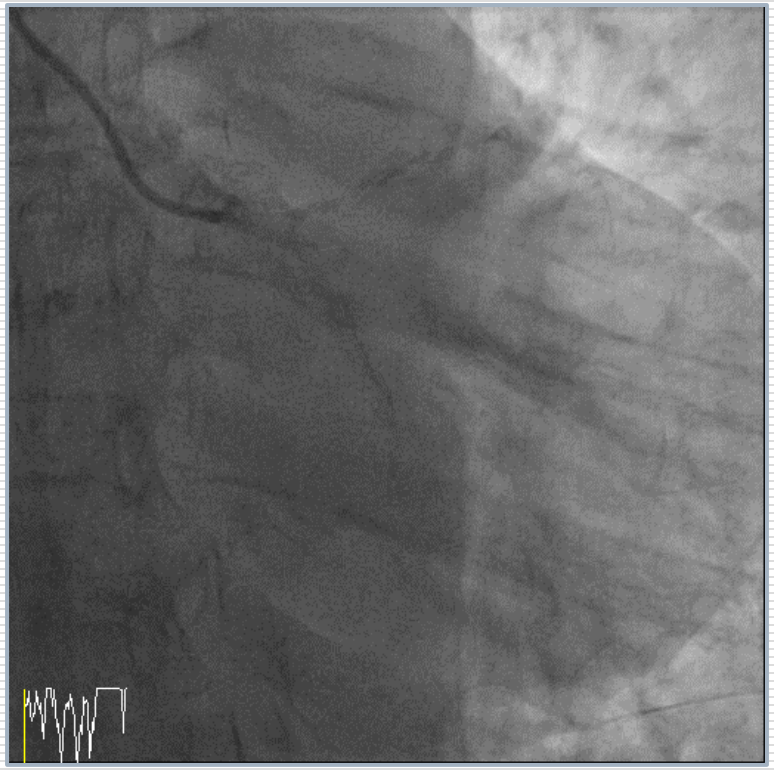
Meta-Analysis on the Risk of Late Mortality Between IABP vs. Medical Therapy in AMICS

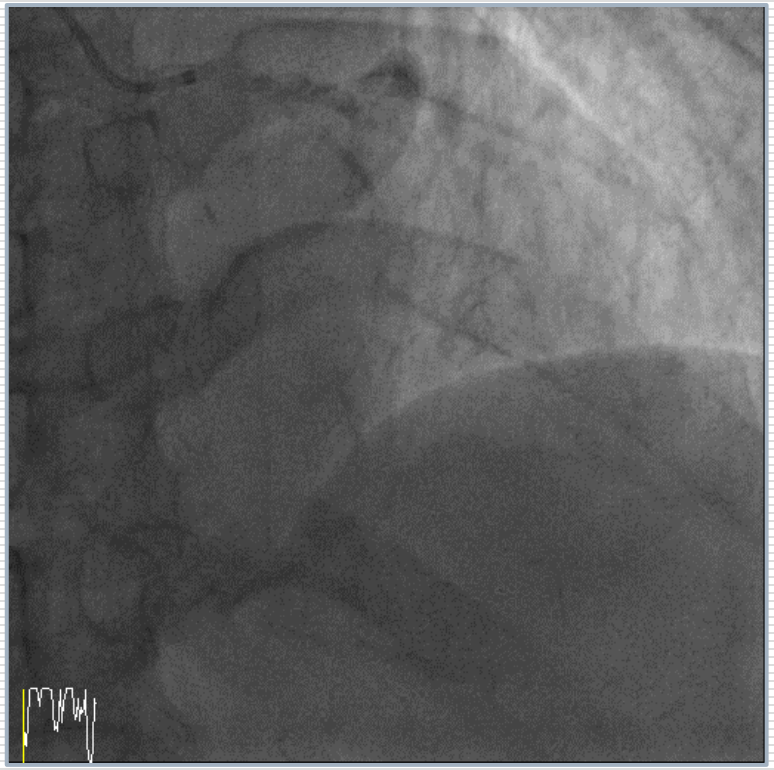
Subgroup/study	IABP Events	IABP Total	Control Events	Control Total	Weight	Risk ratio M-H, Random, 95%CI
Observational studies						
Gu, 2010	21	43	36	48	18.8%	0.65 [0.46, 0.92]
Dziewierz, 2014	10	30	9	21	9.7%	0.78 [0.38, 1.58]
Kunadian, 2015 (BCIS Registry)	1547	2971	1186	3149	26.6%	1.38 [1.31, 1.46]
Subtotal (95%CI)		3044		3218	55.1%	0.92 [0.51, 1.67]
Total events	1578		1231			
Heterogeneity: $Tau^2 = 0.23$, $\chi^2 = 20.01$, df = 2 ($P < 0.0001$); $I^2 = 90\%$						
Test for overall effect: $Z = 0.28$ ($P = 0.78$)						
RCTs						
French, 2003 (SHOCK Trial)	74	132	7	20	11.4%	1.60 [0.87, 2.97]
Prondinsky, 2010 (IABP-SHOCK Ⅰ)	9	16	6	16	8.7%	1.50 [0.70, 3.23]
Thiele, 2012 (IABP-SHOCK Ⅱ)	155	299	152	296	24.8%	1.01 [0.86, 1.18]
Subtotal (95%CI)		447		332	44.9%	1.16 [0.86, 1.58]
Total events	238		165			
Heterogeneity: $Tau^2 = 0.03$, $\chi^2 = 2.93$, df = 2 ($P = 0.23$); $I^2 = 32\%$						
Test for overall effect: $Z = 0.96$ ($P = 0.34$)						
Total (95%CI)		3491		3550	100.0%	1.08 [0.82, 1.41]
Total events	1816		1396			
Heterogeneity: $Tau^2 = 0.07$, $\chi^2 = 32.56$, df = 5 ($P < 0.00001$); $I^2 = 85\%$						
Test for overall effect: $Z = 0.52$ ($P = 0.60$)						
Test for subgroup differences: $\chi^2 = 0.48$, df = 1 ($P = 0.49$), $I^2 = 0\%$						

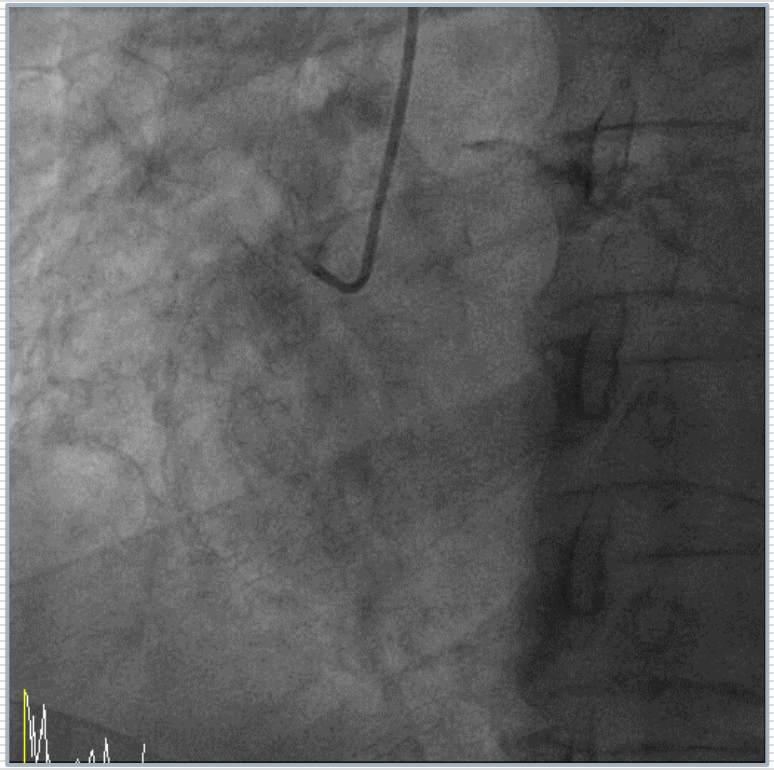


World J Cardiol 2016;8:98-111

Case: 81-Year-Old Female

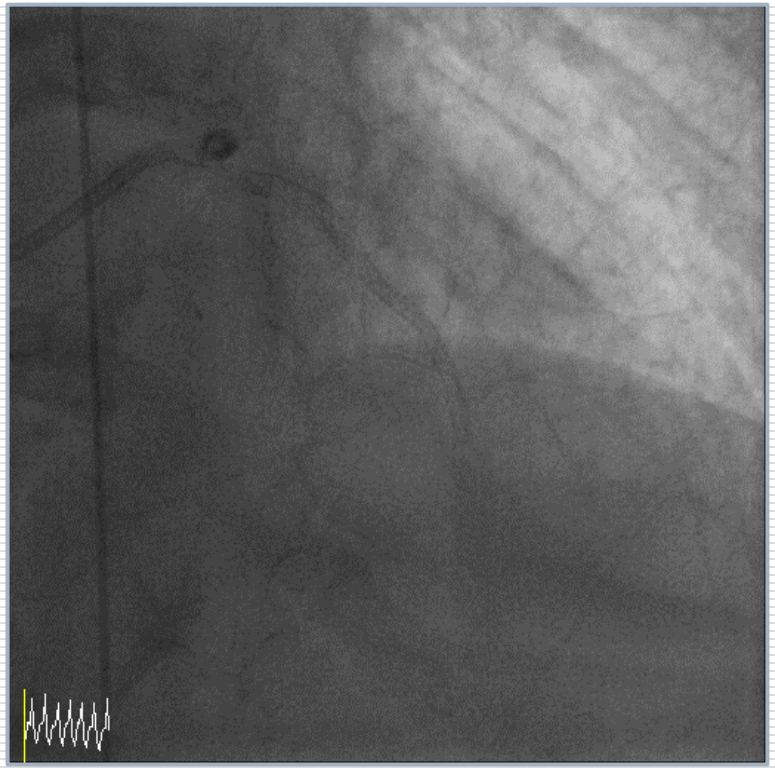


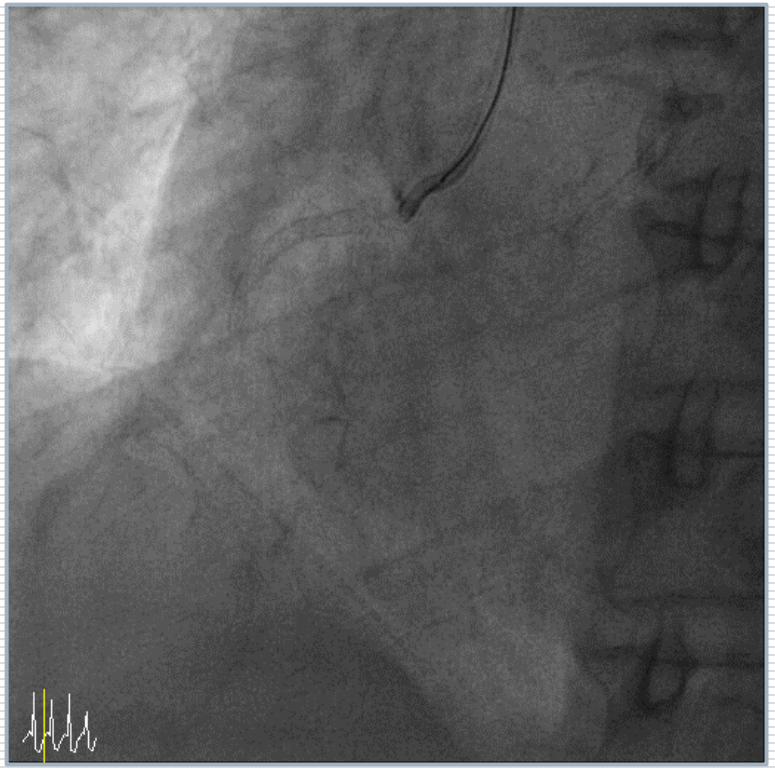




- BP: 110/60 mmHg, HR: 75 bpm
- Unstable angina
- LVEF = 29%
- 3-vessel CAD with unprotected LM disease
- Severe calcification
- Concomitant CTO

Case: 81-Year-Old Female: Elective IABP and PCI





- Elective IABP support
- Trans-radial 6F
- Child-mother technique (Heartfail)
- Buddy-wire cutting

Elective Intra-aortic Balloon Support During High-Risk Percutaneous Coronary Intervention (BCIS-1 Trial)

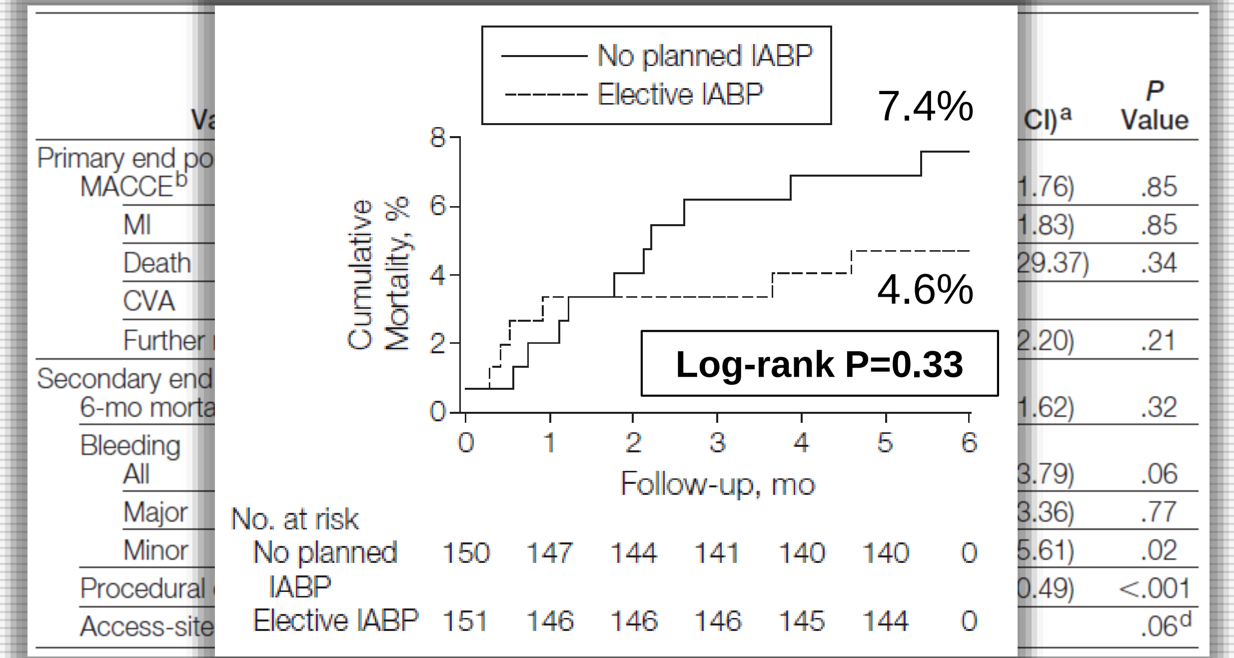
301 Patients with severe LV systolic function (LVEF ≤30%) and extensive coronary disease (Jeopardy score ≥8/12)
28% LM disease

1 Elective IAPB, n= 151

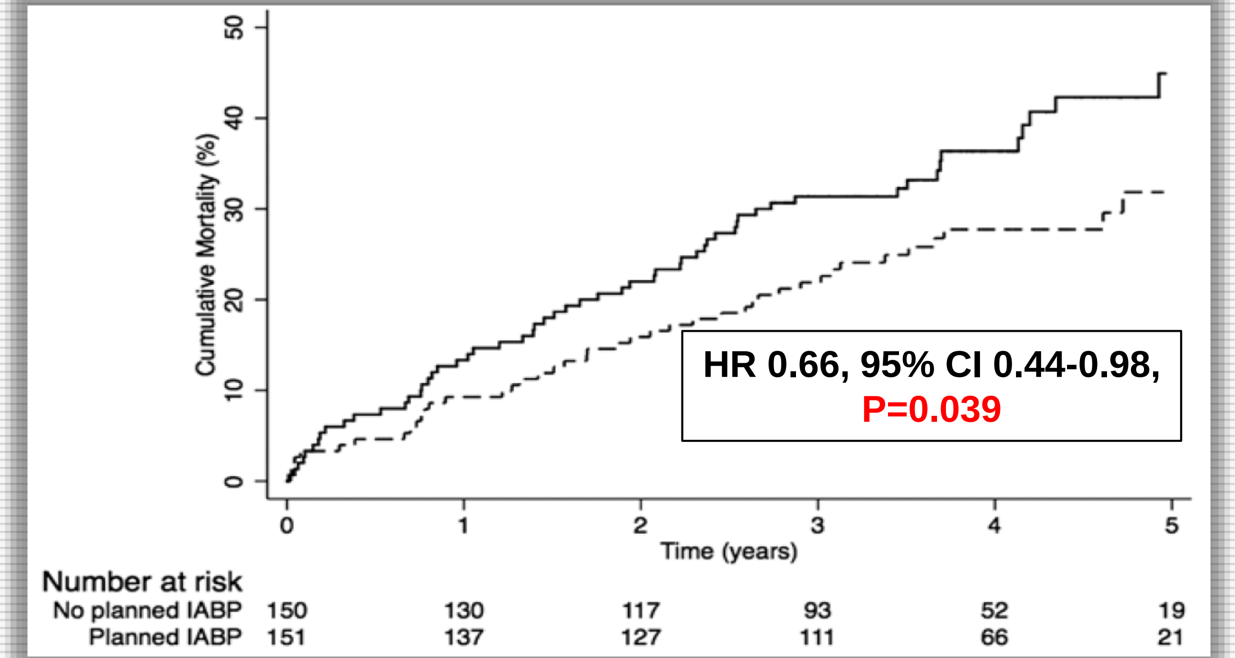
1 No planned IABP, n=150

- Primary endpoint : death, AMI, CV event, or further revascularization at hospital discharge
- Secondary endpoint: 6 month all-cause mortality, major procedural complications

Endpoints

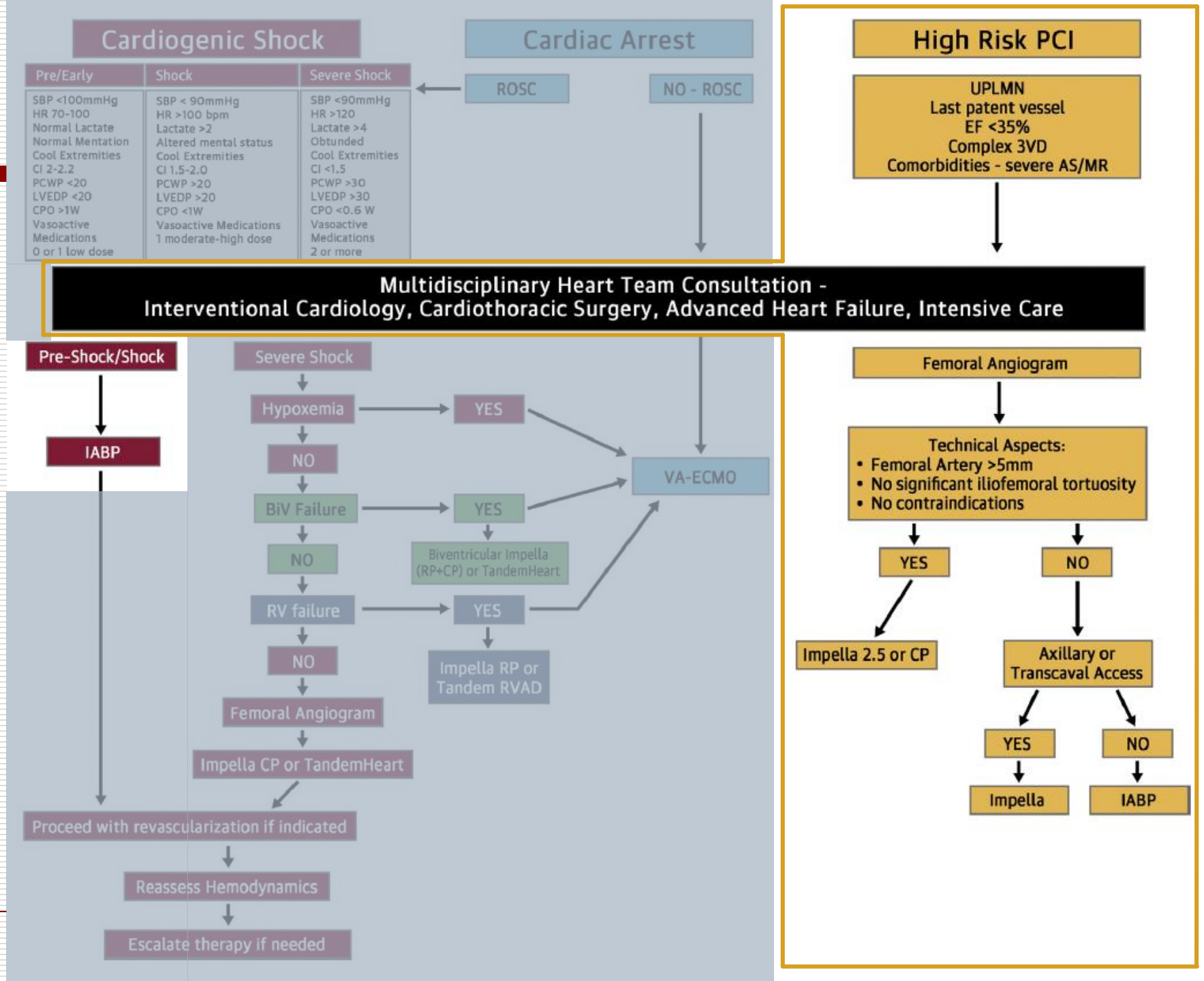


Long-term (median FU 51 months) all-cause mortality



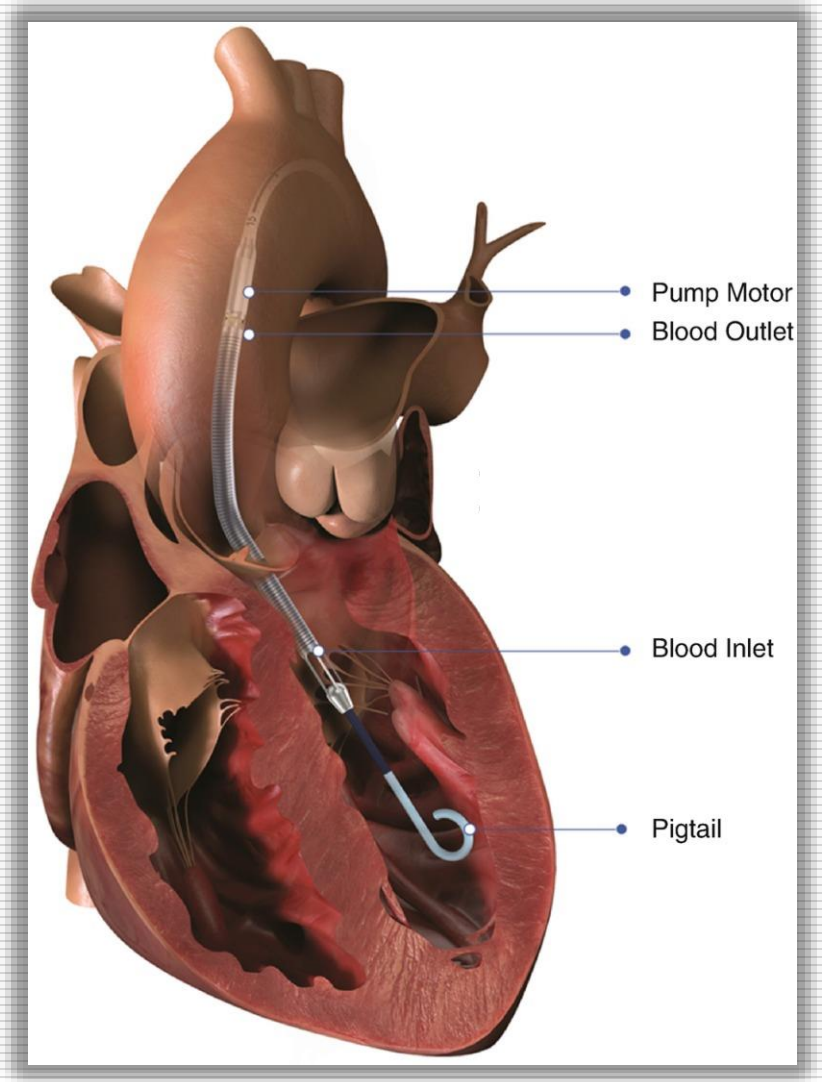
JAMA 2010;304:867-874, Circulatin 2013;127:207-212.

In Whom and When?



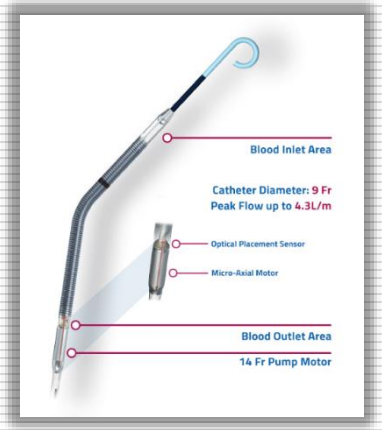
J Am Coll Cardiol Intv 2016;9:871-883

Impella



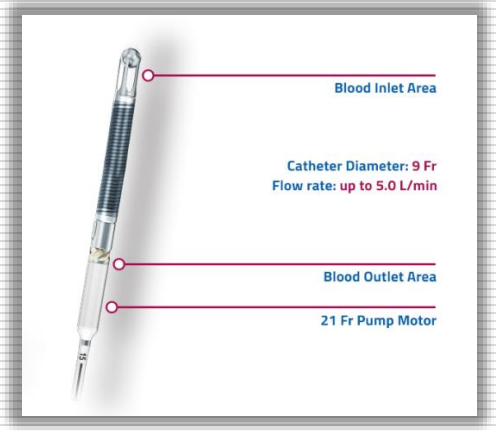
- Catheter-mounted axial flow pump
- Continuously displaces blood from the LV to the ascending aorta
- Increased cardiac index, ventricular unloading, decreased myocardial oxygen consumption, increased coronary perfusion, increased end organ perfusion
- Independent of heart rate or native cardiac function

Impella 2.5®



Impella CP®/ SmartAssist®

Impella 5.0®



Impella LD®

Impella 2.5 Provides A Better Hemodynamic Support Than IABP in AMI Cardiogenic Shock (ISAR-SHOCK)

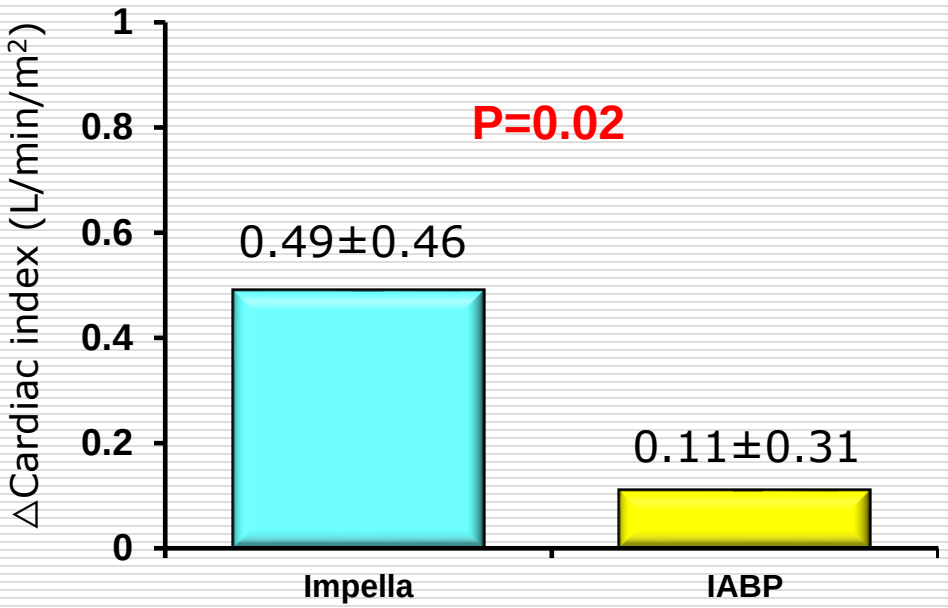
25 Patients with cardiogenic shock caused by myocardial infarction

1 → Impella LP 2.5®, n= 13

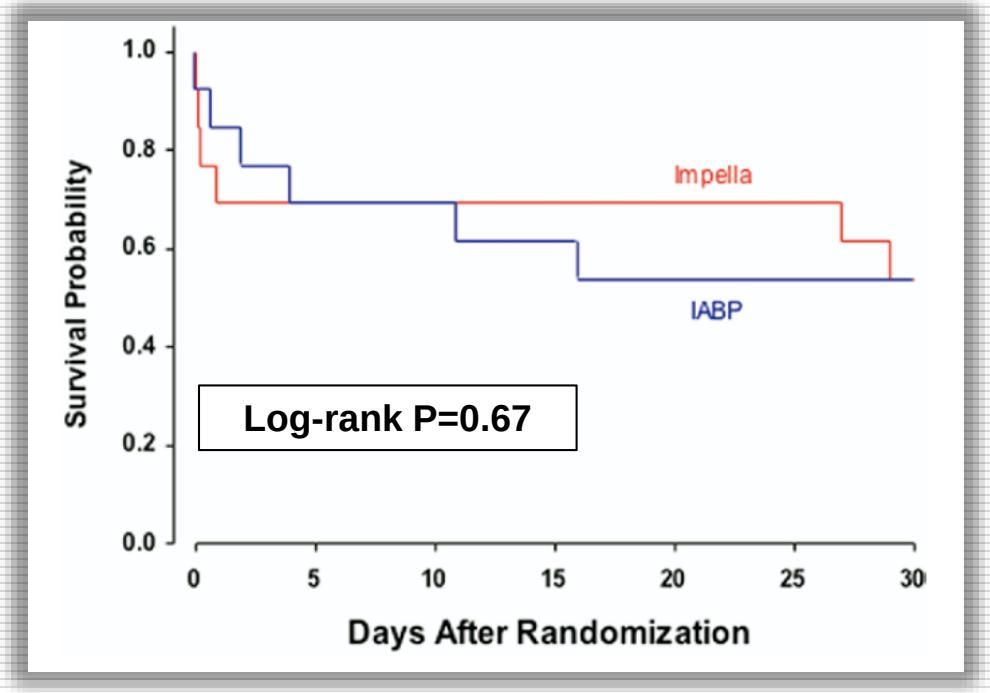
1 → IABP, n=12

- Primary endpoint : change of the cardiac index from baseline to 30 min after implantation
- Secondary endpoints: lactic acidosis, hemolysis, and mortality after 30 days

Primary endpoint



Mortality after 30 days



J Am Coll Cardiol 2008;52:1584-1588

No Mortality Benefit with Impella CP in Comparison with IABP in AMI Cardiogenic Shock (Impress Trial)

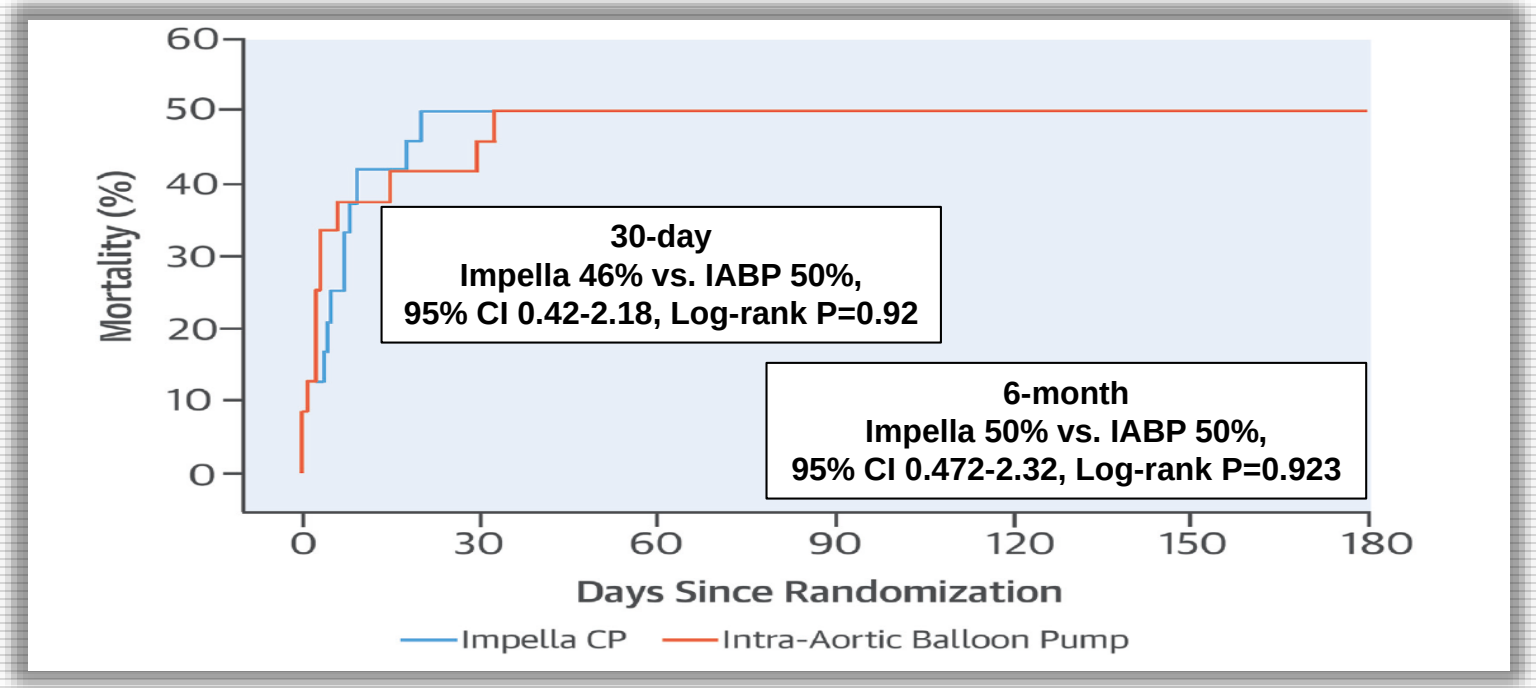
48 Patients with **severe CS** (SBP <90 mmHg or need for inotropic/vasoactive medication and requirement for mechanical ventilation) complicating **AMI**

1 → **Impella CP®, n= 24**

1 → **IABP, n=24**

- Primary endpoint : 30-day all-cause mortality
- Secondary endpoint: 6-month all-cause mortality

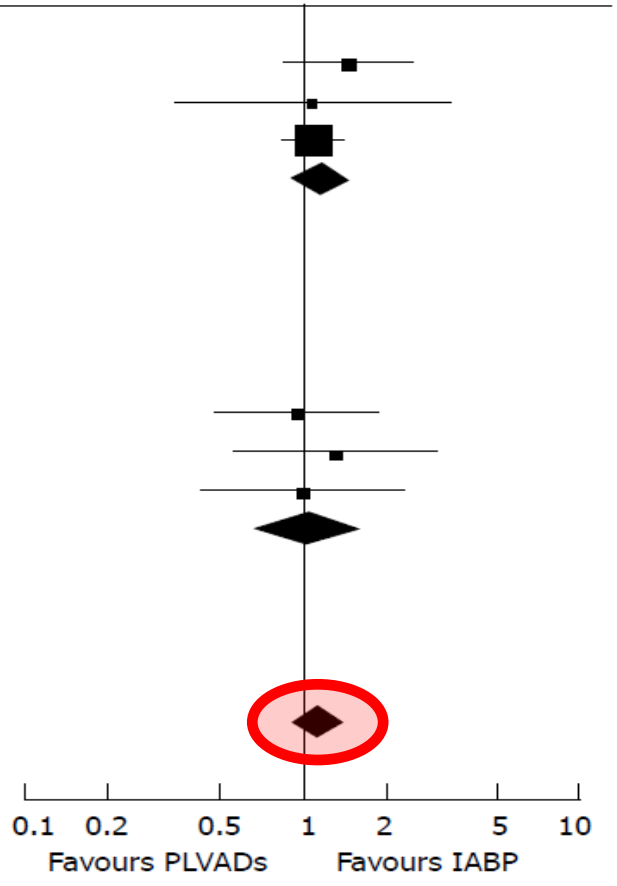
Mortality



J Am Coll Cardiol 2017;69:278-287

Meta-Analysis on the Risk of In-Hospital Mortality Between LVAD vs. IABP in AMICS

Subgroup/study	PLVADs Events	PLVADs Total	IABP Events	IABP Total	Weight	Risk ratio M-H, Random, 95%CI
Observational studies						
Schwartz, 2012	13	26	17	50	14.6%	1.47 [0.85, 2.54]
Shah, 2012	2	4	6	13	3.3%	1.08 [0.35, 3.40]
Manzo-Silberman, 2013	27	35	30	43	60.8%	1.11 [0.85, 1.44]
Subtotal (95%CI)		65		106	78.7%	1.16 [0.92, 1.47]
Total events	42		53			
Heterogeneity: Tau^2 = 0.00, χ^2 = 0.95, df = 2 (P = 0.62); I^2 = 0%						
Test for overall effect: Z =1.27 (P = 0.20)						
RCTs						
Thiele, 2005	9	21	9	20	9.0%	0.95 [0.48, 1.90]
Burkoff, 2006	9	19	5	14	6.0%	1.33 [0.57, 3.10]
Seyfarff, 2008 (ISAR-SHOCK)	6	13	6	13	6.3%	1.00 [0.44, 2.29]
Subtotal (95%CI)		53		47	21.3%	1.06 [0.68, 1.66]
Total events	24		20			
Heterogeneity: Tau^2 = 0.00, χ^2 = 0.38, df = 2 (P = 0.83); I^2 = 0%						
Test for overall effect: Z = 0.26 (P = 0.80)						
Total (95%CI)		118		153	100.0%	1.14 [0.93, 1.41]
Total events	66		73			
Heterogeneity: Tau^2 = 0.00, χ^2 = 1.40, df = 5 (P = 0.92); I^2 = 0%						
Test for overall effect: Z = 1.25 (P = 0.21)						
Test for subgroup differences: χ^2 = 0.13, df = 1 (P = 0.72), I^2 = 0%						



World J Cardiol 2016;8:98-111

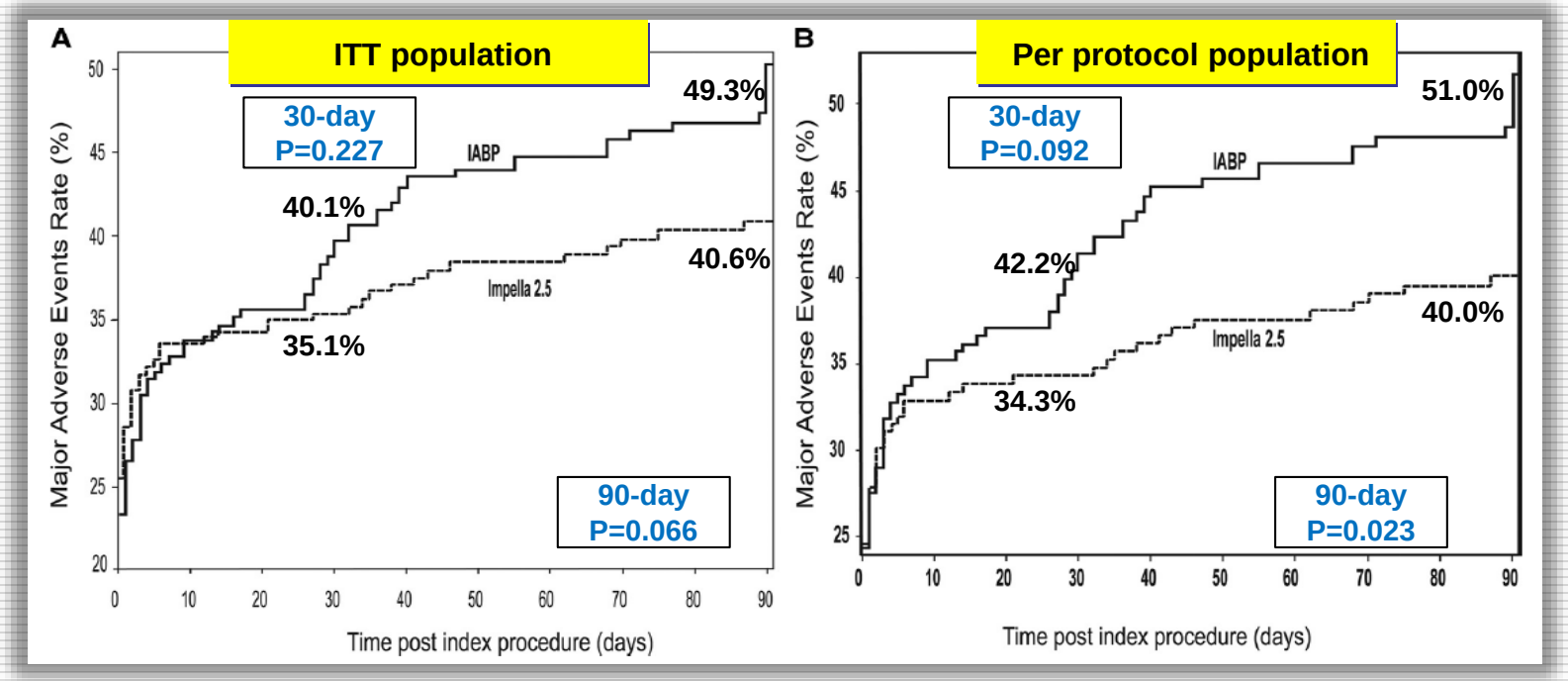
Elective Impella 2.5 vs. IAPB in Patients Undergoing High-Risk Coronary Intervention (PROTECT II Study)

452 Patients with complex 3-vessel disease or unprotected LM disease and severely depressed LV function (LVEF ≤30% or 35%)

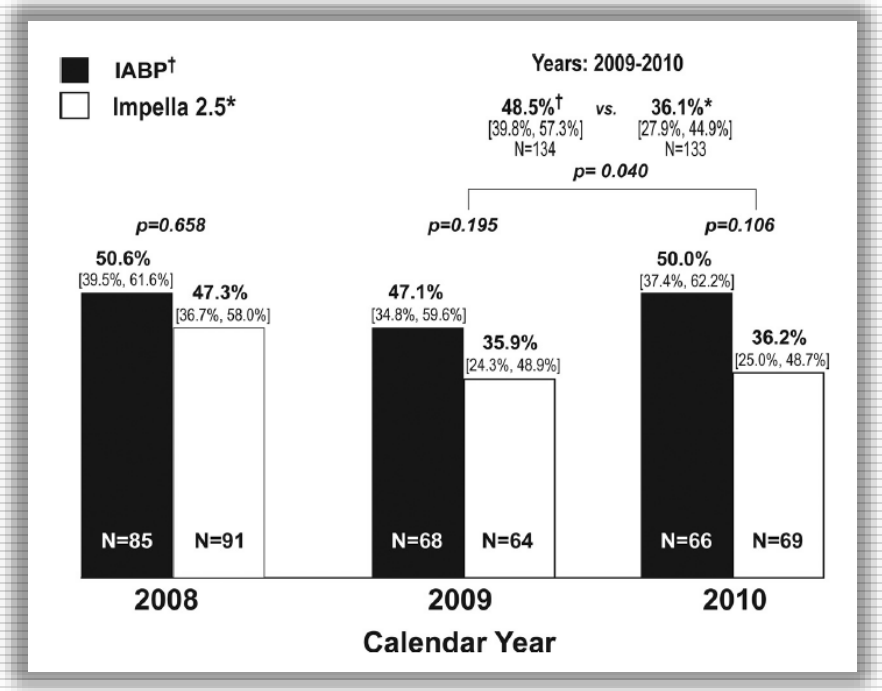
1. Elective Impella 2.5® during non emergent high risk PCI, n= 226
1. Elective IABP during non emergent high risk PCI, n=226

- Primary endpoint : 30-day MACE (death, AMI, stroke or TIA, any repeat revasc., cardiac or vascular op, AKI, severe intraprocedural hypotension, CPR, cardioversion for VT, AR, angiographic failure of PCI)

MACE

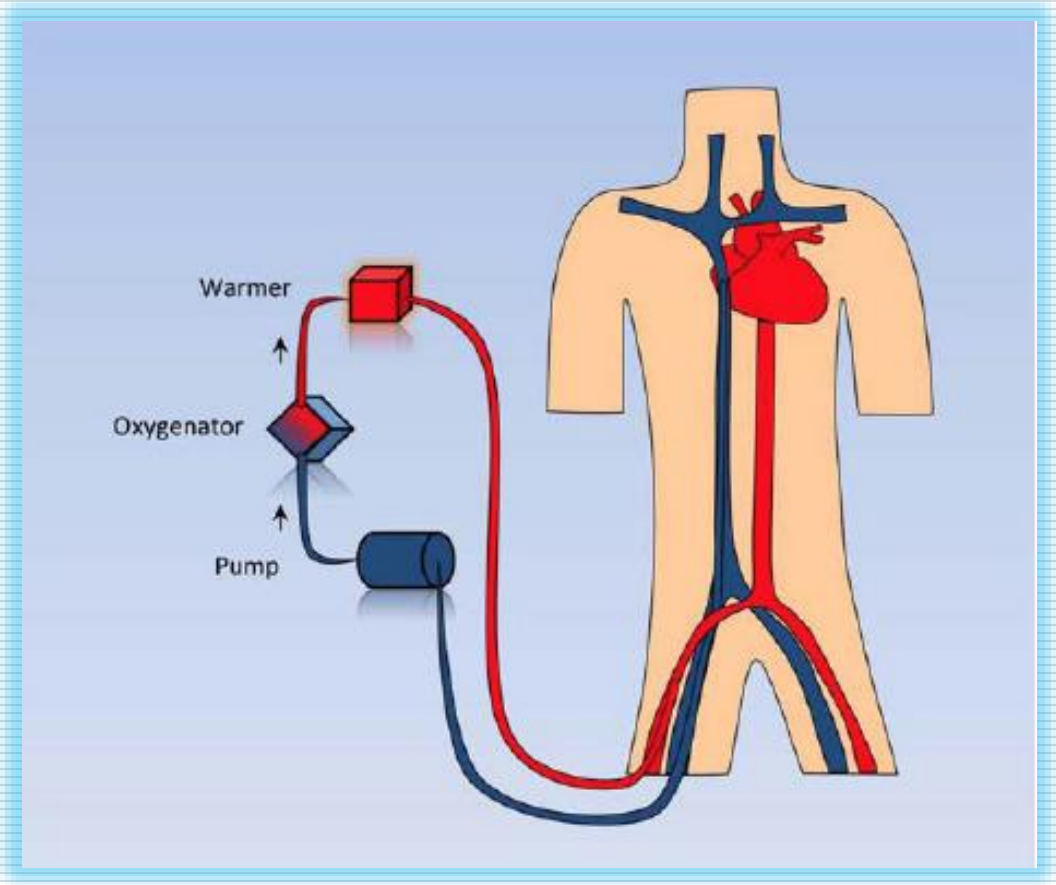


90-day MACE over the course of the trial



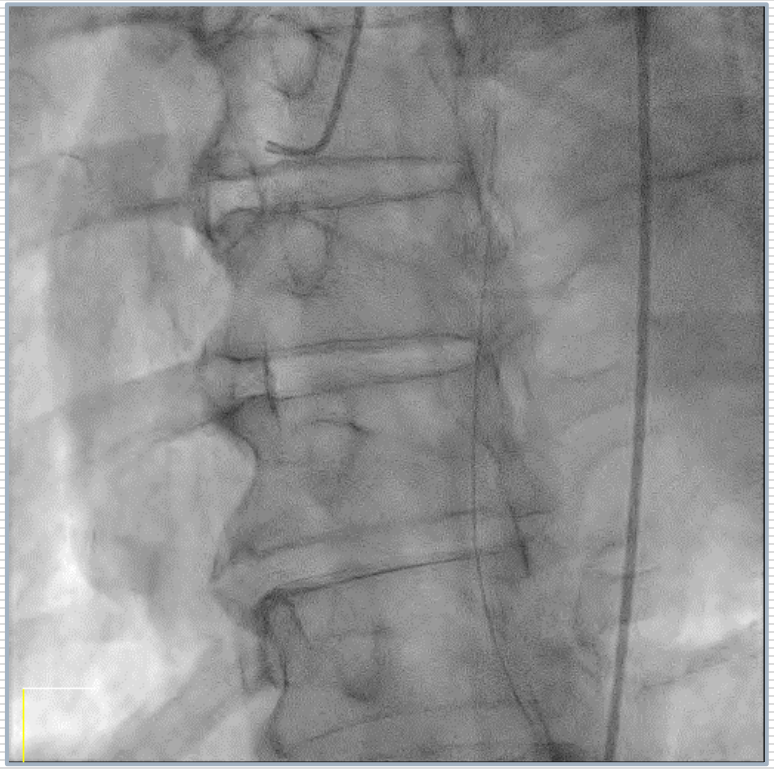
Circulation 2012;126:1717-1727

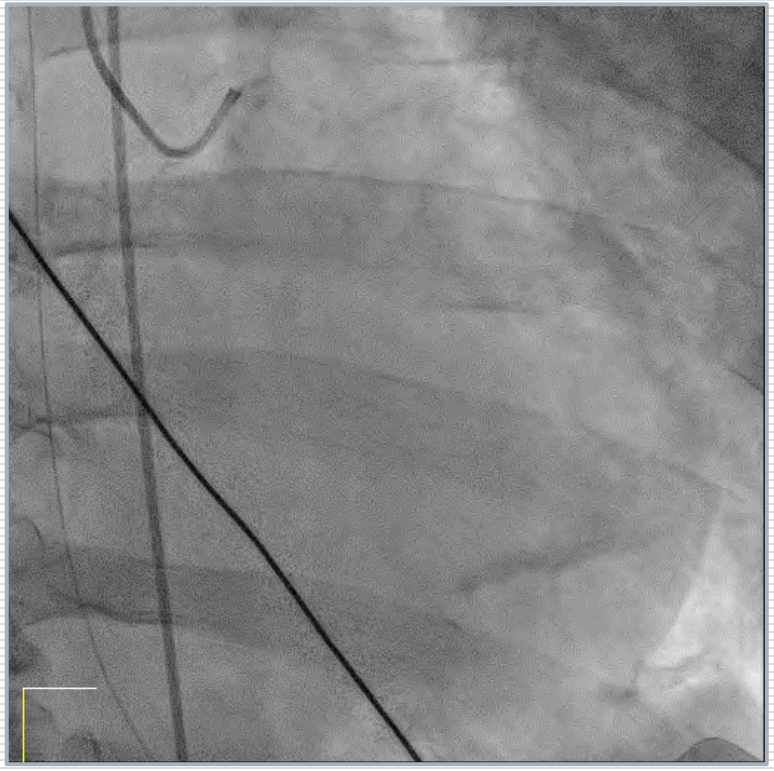
VA ECMO

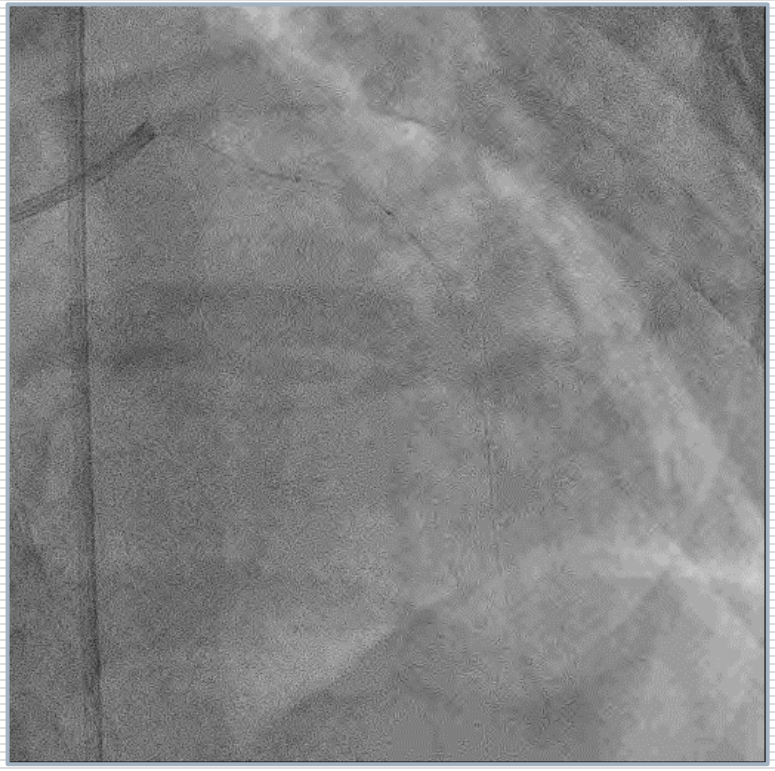


- VA-ECMO withdraws venous blood and returns it to the arterial system via a centrifugal pump
- Providing gas exchange, oxygenation, and circulatory support
- Useful in patients with cardiogenic shock and impaired oxygenation
- Reducing biventricular preload and increasing mean arterial pressure
- May increase LV afterload, thereby often needing LV venting strategies

Case: 69-Year-Old Male

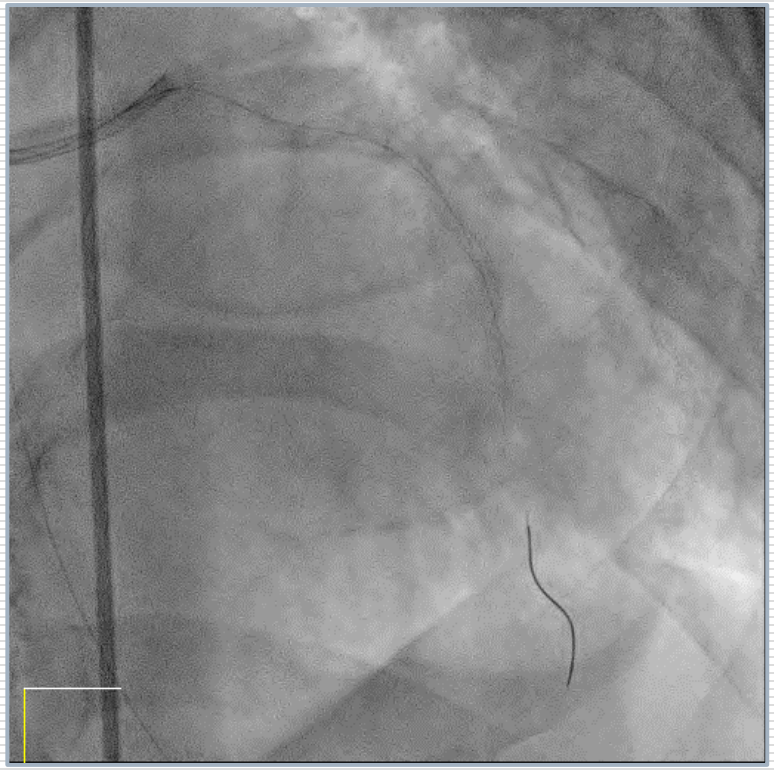


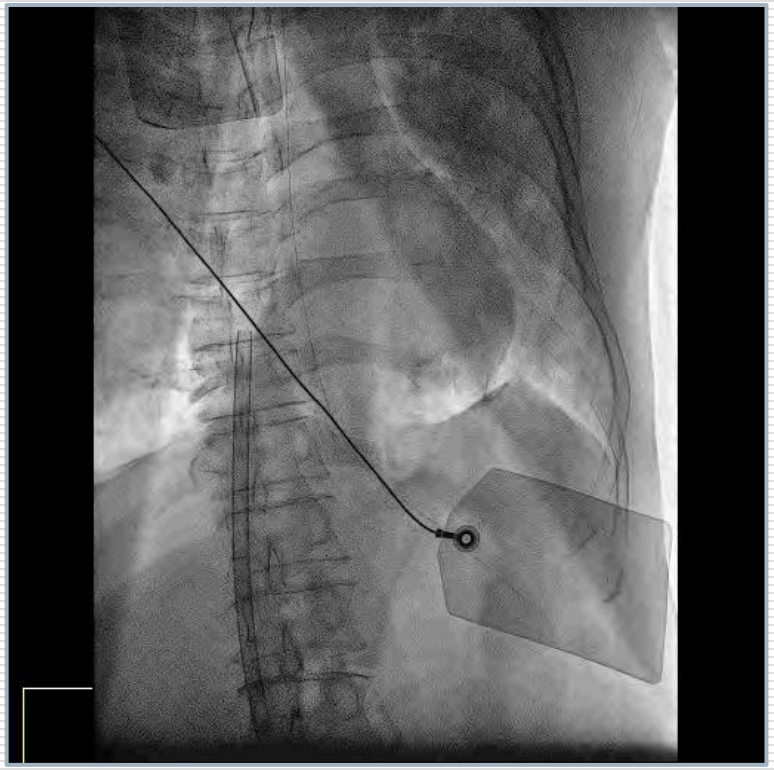




- Acute STEMI
- Aborted cardiac arrest (VF)
- BP : 80/50 mmHg, HR: 115 bpm on norepinephrine
- LVEF = 25-30%
- Thrombotic occlusion at pLAD
- Concomitant CTO at mRCA

Case: 69-Year-Old Male: Emergent VA ECMO and Primary PCI



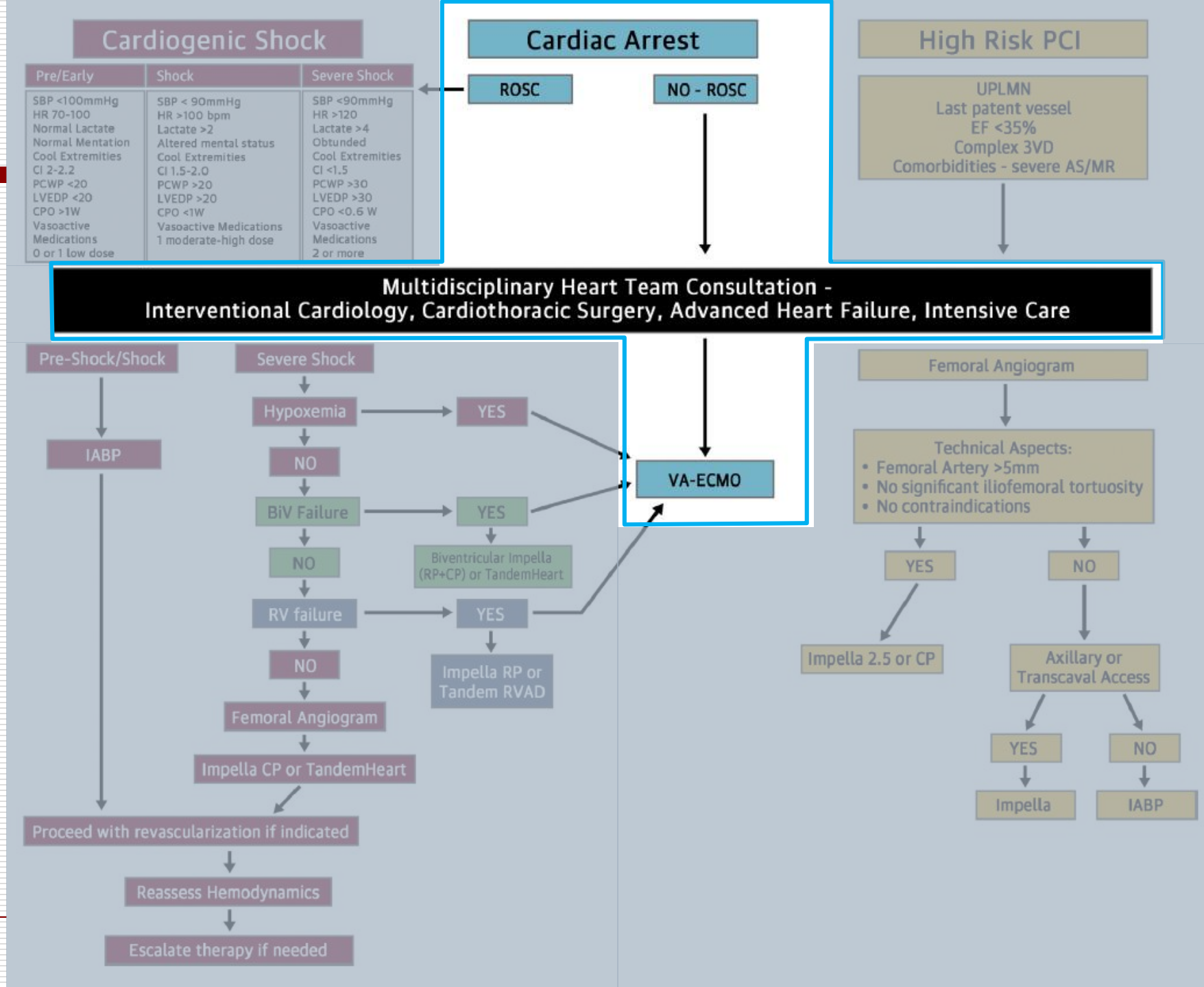


- Emergent VA ECMO
- Trans-femoral 7F
- DES #2

Outcomes of VA-ECMO by Cardiac Indication

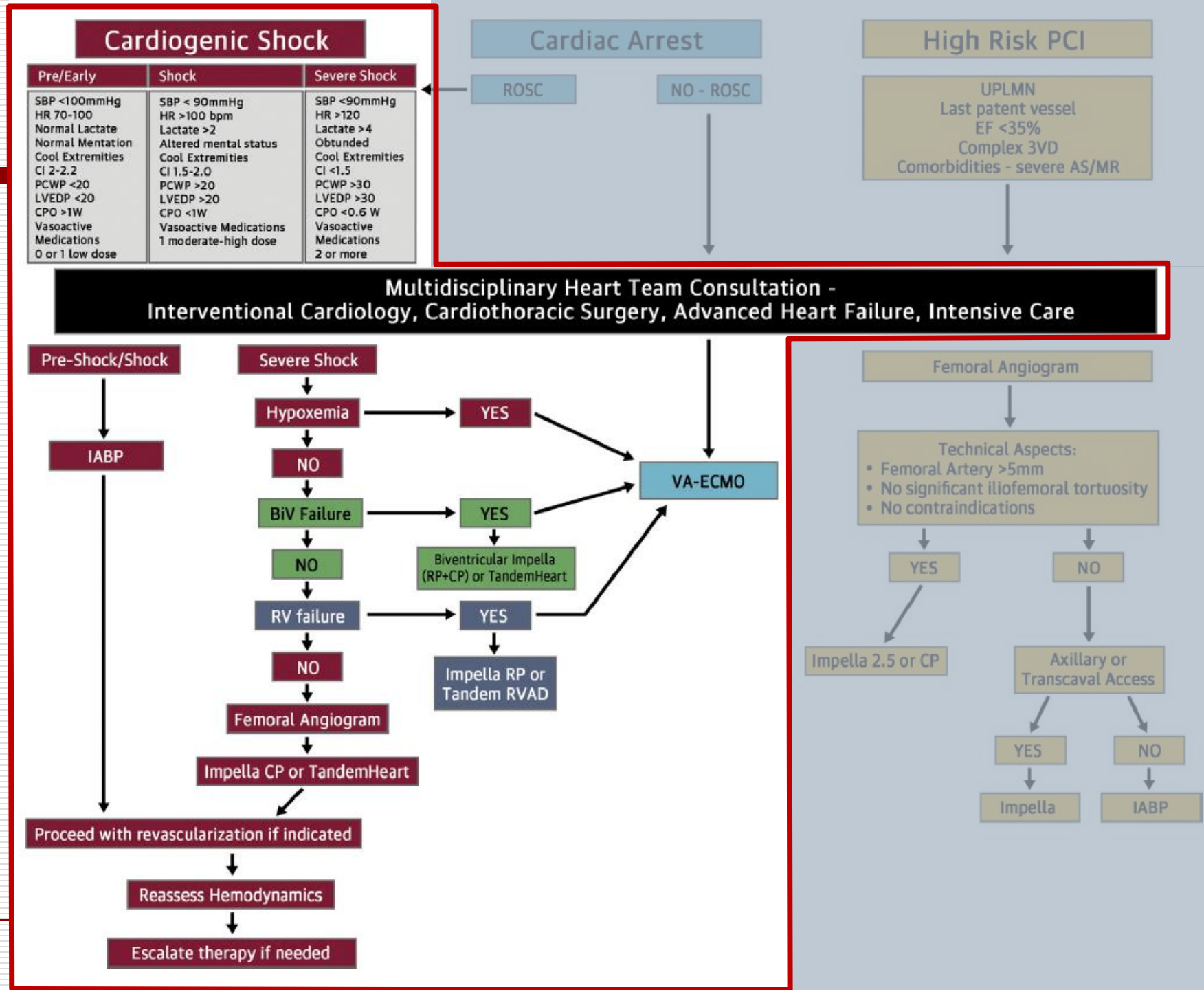
Reference	Population	Design	Duration (days)	Key Results
Post-cardiotomy				
Rastan et al. 2010 (Online Ref. 1)	N = 517, refractory shock, mixed procedures	Prospective cohort, multicenter	3.3 ± 2.9	Weaned: 63% In-hospital mortality: 75% Survival: 6 months 18%, 1 yr 17%, 5 yrs 14%
Biancari et al. 2017 (Online Ref. 2)	N = 148, shock or respiratory failure after isolated CABG	Retrospective cohort, multicenter	6.4 ± 5.6	Weaned: 49% In-hospital mortality: 64% Survival: 1 yr 31%, 2 yrs 28%, 3 yrs 26%
Post-transplantation				
D'Alessandro et al. 2010 (Online Ref. 3)	N = 54, recipients with early graft failure for any cause	Retrospective cohort, single-center	7 ± 3	Weaned: 67% In-hospital mortality: 50% Survival: 1 yr 73%
Marasco et al. 2010 (Online Ref. 4)	N = 39, recipients with primary graft failure	Retrospective cohort, single-center	6.8 ± 2.6	Weaned: 87% In-hospital mortality: 26% Survival: 1 yr 73%
CS				
Xie et al. 2015 (Online Ref. 5)	N = 1,199 (22 studies), CS or CA	Meta-analysis	NR	In-hospital mortality: 60% (95% CI: 53%–66%) Survival: 3 months 56%, 1 yr 54% Survival at 1 month CS 53% vs. CA 36%
Dangers et al. 2017 (Online Ref. 6)	N = 105, ADHF	Prospective cohort, single-center	NR	Survival: 1 yr 42% (many received a transplant)
Myocarditis				
Cheng et al. 2014 (Online Ref. 7)	N = 170, acute myocarditis	Meta-analysis	NR	In-hospital mortality: 33% (95% CI: 26%–41%)
Cardiac arrest				
Maekawa et al. 2013 (Online Ref. 8)	N = 53, out-of-hospital CA with CPR >20 min	Prospective cohort, propensity matched	NR	Survival to discharge: ECMO 38% vs. CPR 13% (p = 0.09) Survival: 3-month. ECMO 38% vs. CPR 8% (p = 0.04)
Choi et al. 2016 (Online Ref. 9)	N = 320, out-of-hospital CA in South Korea	Retrospective cohort, propensity matched	NR	Survival to discharge: ECMO 18% vs. CPR 16% (ECMO adjusted OR: 0.61; 95% CI: 0.39–0.94)
Mixed				
Chang et al. 2016 (Online Ref. 10)	N = 4,227, supported in Taiwan	Retrospective cohort, administrative	2 ± 1	In-hospital mortality: 65% Survival: 1 month 40%, 1 yr 23%
Batra et al. 2016 (Online Ref. 11)	N = 1,286, supported in New York state	Retrospective cohort, administrative	NR	In-hospital mortality: 54% Survival: 1 month 48%, 1 yr 38%
Aso et al. 2016 (Online Ref. 12)	N = 5,263, supported in Japan	Retrospective cohort, administrative	NR	Weaned: 64% In-hospital mortality: 73% (shock 74%, PE 64%)

In whom and When?



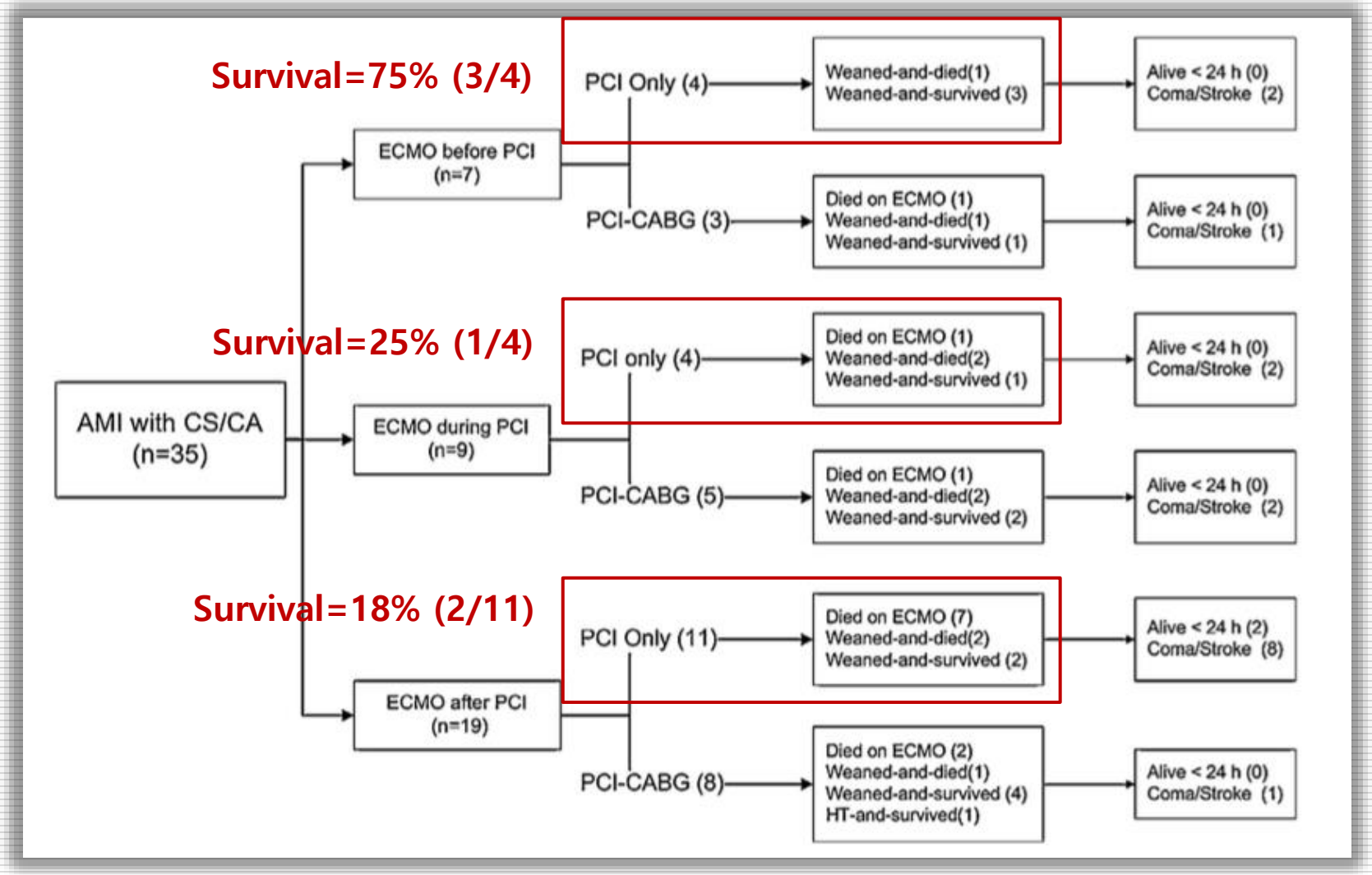
J Am Coll Cardiol Intv 2016;9:871-883

In Whom and When?



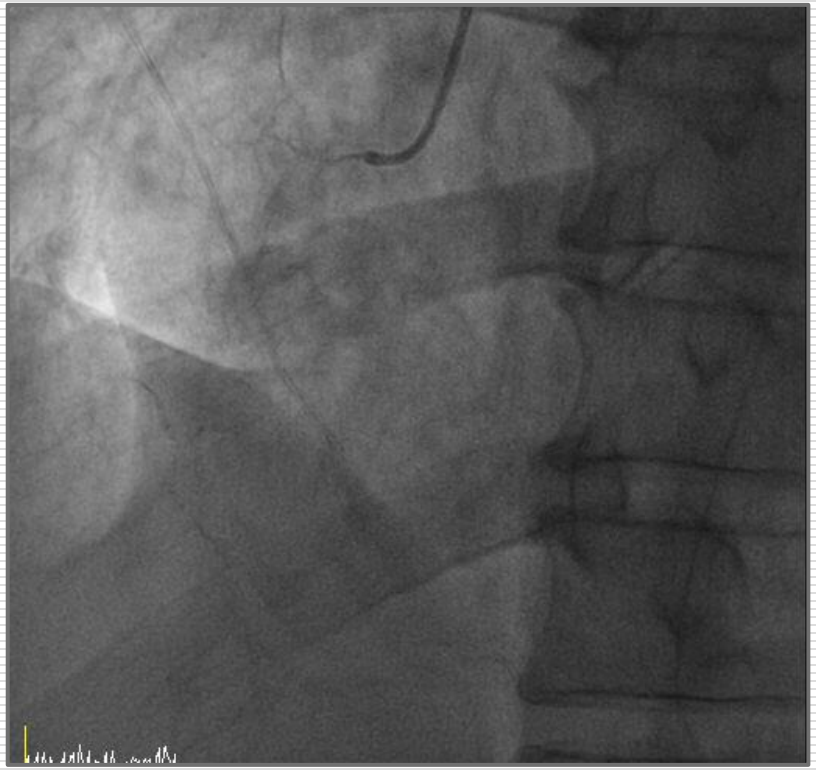
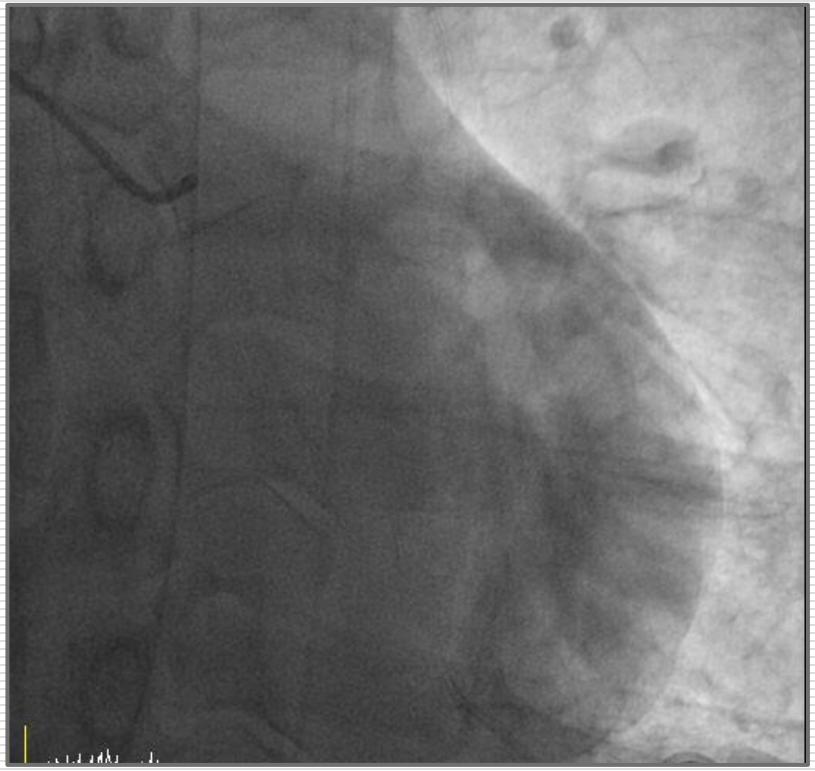
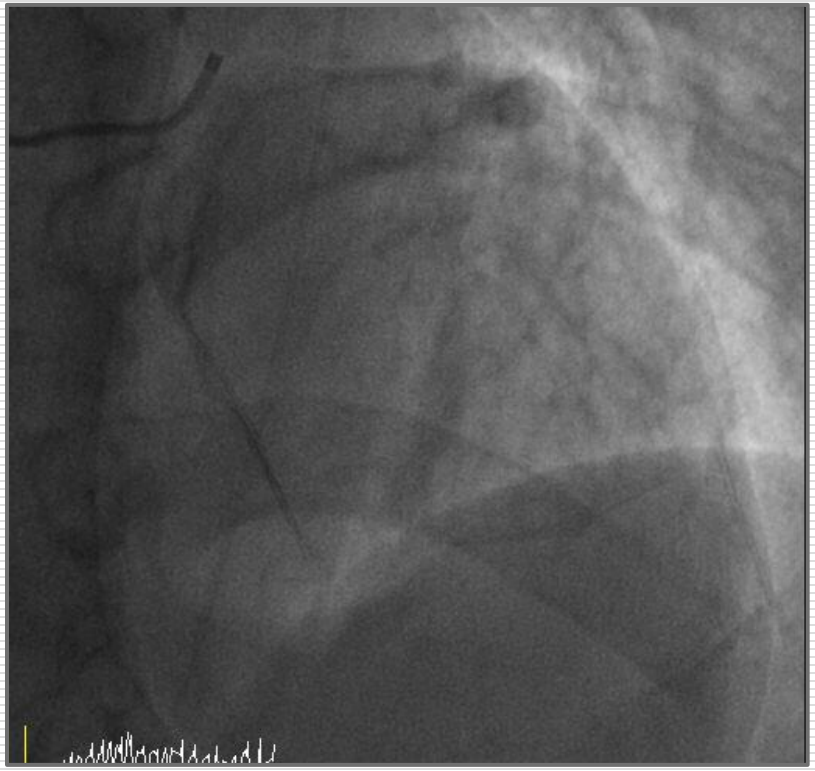
J Am Coll Cardiol Intv 2016;9:871-883

TIMING of VA-ECMO SUPPORT



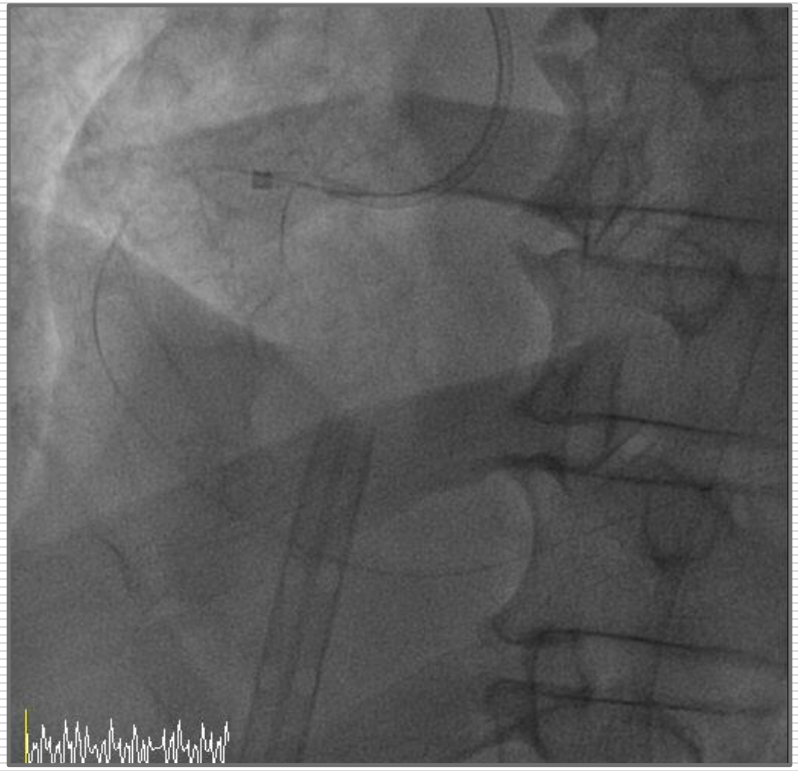
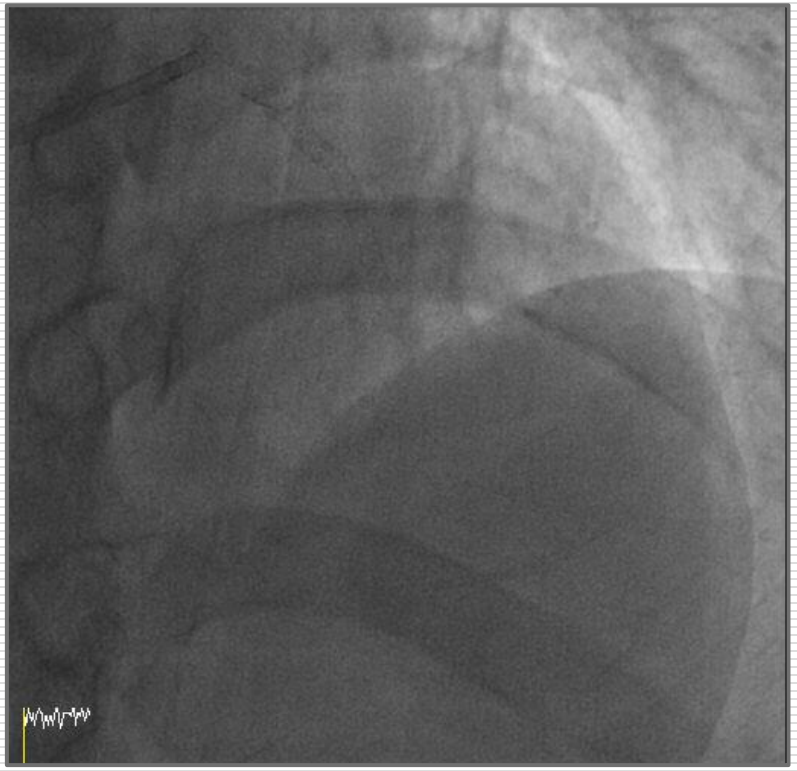
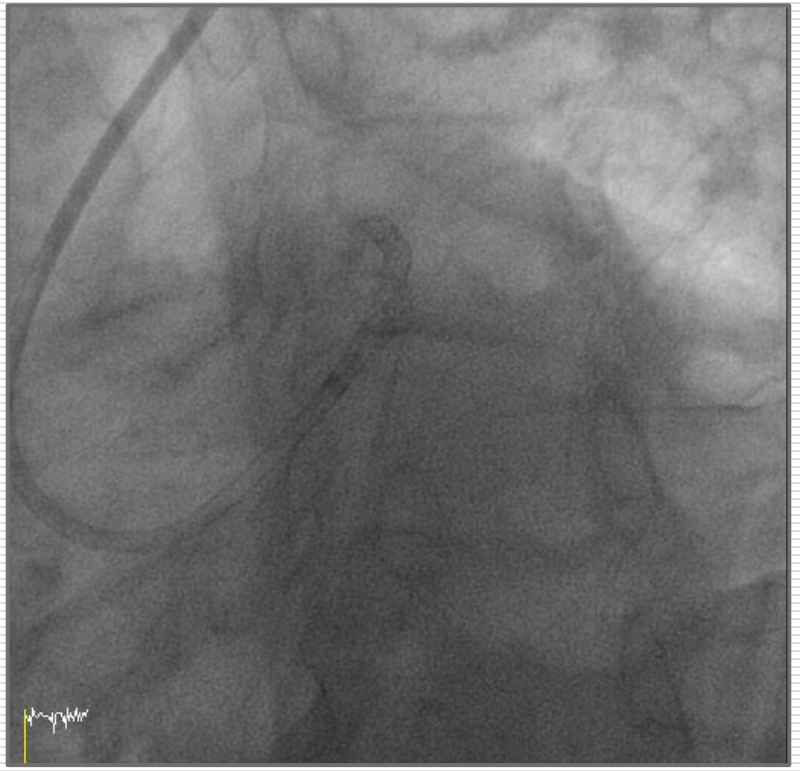
Resuscitation 2013;84:940-945

Case: 58-Year-Old Male

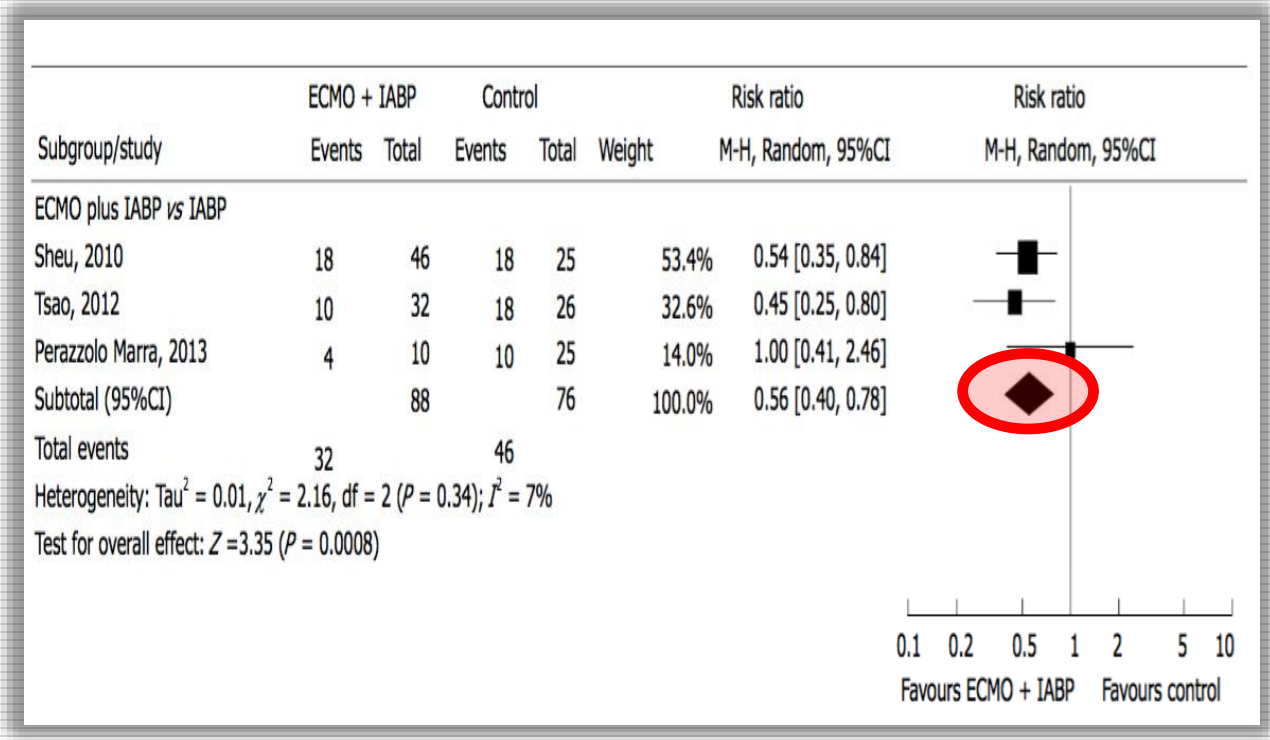
- Acute STEMI
- Cardiogenic shock
- BP : 80/50 mmHg, HR: 90 bpm on norepinephrine
- LVEF = 30%
- Thrombotic occlusion at ostial LAD
- Critical stenosis at LM shaft, ostial LCX, and mRCA

Case: 58-Year-Old Male:
Emergent VA ECMO + IABP and Primary PCI

Meta-Analysis on the Risk of In-Hospital Mortality in Patients with AMI Complication Cardiogenic Shock

ECMO plus IAVP vs. IABP alone

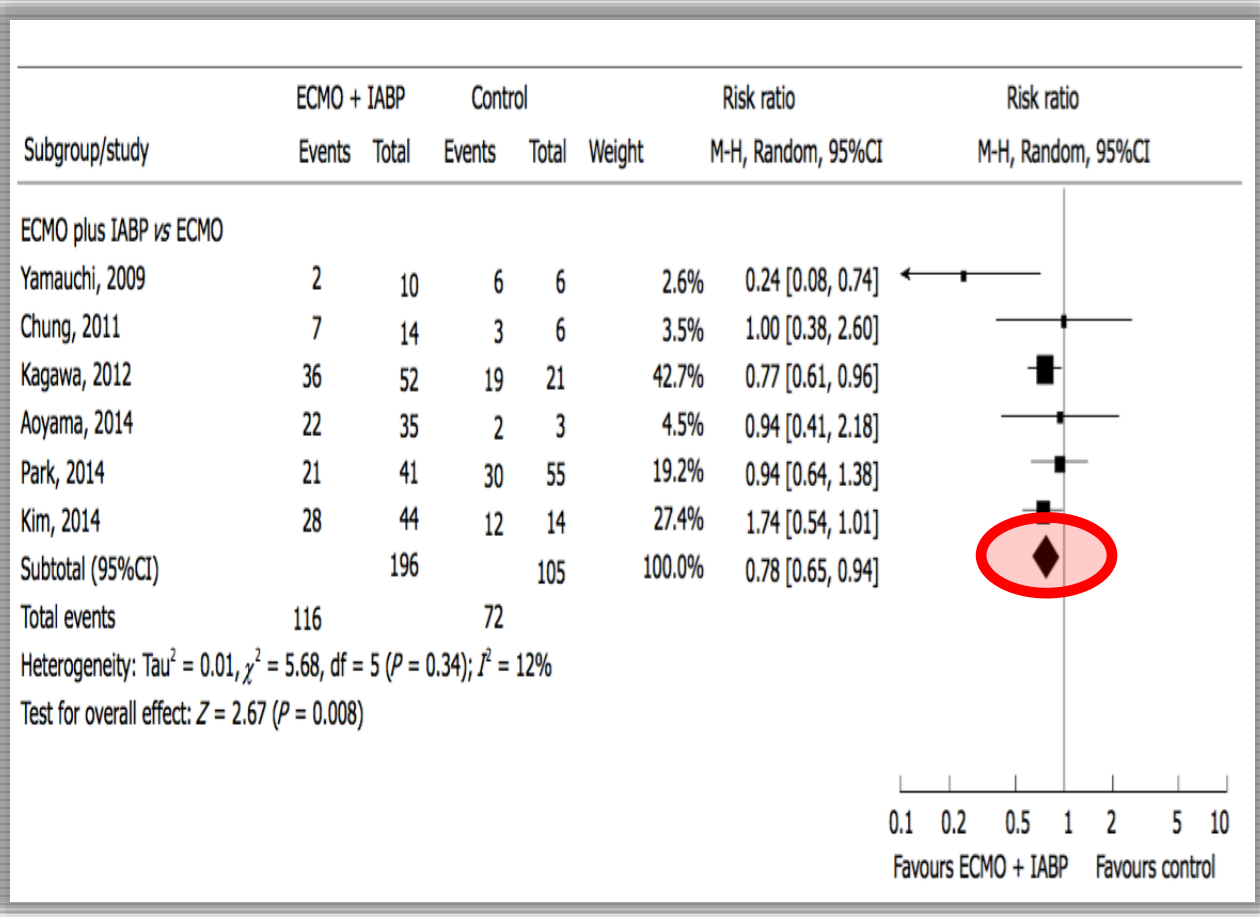


Subgroup/study	ECMO + IABP Events	ECMO + IABP Total	Control Events	Control Total	Weight	Risk ratio M-H, Random, 95%CI
ECMO plus IABP *vs* IABP						
Sheu, 2010	18	46	18	25	53.4%	0.54 [0.35, 0.84]
Tsao, 2012	10	32	18	26	32.6%	0.45 [0.25, 0.80]
Perazzolo Marra, 2013	4	10	10	25	14.0%	1.00 [0.41, 2.46]
Subtotal (95%CI)		88		76	100.0%	0.56 [0.40, 0.78]
Total events	32		46			

Heterogeneity: $Tau^2 = 0.01, \chi^2 = 2.16$, df = 2 ($P = 0.34$); $I^2 = 7\%$

Test for overall effect: $Z = 3.35$ ($P = 0.0008$)

ECMO plus IAVP vs. ECMO alone



Subgroup/study	ECMO + IABP Events	ECMO + IABP Total	Control Events	Control Total	Weight	Risk ratio M-H, Random, 95%CI
ECMO plus IABP *vs* ECMO						
Yamauchi, 2009	2	10	6	6	2.6%	0.24 [0.08, 0.74]
Chung, 2011	7	14	3	6	3.5%	1.00 [0.38, 2.60]
Kagawa, 2012	36	52	19	21	42.7%	0.77 [0.61, 0.96]
Aoyama, 2014	22	35	2	3	4.5%	0.94 [0.41, 2.18]
Park, 2014	21	41	30	55	19.2%	0.94 [0.64, 1.38]
Kim, 2014	28	44	12	14	27.4%	1.74 [0.54, 1.01]
Subtotal (95%CI)		196		105	100.0%	0.78 [0.65, 0.94]
Total events	116		72			

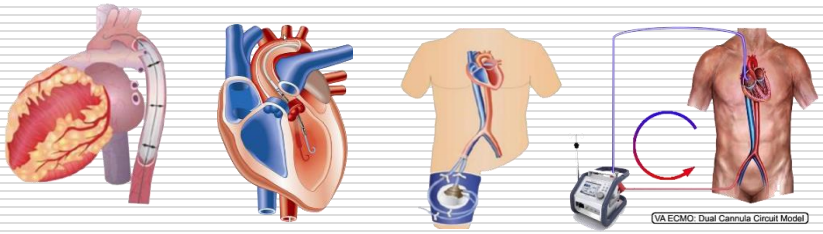
Heterogeneity: $Tau^2 = 0.01, \chi^2 = 5.68$, df = 5 ($P = 0.34$); $I^2 = 12\%$

Test for overall effect: $Z = 2.67$ ($P = 0.008$)

World J Cardiol 2016;8:98-111

Summary

- In unstable patients undergoing high risk PCI, elective IABP (with/without VA-ECMO) can be used as first-line hemodynamic support device(s) here in Korea (where Impella is not available).
- In patients with pre-shock or shock at an early stage, IABP may be used.
- In patients with cardiogenic shock with severe LV failure, Impella or Tandem Heart are appropriate hemodynamic support devices. However, VA-ECMO is an inevitable choice in Korea. VA-ECMO and concomitant use of IABP may be helpful to decrease mortality compared with VA-ECMO alone.
- With current available data, we can not say there is an obvious survival benefit with hemodynamic support device in CHIP.



Intraaortic Balloon Support for Myocardial Infarction with Cardiogenic Shock (IAPB-SHOCK 2 Trial)

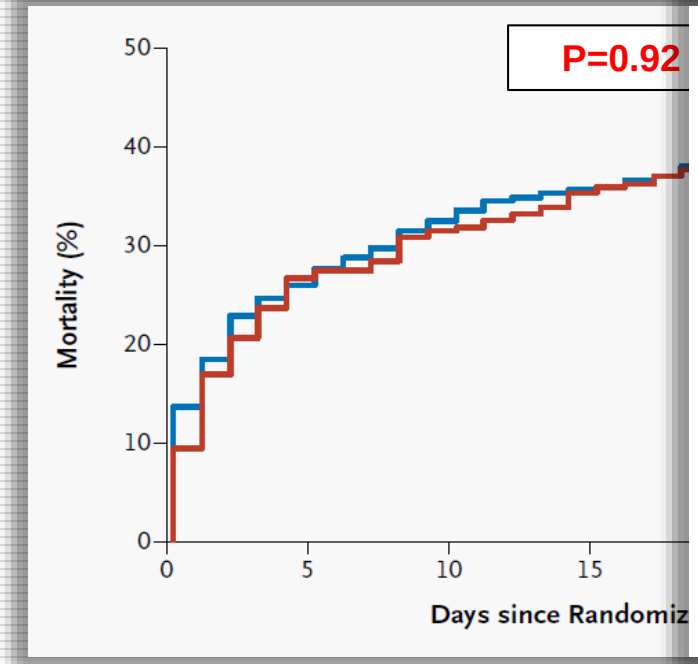
600 Patients with cardiogenic shock complication acute MI.
All patients were expected to undergo early revascularization

1 → IAPB, n= 301 (300)

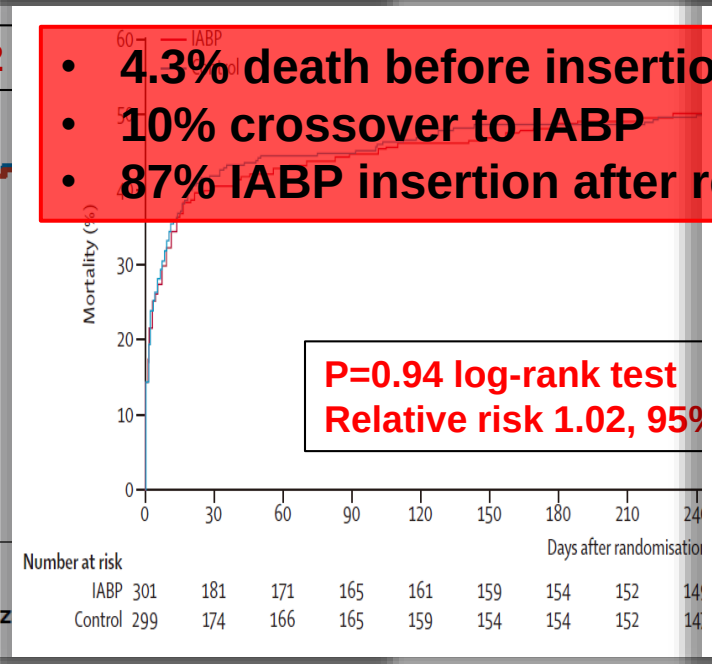
1 → Control, n=299 (298)

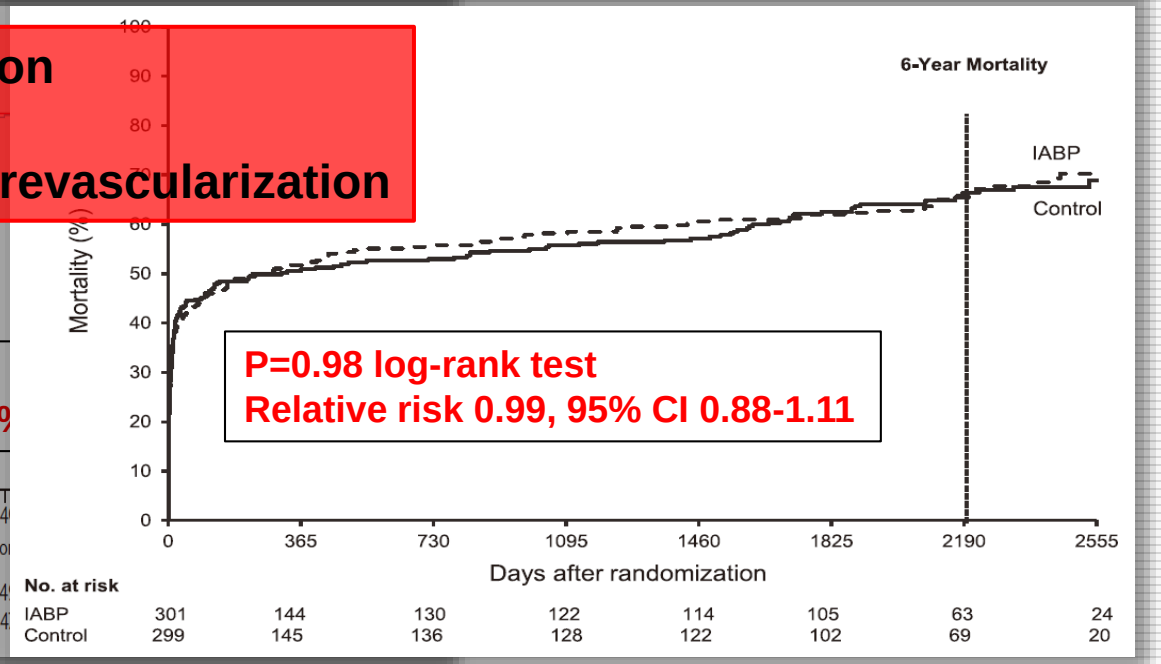
- Primary efficacy endpoint : 30-day all-cause mortality
- Safety assessment: major bleeding, peripheral ischemic complications, sepsis, and stroke

Primary efficacy endpoint (30-day a | **12-month all-cause m** | **6-year all-cause mortality**



- 4.3% death before insertion
- 10% crossover to IABP
- 87% IABP insertion after revascularization





New Engl J Med 2012;367:1287-1296, Lancet 2013; 382:1638-1645, Circulation 2019;139:395-403.