Intraaortic Balloon Counterpulsation- Supportive Data for a Role in Cardiogenic Shock

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COI: none relevant

Cardiogenic Shock After Acute MI

Typical characteristics

- Age > 65
- Anterior MI
- Systolic BP <100 mmHg
- Heart Rate >100 bpm
- Accounts for 90% of risk (GUSTO 1)

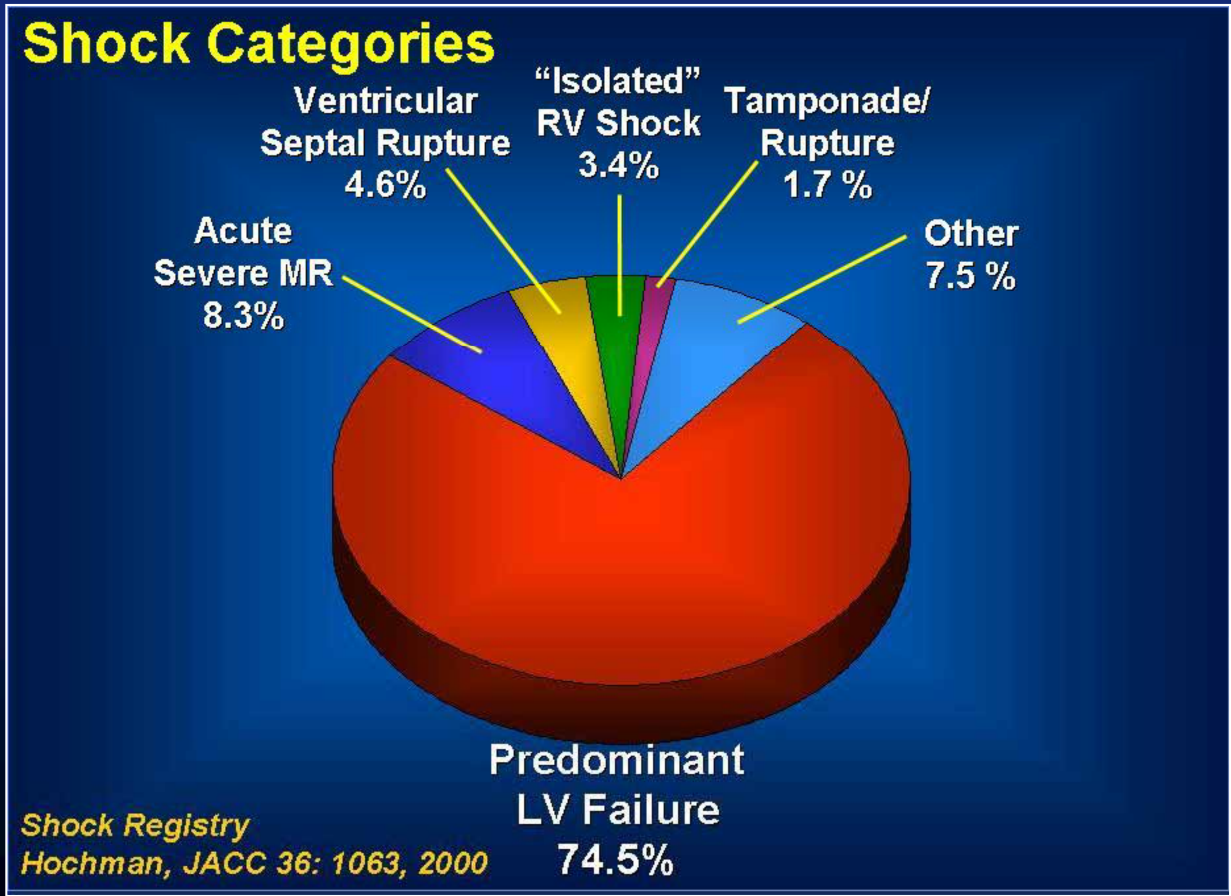
Additional Facts

- 75% of patients develop CS within 24 hours, but present on admission in only 15%
- Average EF is only moderately reduced (~ 30%)
- SVR is not severely elevated in many patients (1350-1400 dynes-sec-cm-5)
- Cardiac power (CI x MAP) is the most powerful hemodynamic predictor of mortality

Hasdai et al. JACC 2000;35:136–43; SHOCK Trial

Cardiogenic Shock Etiology

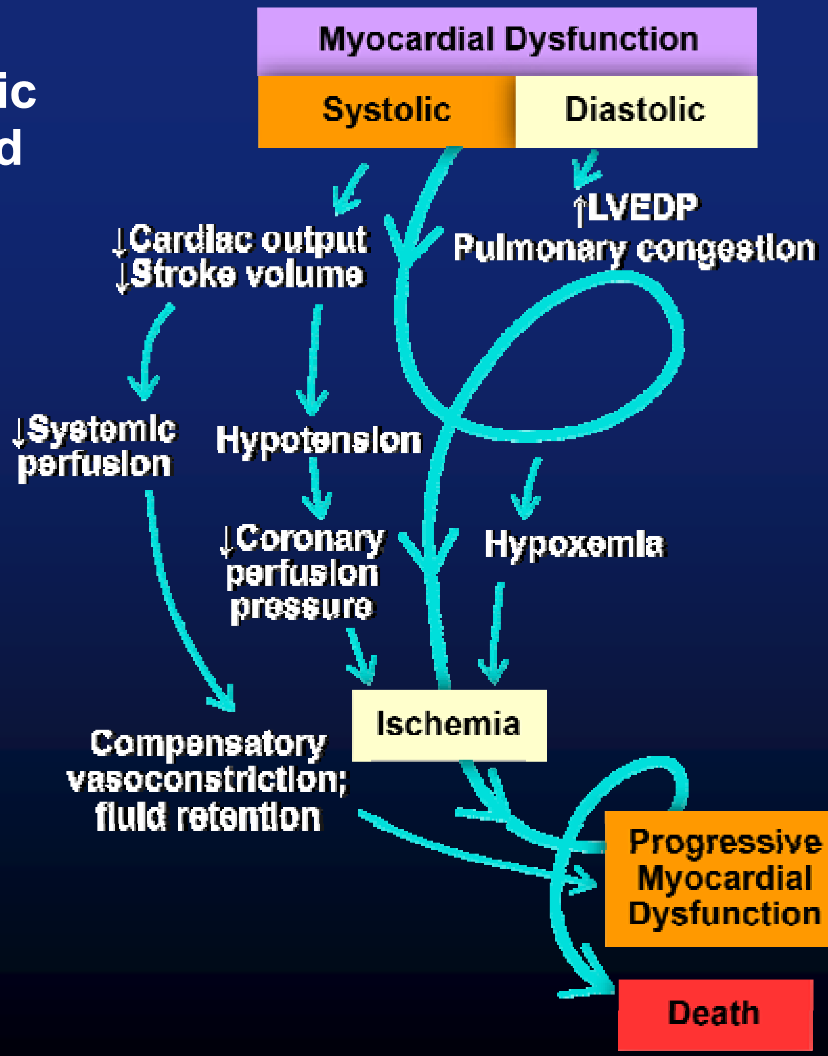
Shock Trial and Registry



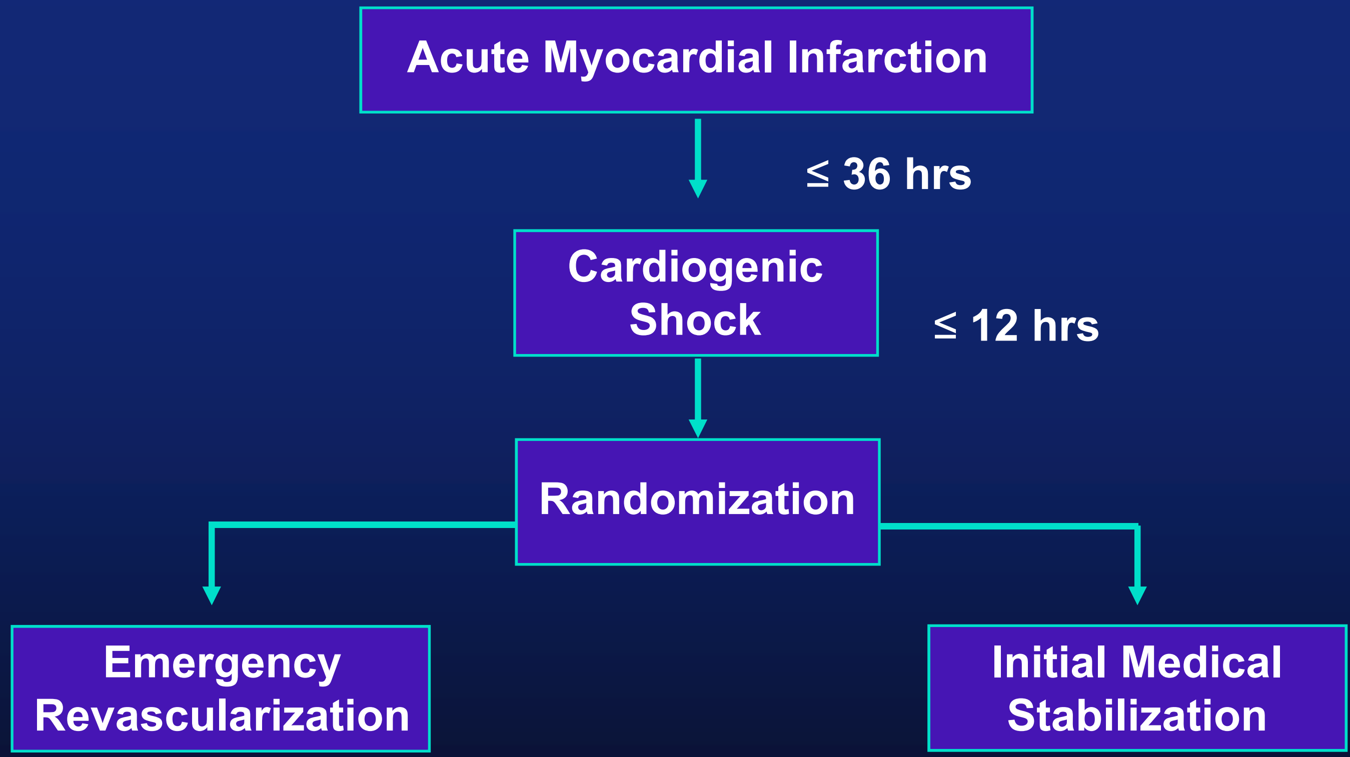
Hochman et al. JACC 2000; 36: 1063

Pathophysiology of Cardiogenic Shock

- When a critical mass of LV is necrotic and fails to pump, stroke volume and CO fall
- Myocardial and coronary perfusion are compromised causing tachycardia and hypotension
- Increased LVEDP further decreases coronary perfusion
- Increase LV wall stress increases myocardial oxygen demand
- Lactic acidosis worsens myocardial performance



Shock Trial



Emergency Revascularization

- IABP/Pharmacologic Support
- Possible Prior Thrombolysis
- Emergency Early PTCA/CABG ≤ 6 hrs

Initial Medical Stabilization

- IABP/Pharmacologic Support
- Thrombolysis Unless Absolute Contraindication
- Possible Delayed Revascularization > 54 hrs

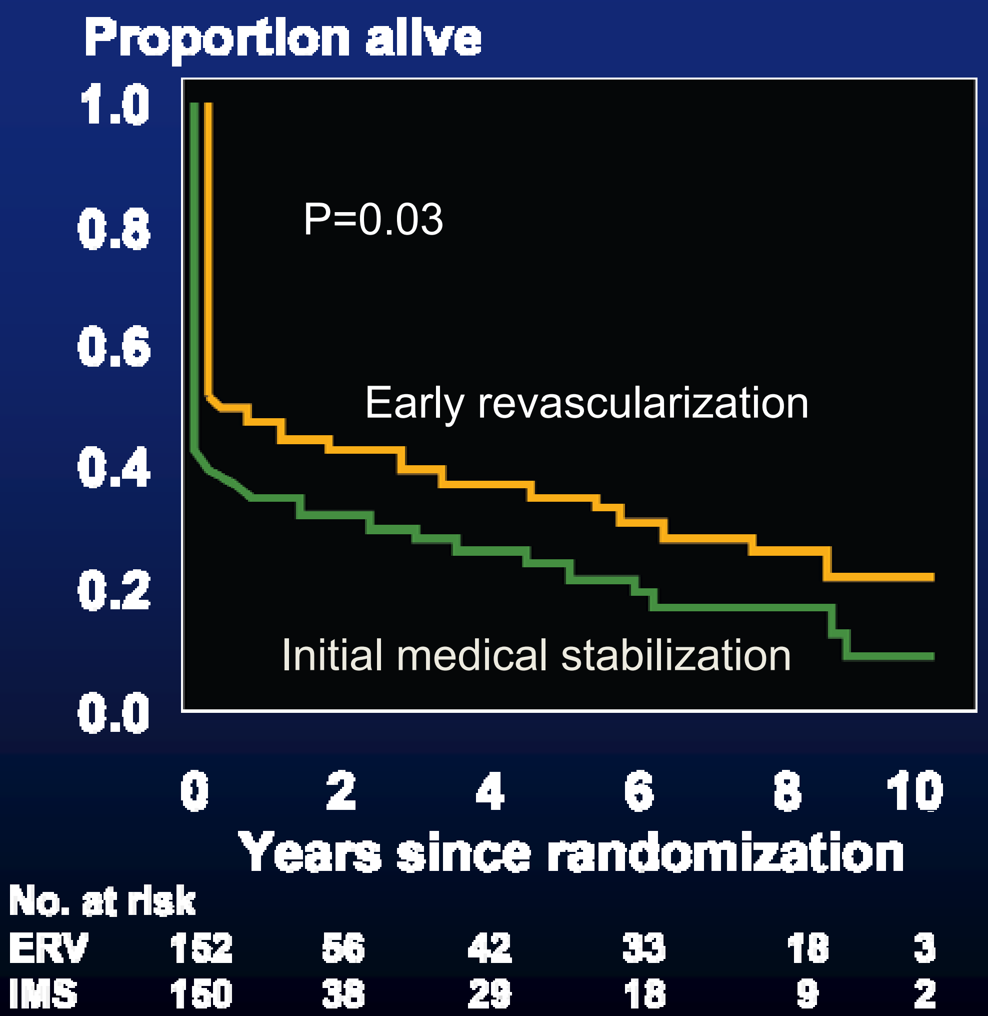
Hochman, AHJ 137: 313, 1

Shock Trial Treatment Received

	Revascularization Treatment n=152	Medical therapy n=150
CPR, VT, or VF before randomization (%)	32.7	23.9
Thrombolytic therapy (%)	49.3	63.3
Inotropes or vasopressors (%)	99.3	98.6
Intraaortic balloon counterpulsation (%)	86.2	86.0
Pulmonary-artery catheterization (%)	93.4	96.0
Left ventricular-assist device (%)	3.6	0.9
Heart transplantation (%)	2.0	0.7
Coronary angiography (%)	96.7	66.7
Angioplasty (%)	54.6	14.0
Stent placed	35.7	52.3
Platelet glycoprotein IIb/IIIa receptor antagonist	41.7	25.0
Coronary-artery bypass grafting (%)	37.5	11.3
Angioplasty or coronary-artery bypass grafting (%)	86.8	25.3
Median time from randomization to 1.4 102.8 revascularization (hr)	(0.6-2.8)	(79.0-162.0)

Hochman et al: NEJM 341:625, 1999

Shock Trial Long Term Outcomes



- Early revascularization, compared to initial medical stabilization, resulted in 13.2% absolute improvement in 6-year survival
- 8 patients needed to be treated to save 1 life

Hochman et al: JAMA 295:2511, 2006

Physiological Effects of IABP

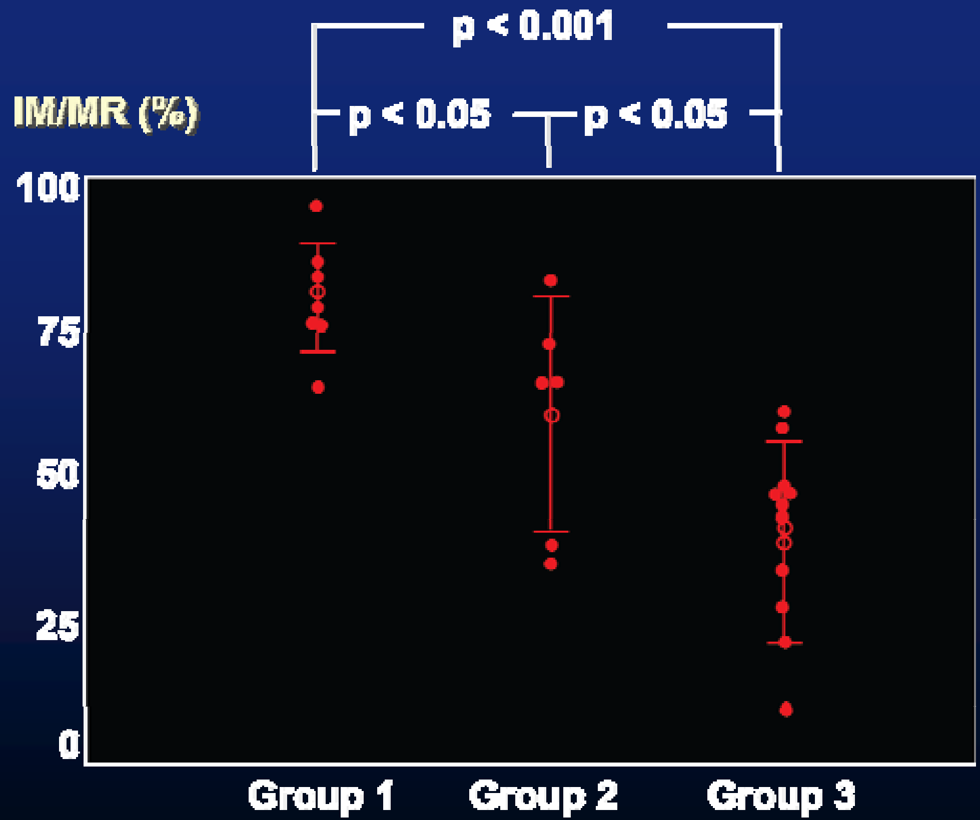
Cardiac Index (L/min/M^2)	↑ 40%
Arterial Lactate (mmol/L)	↓ 42%
Coronary Blood Flow (M^2/100g/min)	↑ 34%

Cardiac Output	↑ 500 ml/min
Heart Rate	↓ 7 bts/min
Systolic BP	↓ 20 mmHg
Diastolic BP	↑ 30 mmHg

Reperfusion and IABP in AMI

Canine LAD occlusion model

Grp 1= 6 hr occlusion
Grp 2= 2 hr occlusion, then reperfusion
Grp 3= 2 hr occlusion, then IABP + reperfusion

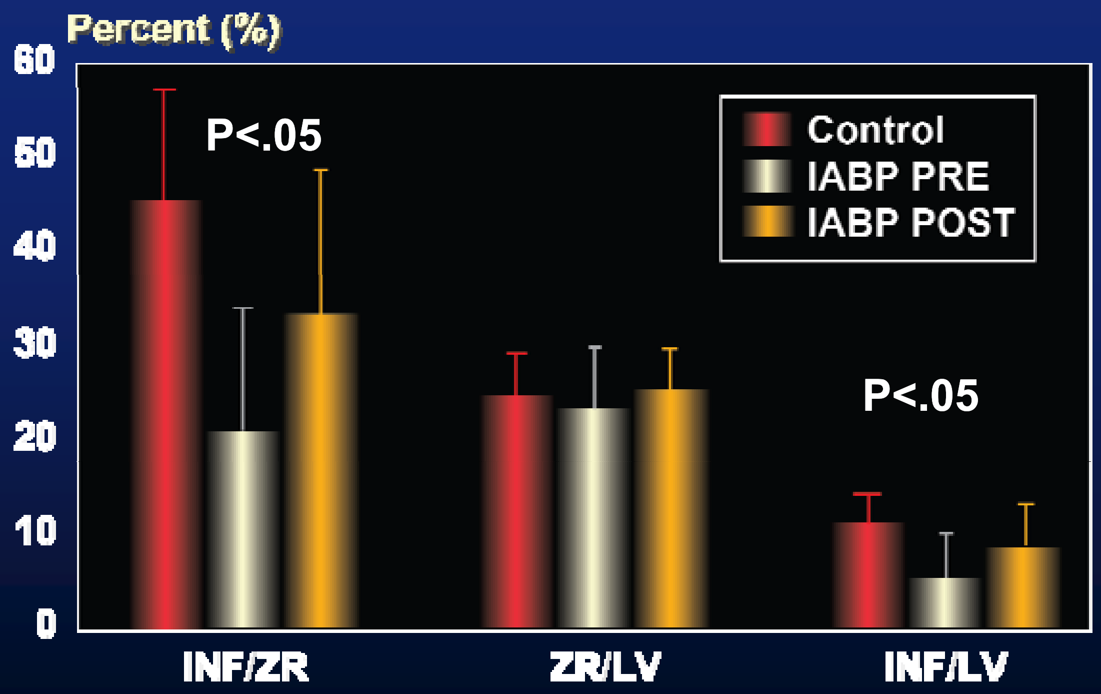


Nanas et al., Ann Thorac Surg 1996;61:629-34

IABP Reduces Infarct Size if Applied Early

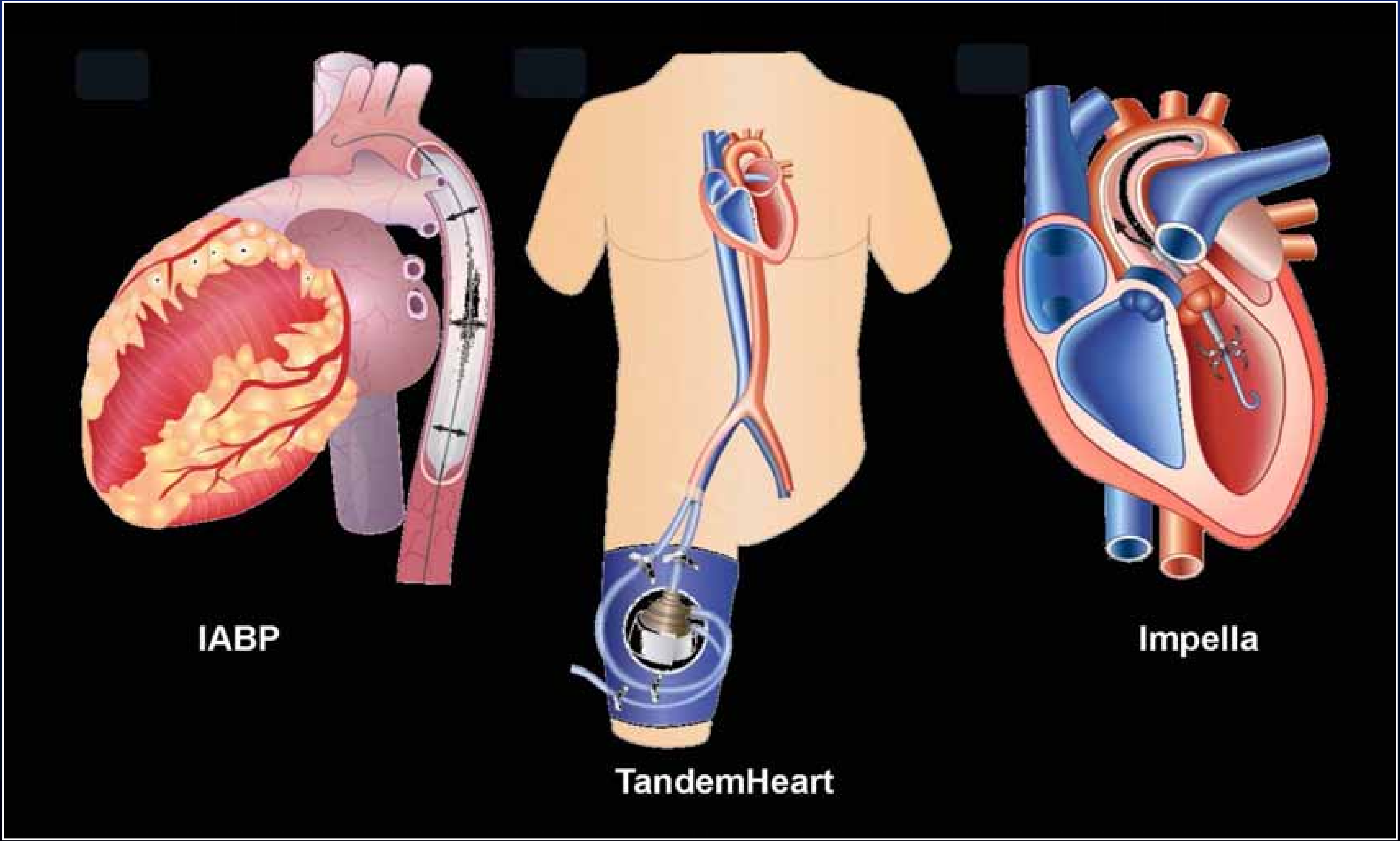
Yorkshire pig LAD 1 hr occl

IABP just before or 15 min
After reperfusion



LeDoux JF et al., Catheterization and Cardiovascular
Interventions 72:513–521 (2008)

Most Commonly Used Mechanical Devices in the CathLab



Comparison of Support Devices

	IABP	TandemHeart	Impella
Catheter Size	7.5-9.0	21/17/15	9
Cannula Size	8.5-10	21/17/15 *	12*
# Insertion Sites	1	2	1
Anticoagulation	+	++/+++	+
Transeptal	No	Yes	No
Limb ischemia	+	+++	++
Priming volume	No	Yes	No
Unloads Directly LV	No	No	Yes
Requires stable rhythm	Yes	No	No
Improve hemodynamics	+	+++	++/+++

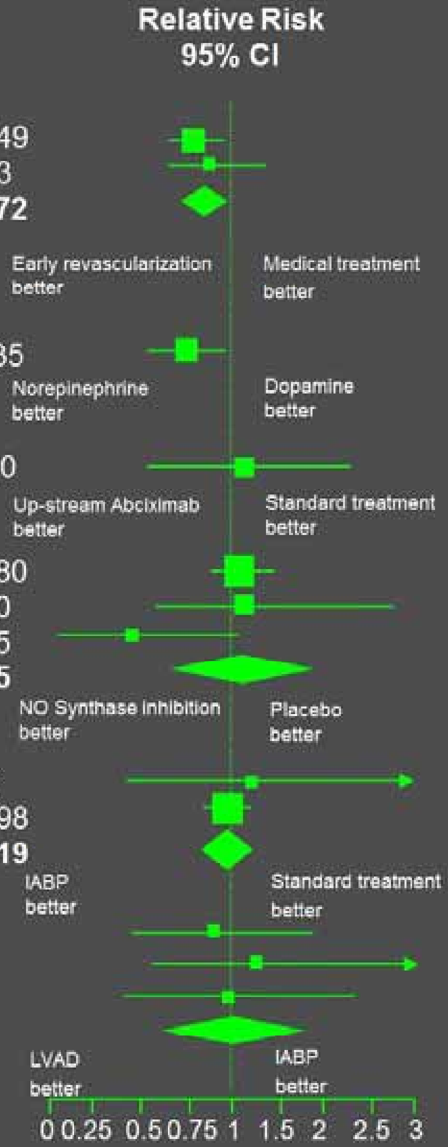
* May require antegrade stick, male->male connection for limb perfusion

IABP: Benefit Summary

- Reduces infarct size
- Improves hemodynamics
- Relatively small diameter vascular access site

Randomized Studies in Cardiogenic Shock

Trial	Follow-up	n/N	n/N	Relative Risk 95% CI
Revascularization (PCI/CABG)				
SHOCK	1-year	76/152	83/149	0.80 (0.66;0.98)
SMASH	30 days	22/32	18/23	0.87 (0.66;1.29)
Total		**103/184**	**117/172**	**0.82 (0.70;0.98)**
Catecholamines				
SOAP II (CS Subgroup)	28 days	64/145	50/135	0.75 (0.55;0.93)
Glycoprotein IIb/IIIa-Inhibitors				
PRAGUE-7	In-hospital	15/40	13/40	1.15 (0.59;2.27)
NO Synthase Inhibitors				
TRIUMPH	30 days	97/201	76/180	1.14 (0.91;1.45)
SHOCK-2	30 days	24/59	7/20	1.16 (0.59;2.69)
Cotter et al	30 days	4/15	10/15	0.40 (0.13;1.05)
Total		**125/275**	**93/215**	**1.05 (0.85;1.29)**
IABP				
IABP-SHOCK I	30 days	7/19	6/21	1.28 (0.45;3.72)
IABP-SHOCK II	30 days	119/300	123/298	0.96 (0.79;1.17)
Total		**126/319**	**129/319**	**0.98 (0.81;1.18)**
LVAD				
Thiele et al	30 days	9/21	9/20	0.95 (0.48;1.90)
Burkhoff et al	30 days	9/19	5/14	1.33 (0.57-3.10)
Seyfarth et al	30 days	6/13	6/13	1.00 (0.44-2.29)
Total		**24/53**	**20/47**	**1.06 (0.68-1.66)**



ONLINE FIRST

Intra-aortic Balloon Counterpulsation and Infarct Size in Patients With Acute Anterior Myocardial Infarction Without Shock

The CRISP AMI Randomized Trial

Manesh R. Patel, MD
Richard W. Smalling, MD, PhD
Holger Thiele, MD
Huiman X. Barnhart, PhD
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Derek Chew, MD
Marc Cohen, MD
John French, MBChB, PhD
Divaka Perera, MD
E. Magnus Ohman, MD

Context Intra-aortic balloon counterpulsation (IABC) is an adjunct to revascularization in patients with cardiogenic shock and reduces infarct size when placed prior to reperfusion in animal models.

Objective To determine if routine IABC placement prior to reperfusion in patients with anterior ST-segment elevation myocardial infarction (STEMI) without shock reduces myocardial infarct size.

Design, Setting, and Patients An open, multicenter, randomized controlled trial, the Counterpulsation to Reduce Infarct Size Pre-PCI Acute Myocardial Infarction (CRISP AMI) included 337 patients with acute anterior STEMI but without cardiogenic shock at 30 sites in 9 countries from June 2009 through February 2011.

Intervention Initiation of IABC before primary percutaneous coronary intervention (PCI) and continuation for at least 12 hours (IABC plus PCI) vs primary PCI alone.

Main Outcome Measures Infarct size expressed as a percentage of left ventricular (LV) mass and measured by cardiac magnetic resonance imaging performed 3 to 5 days after PCI. Secondary end points included all-cause death at 6 months and vascular complications and major bleeding at 30 days. Multiple imputations were performed for missing infarct size data.

Results The median time from first contact to first coronary device was 77 minutes (interquartile range, 53 to 114 minutes) for the IABC plus PCI group vs 68 minutes (interquartile range, 40 to 100 minutes) for the PCI alone group ($P=.04$). The mean infarct size was not significantly different between the patients in the IABC plus PCI group and in the PCI alone group (42.1% [95% CI, 38.7% to 45.6%] vs 37.5% [95% CI, 34.3% to 40.8%], respectively; difference of 4.6% [95% CI, −0.2% to 9.4%], $P=.06$; imputed difference of 4.5% [95% CI, −0.3% to 9.3%], $P=.07$) and in patients with proximal left anterior descending Thrombolysis in Myocardial Infarction flow scores of 0 or 1 (46.7% [95% CI, 42.8% to 50.6%] vs 42.3% [95% CI, 38.6% to 45.9%], respectively; difference of 4.4% [95% CI, −1.0% to 9.7%], $P=.11$; imputed difference of 4.8% [95% CI, −0.6% to 10.1%], $P=.08$). At 30 days, there were no significant differences between the IABC plus PCI group and the PCI alone group for major vascular complications (n=7 [4.3%; 95% CI, 1.8% to 8.8%] vs n=2 [1.1%; 95% CI, 0.1% to 4.0%], respectively; $P=.09$) and major bleeding or transfusions (n=5 [3.1%; 95% CI, 1.0% to 7.1%] vs n=3 [1.7%; 95% CI, 0.4% to 4.9%]; $P=.49$). By 6 months, 3 patients (1.9%; 95% CI, 0.6% to 5.7%) in the IABC plus PCI group and 9 patients (5.2%; 95% CI, 2.7% to 9.7%) in the PCI alone group had died ($P=.12$).

Conclusion Among patients with acute anterior STEMI without shock, IABC plus primary PCI compared with PCI alone did not result in reduced infarct size.

Trial Registration clinicaltrials.gov Identifier: NCT00833612

JAMA. 2011;306(12):1329-1337
Published online August 30, 2011. doi:10.1001/jama.2011.1280 www.jama.com

Primary percutaneous reperfusion for patients with acute ST-segment elevation myocardial infarction (STEMI) has been shown to reduce mortality and is considered the standard of care when available.[1,2] The benchmarked standards for time to reperfusion have shortened over time; despite significant reductions in door-to-balloon times over the past few years in the United States, the STEMI mortality rate has not significantly improved.[3,4]

Patients with acute STEMI, representing 30% to 45% of approximately 1.5 million hospitalizations for acute coronary syndromes annually in the United States,[5] are still at substantial acute mortality risk with 1-year mortality estimated to be between 6% and 15%.[2,5] This may be related to microvascular obstruction resulting in no reflow at the time of mechanical reperfusion and infarct expansion over time.[6,7] Additionally, this increase in infarct size is associated with adverse remodeling and decreased left ventricular (LV) function leading to heart failure and long-term morbidity following STEMI.[8,9]

For editorial comment see p 1376.

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No difference in Infarct size

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113 min sx -> 1st contact

196 min sx -> 1st device

Randomized Studies in Cardiogenic Shock

The NEW ENGLAND JOURNAL of MEDICINE

ORIGINAL ARTICLE

Intraaortic Balloon Support for Myocardial Infarction with Cardiogenic Shock

Holger Thiele, M.D., Uwe Zeymer, M.D., Franz-Josef Neumann, M.D., Miroslaw Ferenc, M.D., Hans-Georg Olbrich, M.D., Jörg Hausleiter, M.D., Gert Richardt, M.D., Marcus Hennersdorf, M.D., Klaus Empen, M.D., Georg Fuernau, M.D., Steffen Desch, M.D., Ingo Eitel, M.D., Rainer Hambrecht, M.D., Jörg Fuhrmann, M.D., Michael Böhm, M.D., Henning Ebelt, M.D., Steffen Schneider, Ph.D., Gerhard Schuler, M.D., and Karl Werdan, M.D., for the IABP-SHOCK II Trial Investigators*

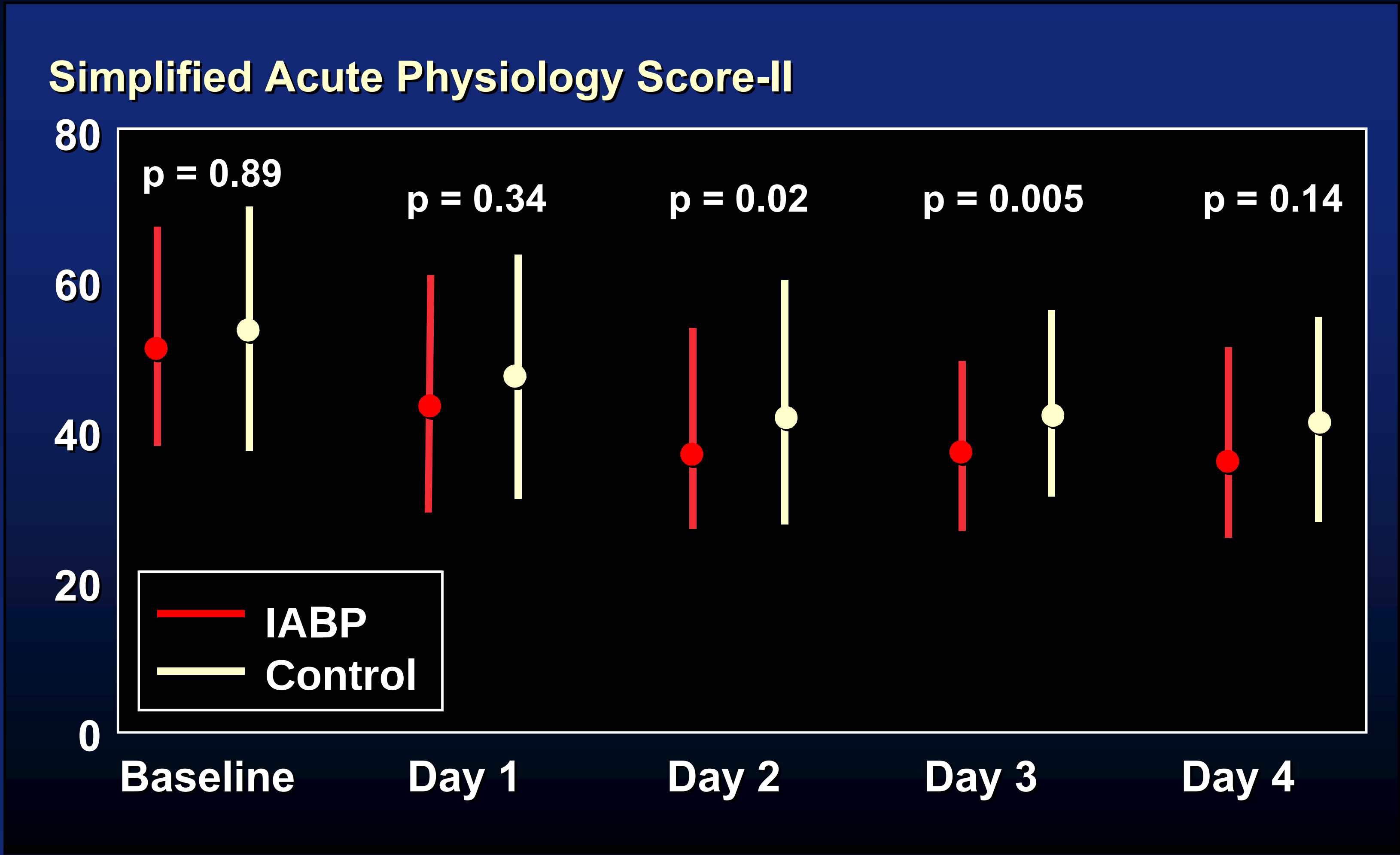
nejm.org published 04.10.2012

Patient Characteristics

	IABP (n=301)	Control (n=299)
Age (years); median (IQR)	70 (58-78)	69 (58-76)
Male sex; n (%)	202 (67.1)	211 (70.6)
Current Smoking; n/total (%)	96/295 (32.5)	108/299 (36.1)
Hypertension; n/total (%)	213/296 (72.0)	199/299 (66.6)
Hypercholesterolemia; n/total (%)	122/295 (41.4)	105/299 (35.1)
Diabetes mellitus; n/total (%)	105/297 (35.4)	90/299 (30.1)
Prior myocardial infarction; n/total n (%)	71/300 (23.7)	61/299 (20.4)
Fibrinolysis < 24 h before randomization; n/total (%)	28/301 (9.3)	20/299 (6.7)
STEMI/LBBB; n/total (%)	200/300 (66.7)	212/298 (71.1)
NSTEMI; n/total (%)	96/300 (32.0)	81/298 (27.2)
Resuscitation before randomization; n/total (%)	127/301 (42.2%)	143/299 (47.8)
Signs of impaired organ perfusion; n/total (%)		
Altered mental status	215/300 (71.7)	232/299 (77.6)
Cold, clammy skin and extremities	257/300 (85.7)	245/299 (81.9)
Oliguria	90/300 (30.0)	99/299 (33.1)
Serum lactate >2.0 mmol/l	226/300 (75.3)	218/298 (73.2)
Creatinine clearance (ml/min); median (IQR)	60.7 (43.4-86.6)	56.8 (39.7-78.1)
Infarct related artery; n/total (%)		
LAD	132/293 (45.1)	121/293 (41.3)
LCX	55/293 (18.8)	57/293 (19.5)
RCA	73/293 (24.9)	79/293 (27.0)
Left main	26/293 (8.9)	28/293 (9.6)
Bypass graft	7/293 (2.4)	8/293 (2.7)
Multivessel disease; n/total (%)	235/296 (79.4)	228/293 (77.9)
Left ventricular ejection fraction (%); median (IQR)	35 (25-45)	35 (25-45)

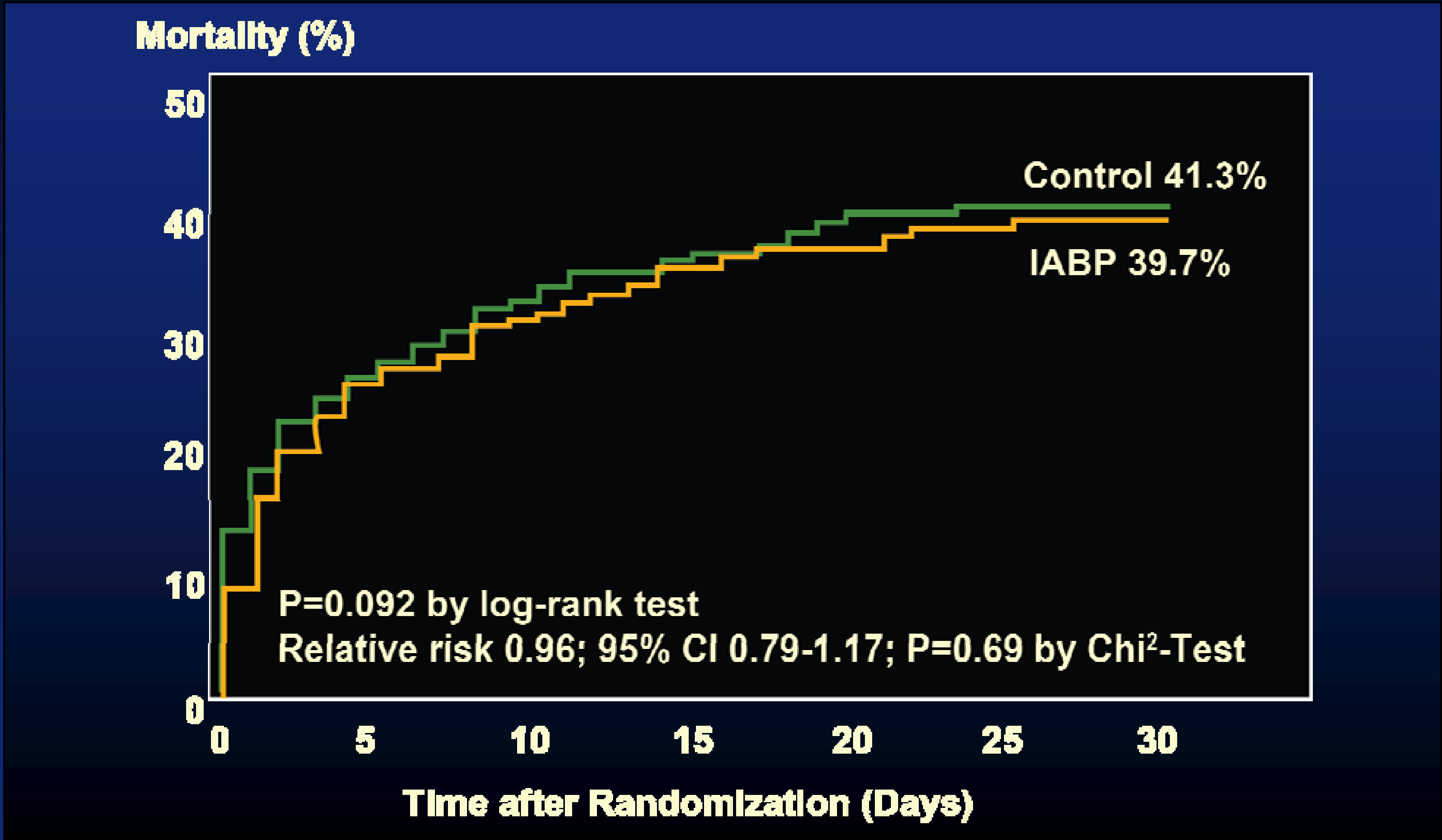
Symptoms -> randomization 4 hrs 40 min; shock -> randomization 2 hrs 16 min; Symptoms -> revasc 5 hrs Personal communication H. Thiele

IABP Shock-II



Thiele H, Zeymer U, Neumann F-J, et al. N Engl J Med 2012;367:1287-96

Primary Study Endpoint (30 Day Mortality)



G. Schuler and H. Thiele, et al.

IABP for High Risk PCI

LVEF ≤ 30%
BCIS-1 Jeopardy Score ≥ 8

Randomize

Elective IABP Insertion

No Planned IABP

PCI

Remove IABP 4-24 hrs after PCI

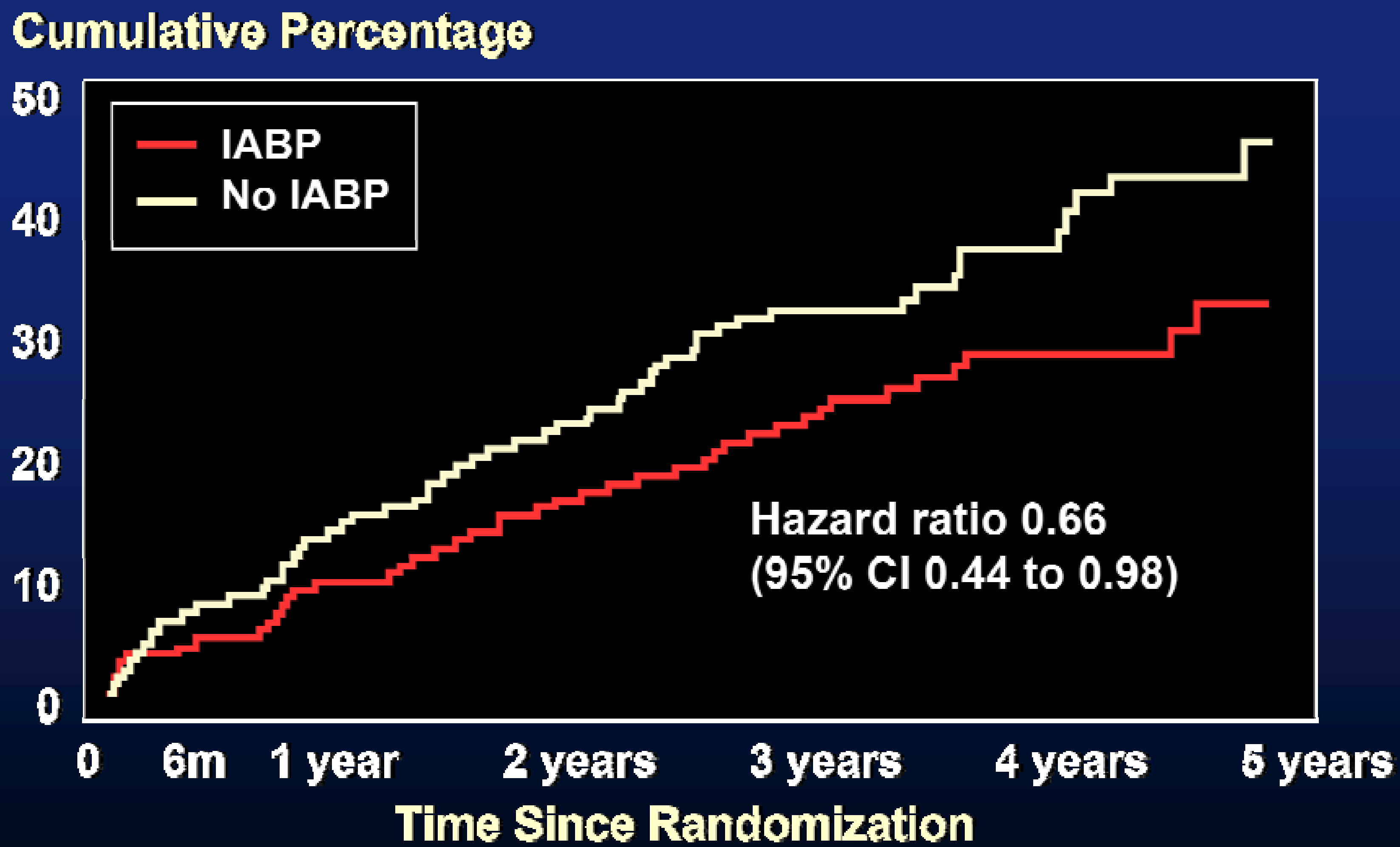
Hospital Follow-up
To discharge or 28 days

6 Month Follow-up
ONS / GROS

Age = 71 yrs,
LVEF = 24%
NYHA 3-4 = 46%

Am Heart J 2009;158:910-916

BCIS-1: All-cause Mortality
by Treatment Assignment



IABP	151	144	137	127	111	66	21
No IABP	150	139	130	117	93	52	19

IABP: Benefit Summary

- Reduces infarct size (in animals, used early)
- Improves hemodynamics (not that much)
- Relatively small diameter vascular access site
- No survival benefit demonstrated

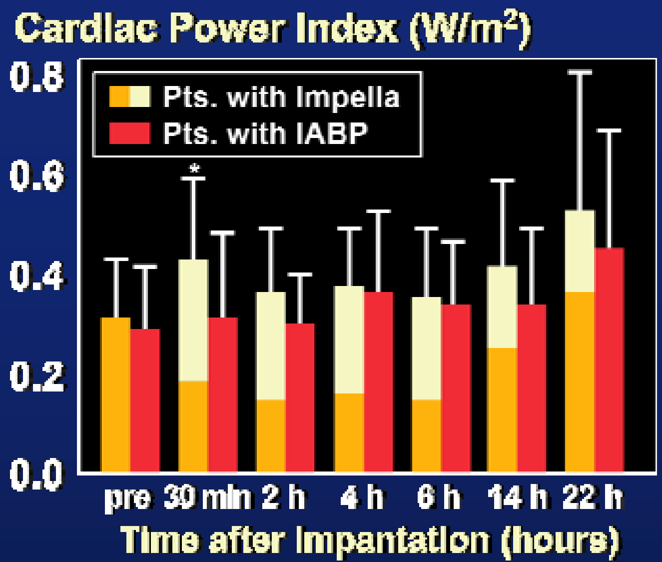
ISAR Shock

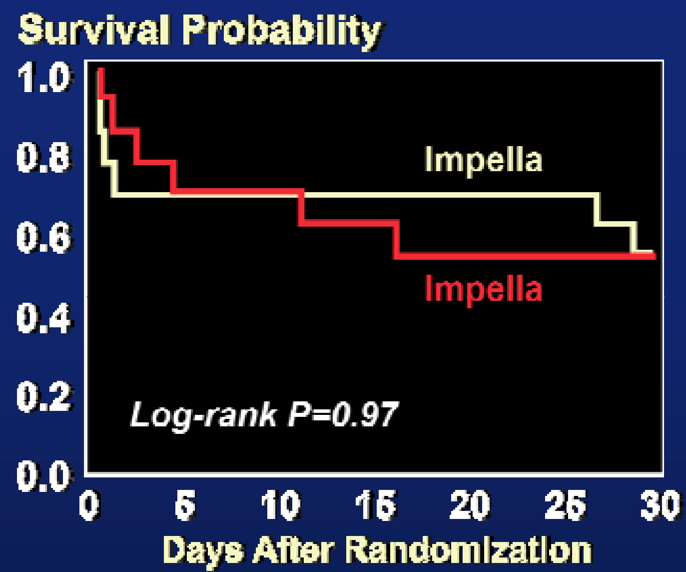
26 Patients

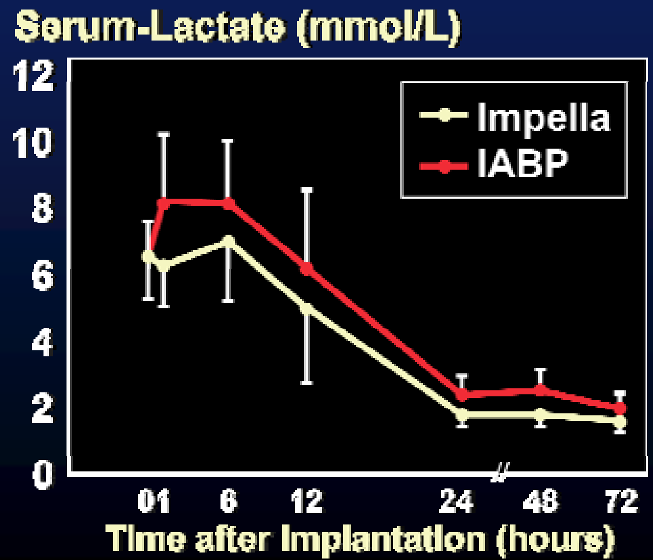
R → IABP

R → 2.5 L Impella

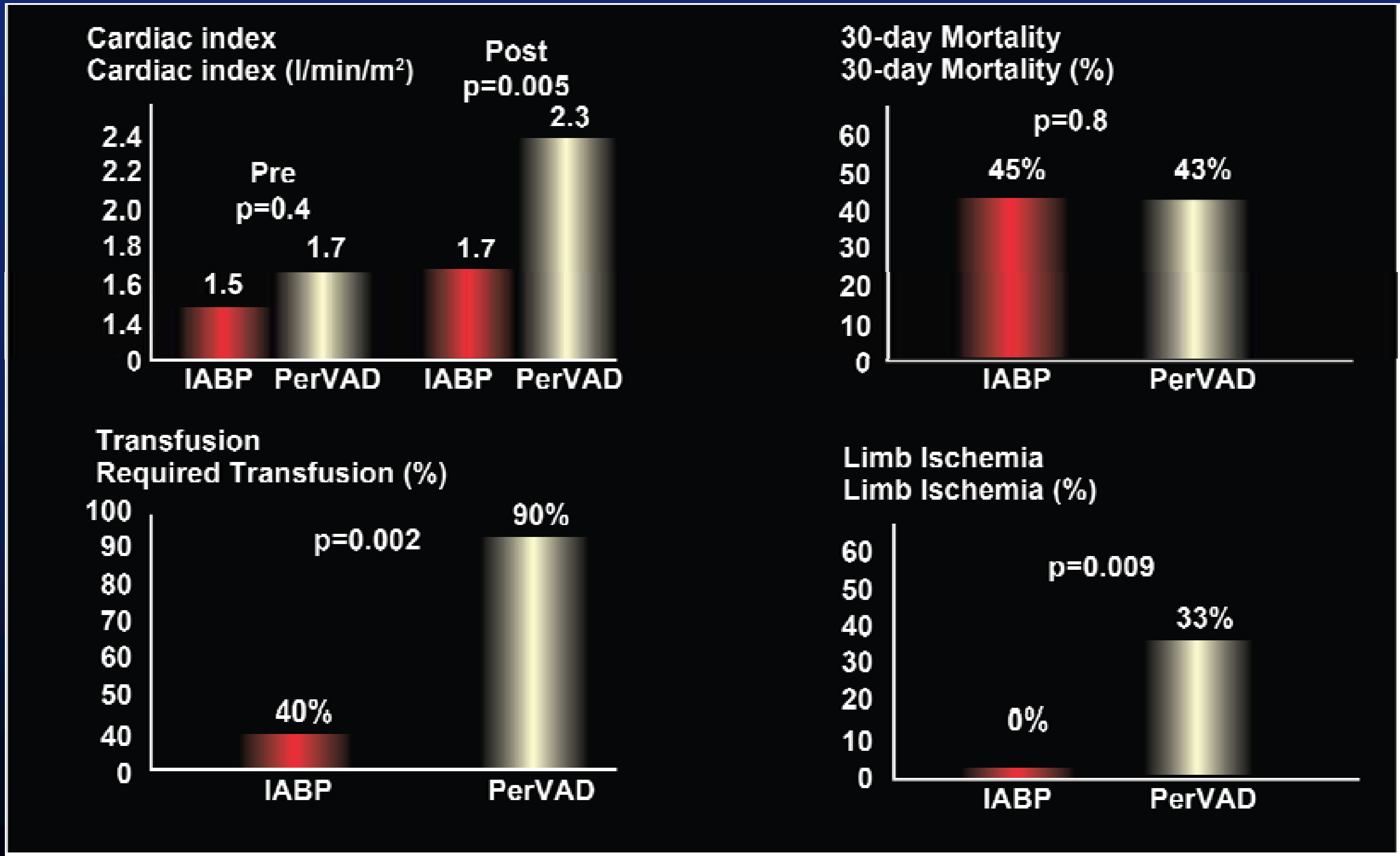
Primary Endpoint
ΔCI baseline →
30 min post-implant





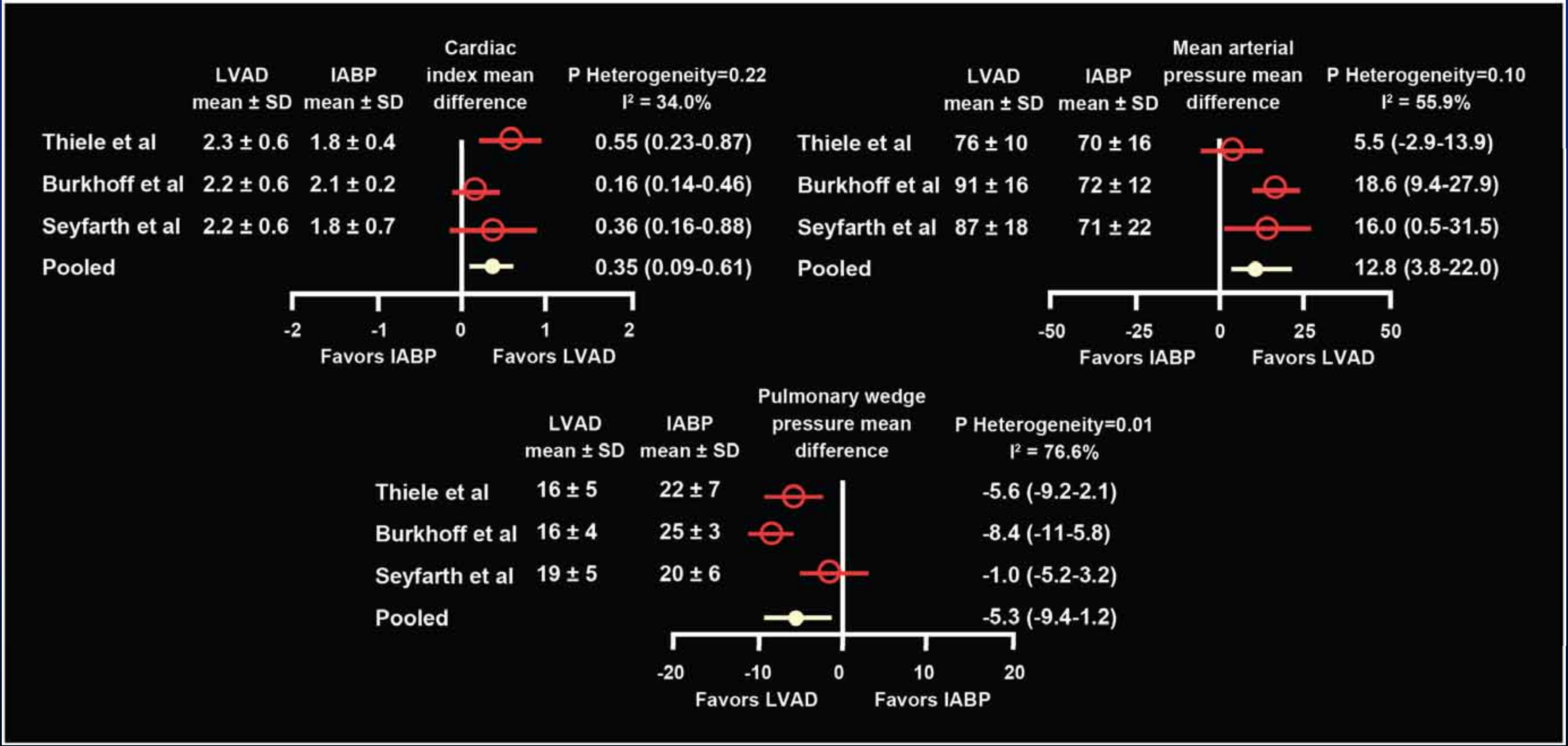


TandemHeart Shock Study



Thiele and al. Eur. Heart Journal 2005 Jul;26(13):1276-83

IABP vs LVAD Meta-Analysis



Cheng et al: EHJ 30:2102, 2009

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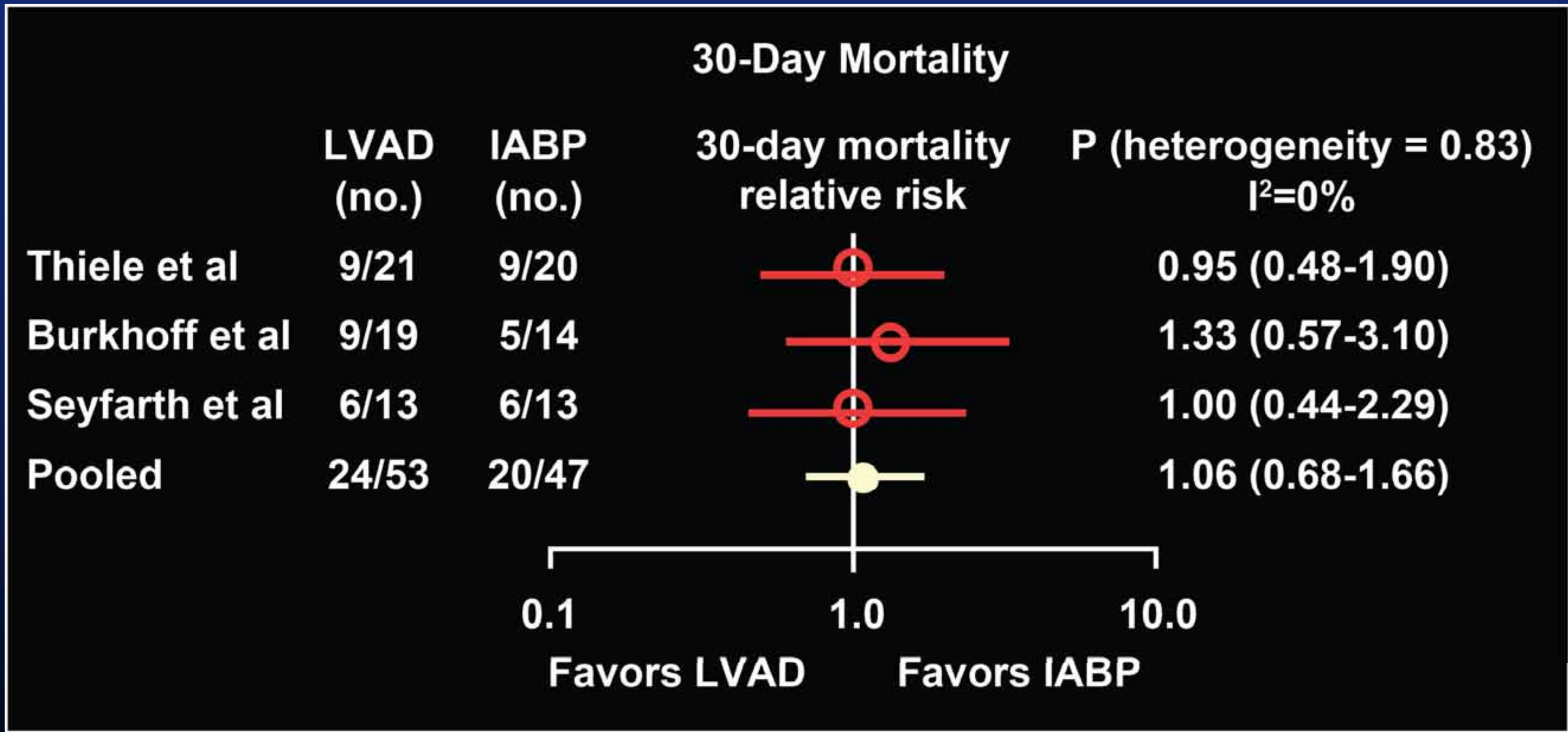

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IABP for Cardiogenic Shock

- Rapid revascularization is primary goal
- IABP allows hemodynamic stabilization to facilitate revascularization
- IABP generally initiated too late to impact infarct size
- Patients with profound shock may require more aggressive support to allow revascularization (with larger devices, more expense and risk of vascular complications)