The Role of the Cardiac Cath Lab Following Cardiac Arrest

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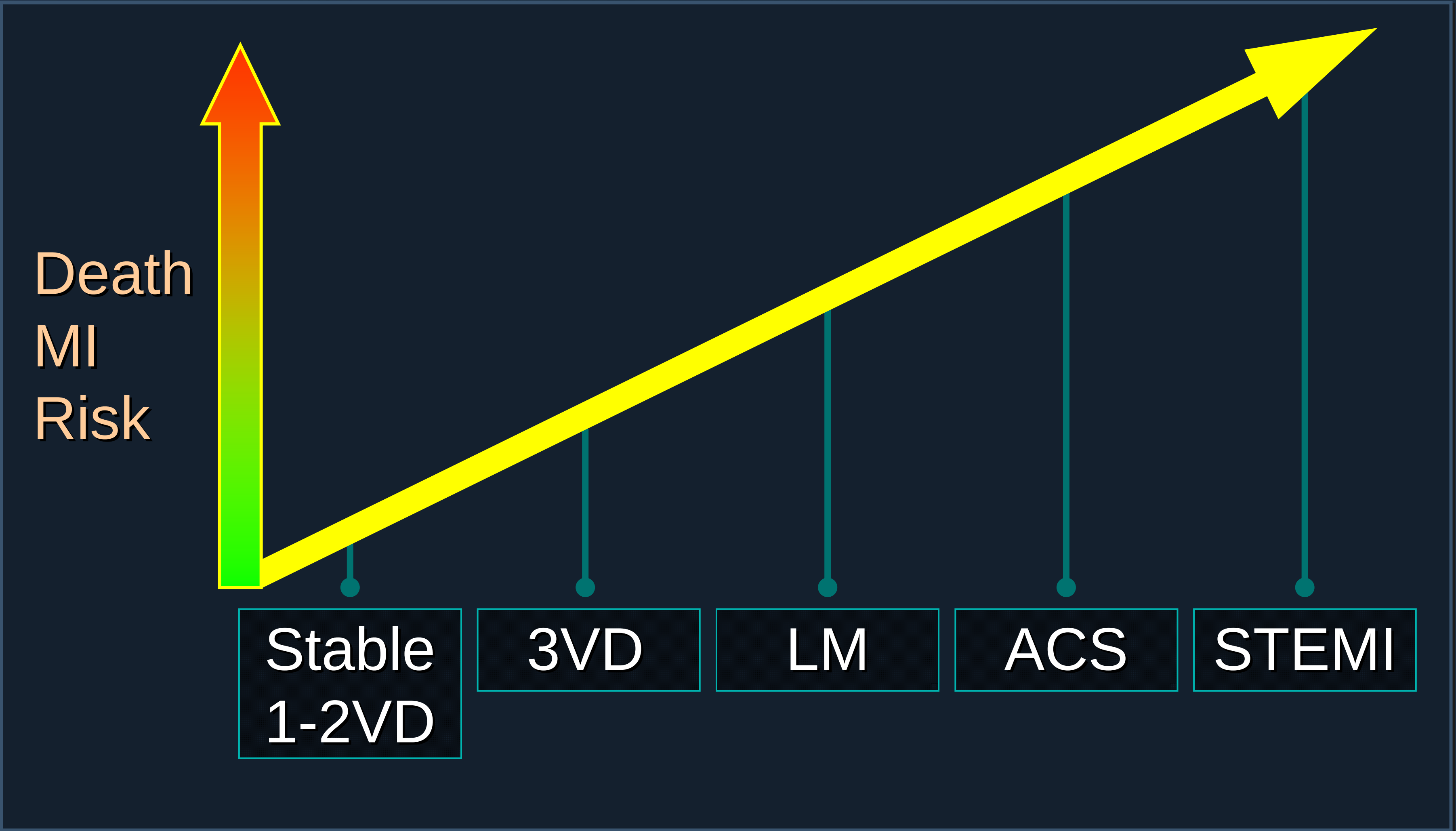
Conflict of Interest Disclosure

- Ajay J. Kirtane
  - Consultant/Honoraria/Lecture Fees from Medtronic CardioVascular, Abbott Vascular, Boston Scientific, St. Jude Medical, Medicines Company
  - Advisor to Medtronic CardioVascular

Level of Evidence for Primary PCI Following Resuscitated Cardiac Arrest

- Virtually all randomized trials of primary PCI have excluded patients with cardiac arrest
- The majority of data is therefore observational
- Observational studies of cardiac arrest are typically small, and patient selection (especially for invasive procedures) plays a large role in outcomes

The Spectrum of CAD



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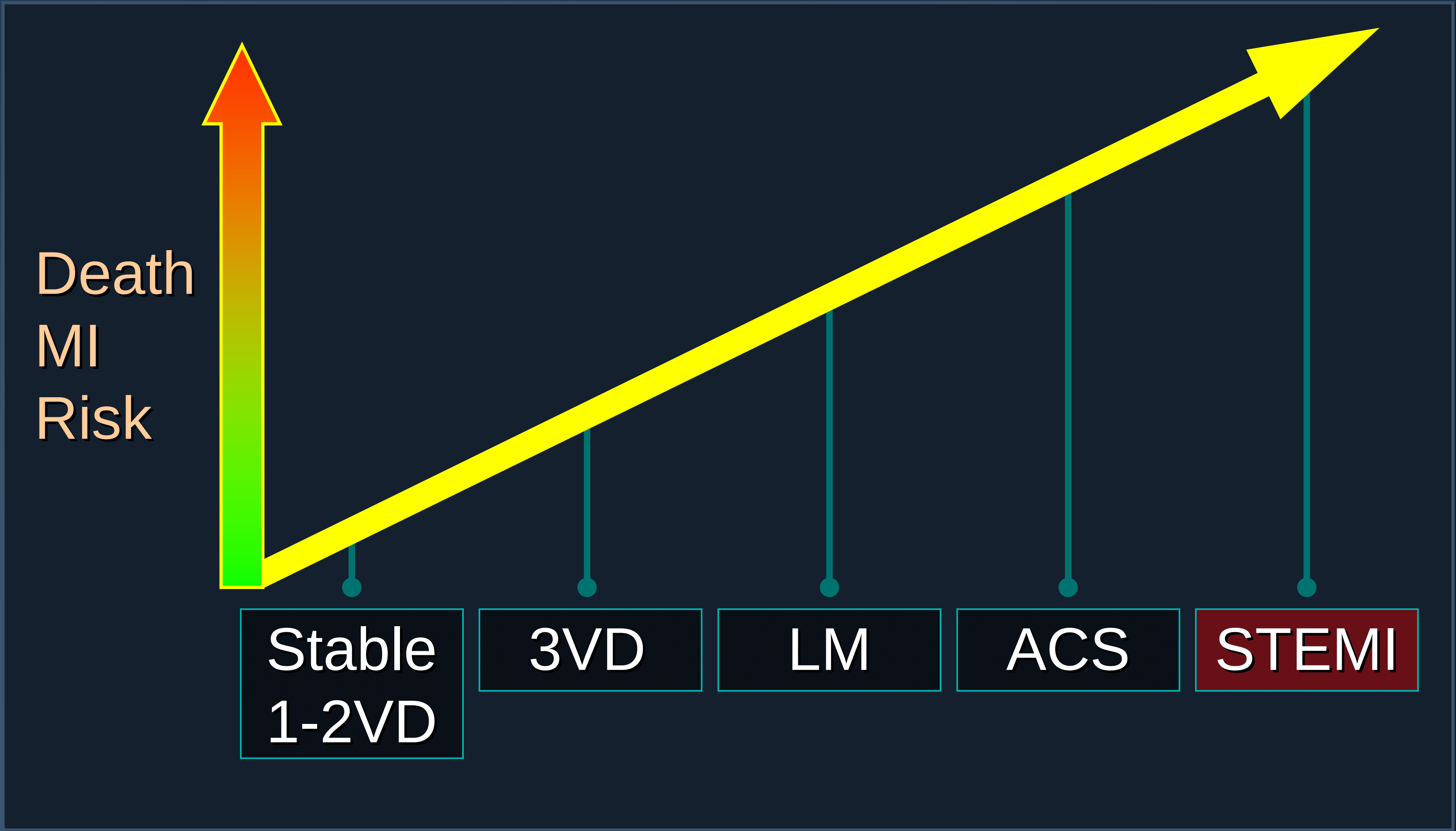
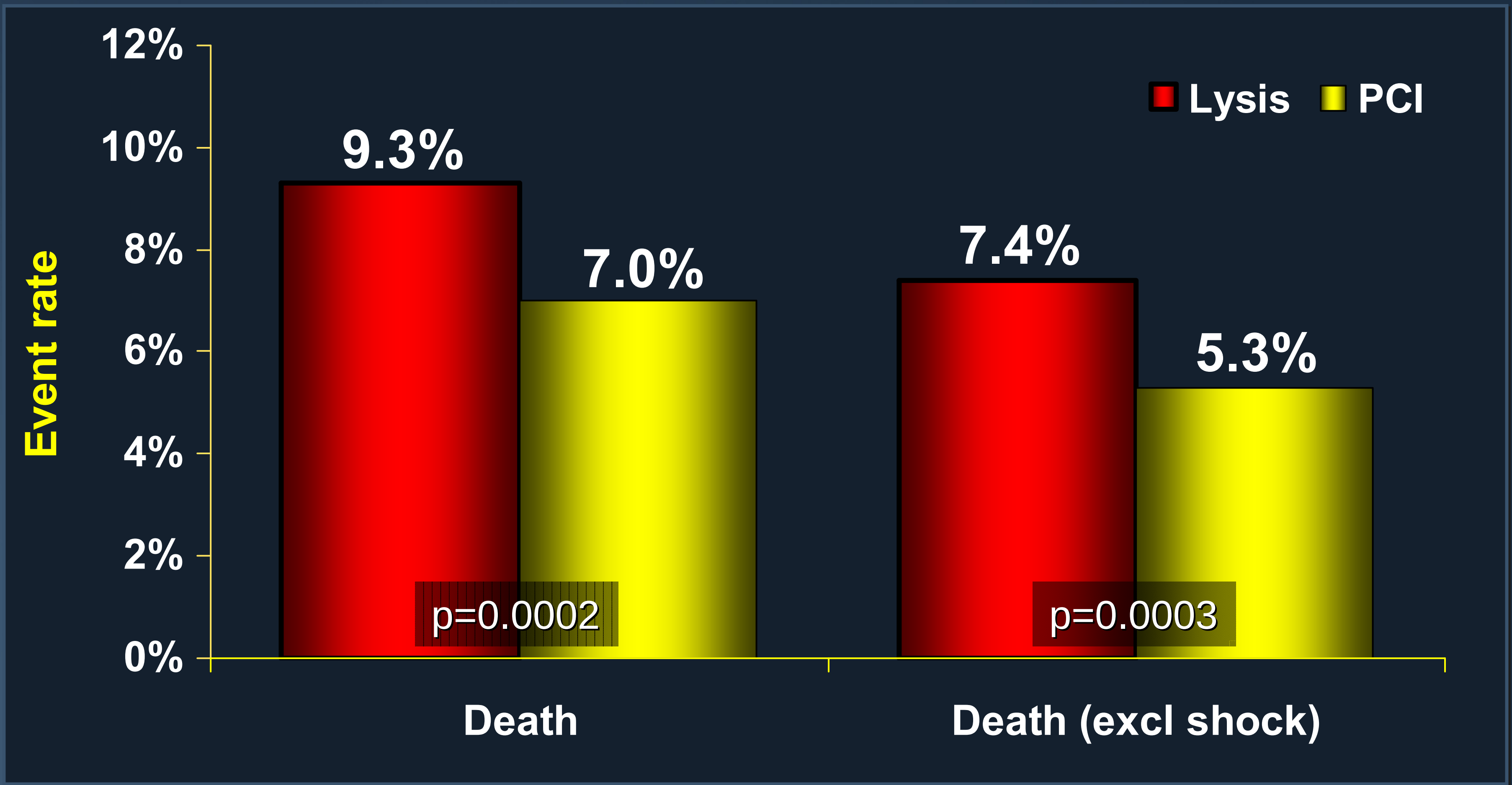


The Pathophysiology of AMI

Ruptured plaque with luminal and intraplaque occlusive thrombus

23 Randomized Trials of PCI vs. Lysis

N = 7,739



Keeley, Grines. Lancet 2003;361:13-20

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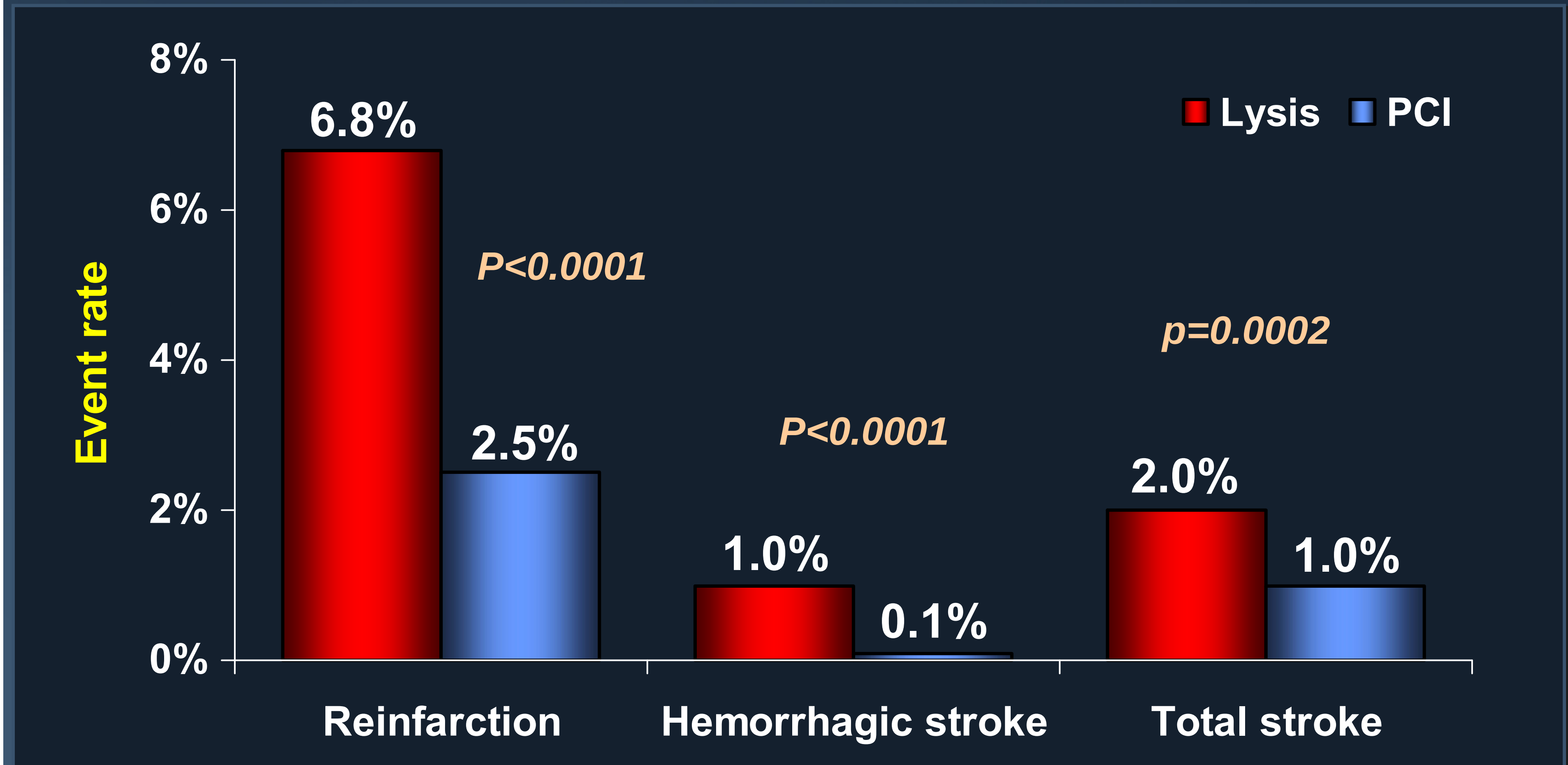
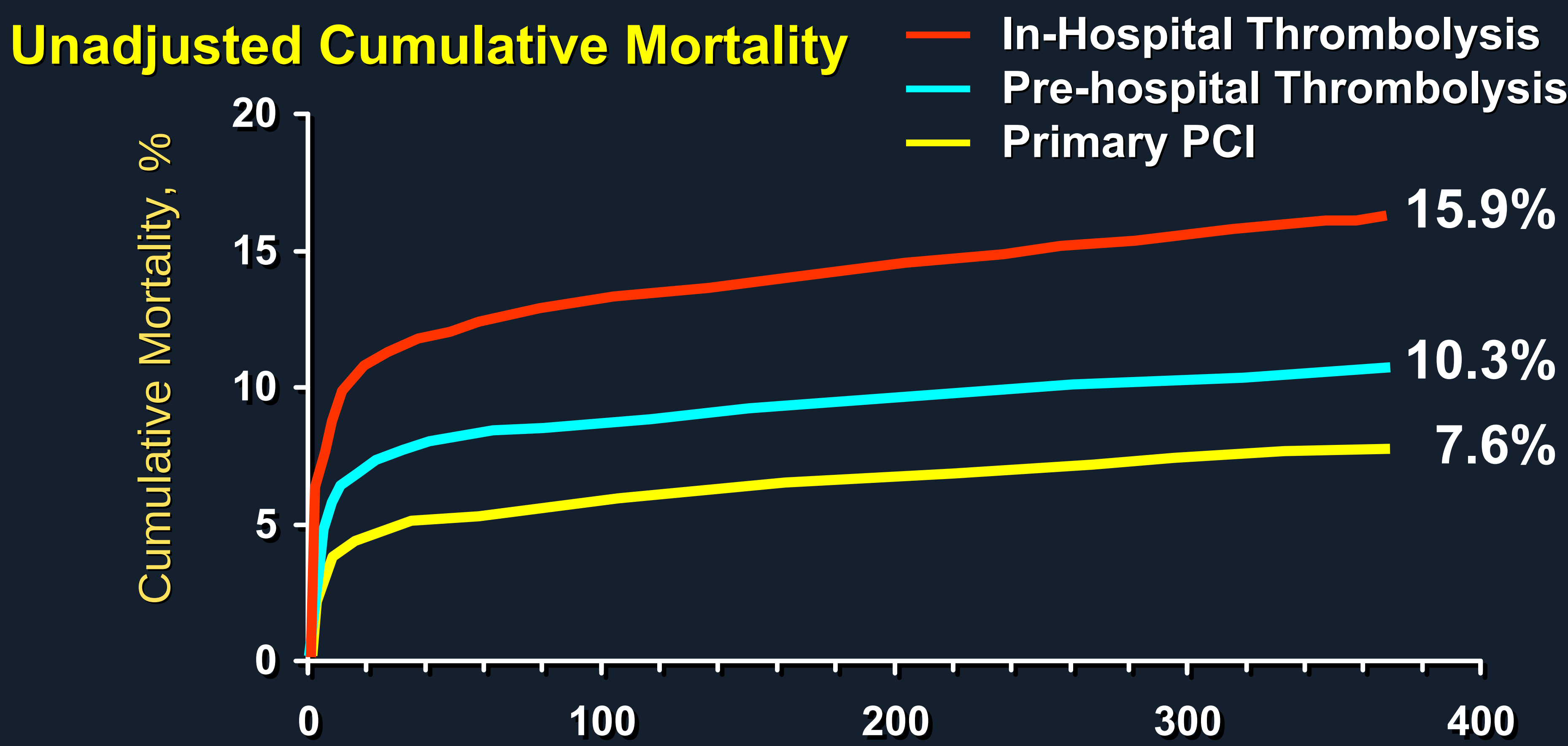


Keeley, Grines. *Lancet* 2003;361:13-20

The RIKS-HIA Registry

Consecutive pts admitted in 75 of 78 hospitals with CCUs in Sweden (N=26,206 STEMIs)

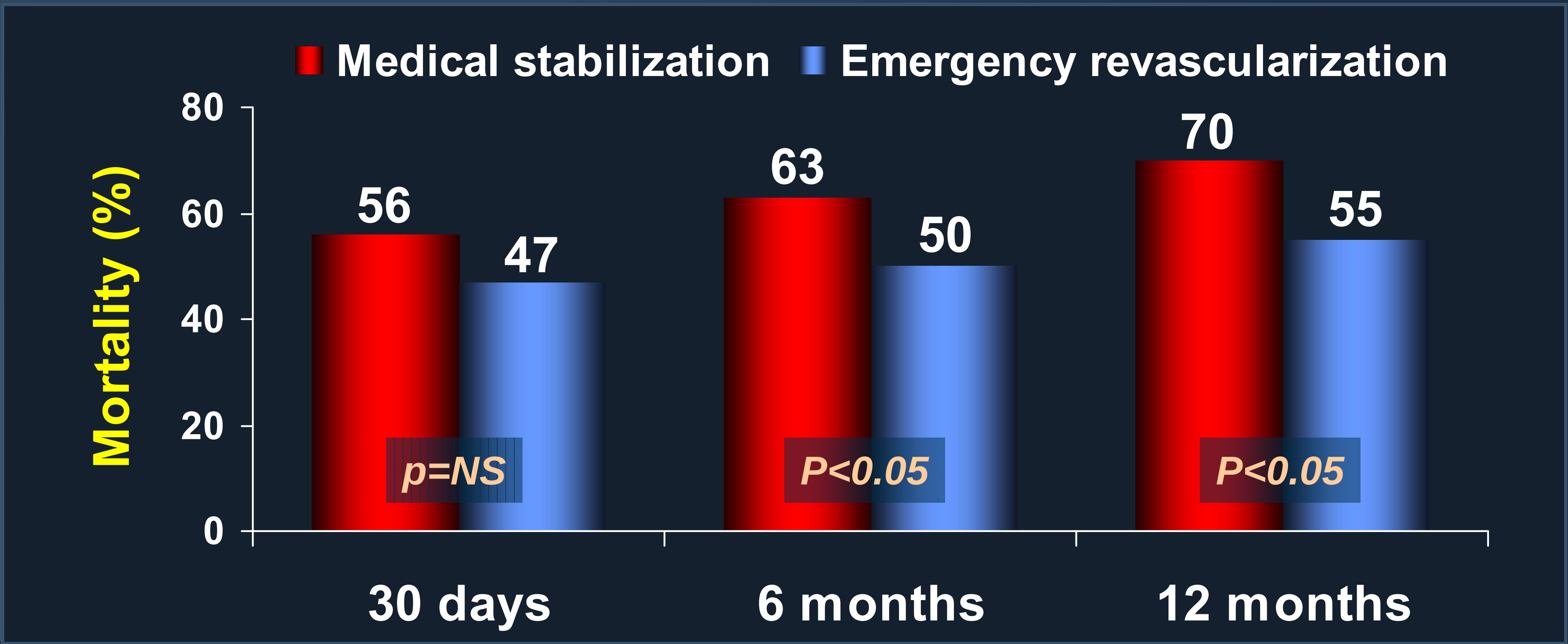


# at Risk				
In Hospital TL	14260	12322	12100	11931
Prehospital TL	2736	2491	2460	2442
Primary PCI	6030	5661	5607	5555

Stenestrand U et al. *JAMA* 2006;296:1749-56

SHOCK Trial

302 pts with cardiogenic shock within 36° of AMI & ST↑/new LBBB randomized to emergency revasc. (n=152) or initial medical care (n=150)



Hochman J et al. *NEJM*

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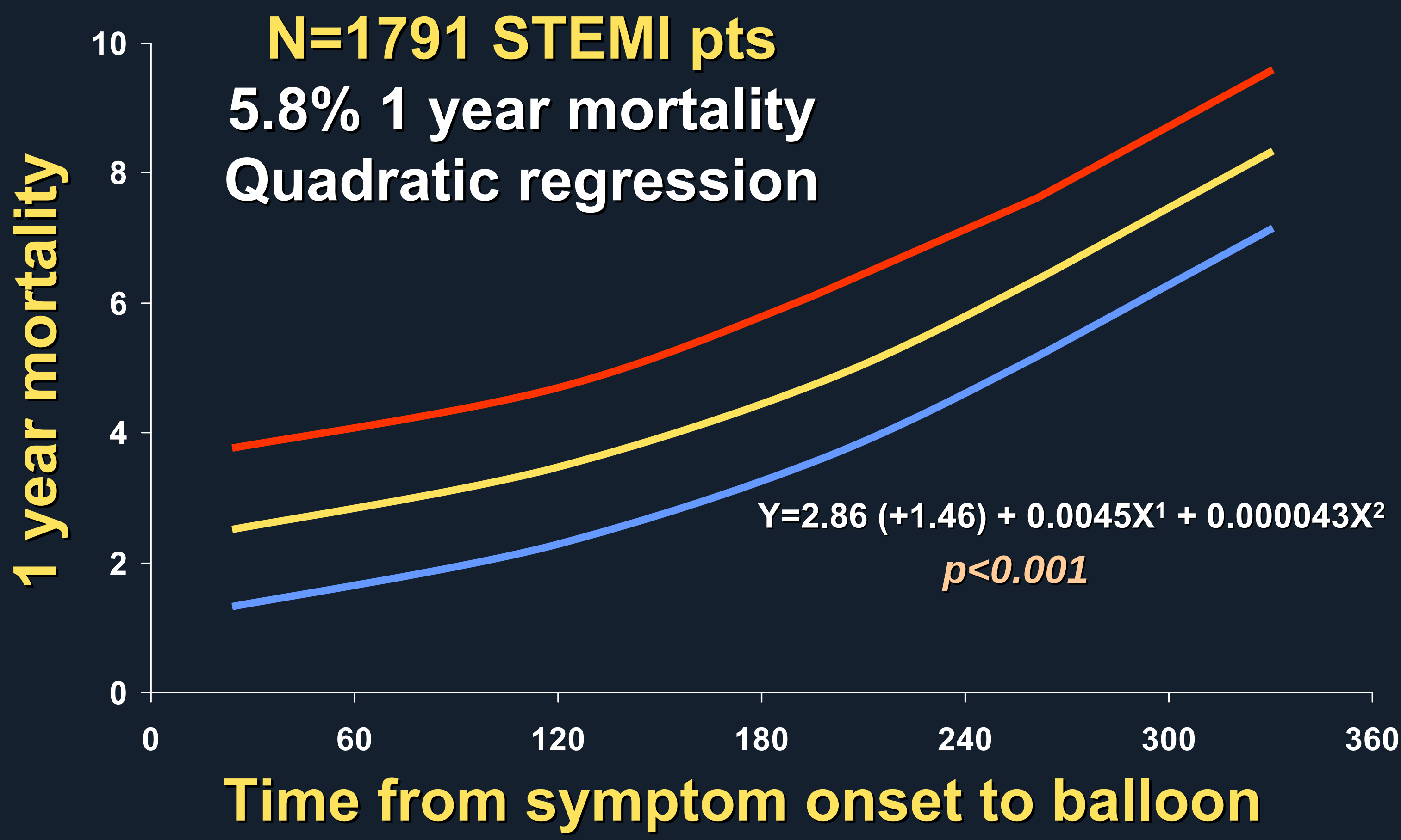
Primary PCI: Impact of Total Ischemic Time



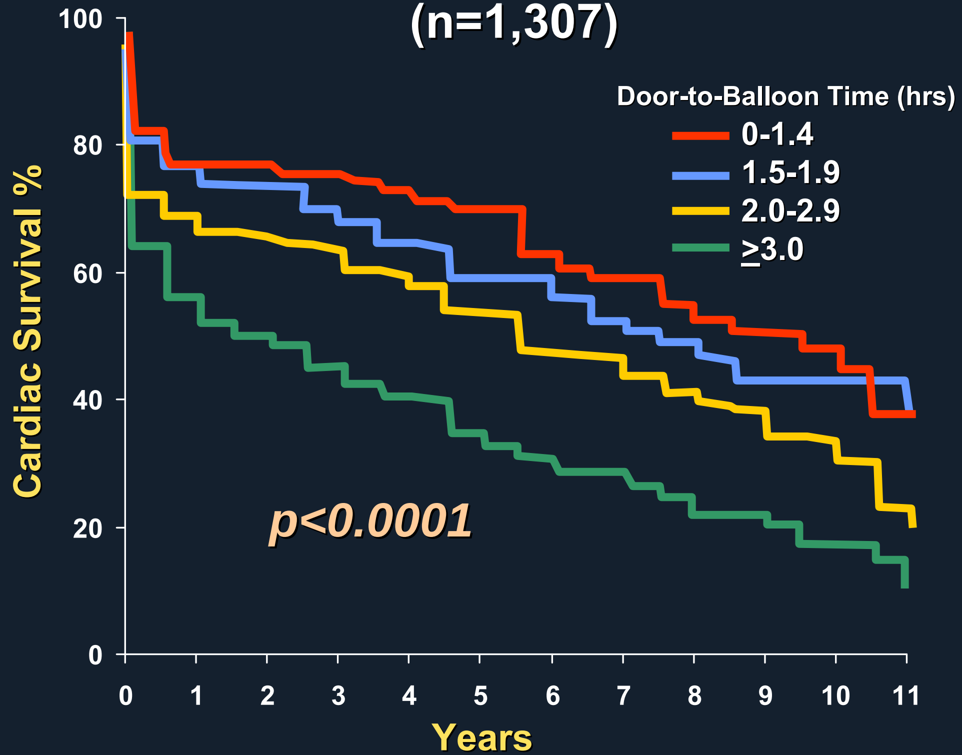
RR for 1-year mortality for each 30 minute delay of 1.08 [1.01 to 1.15], *p=0.041*

Impact of Patient Risk on the Relationship Between DBT and Mortality

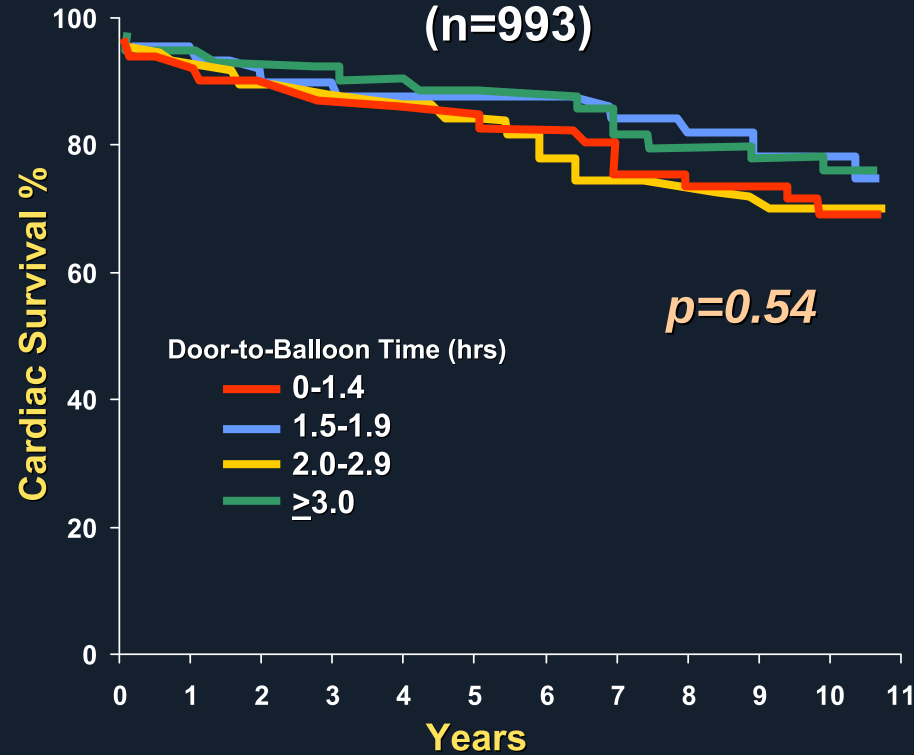
2300 pts undergoing primary PCI (Moses Cone)

High risk = Killip class 3/4, age >70 years, or anterior infarction

High Risk Patients (n=1,307)

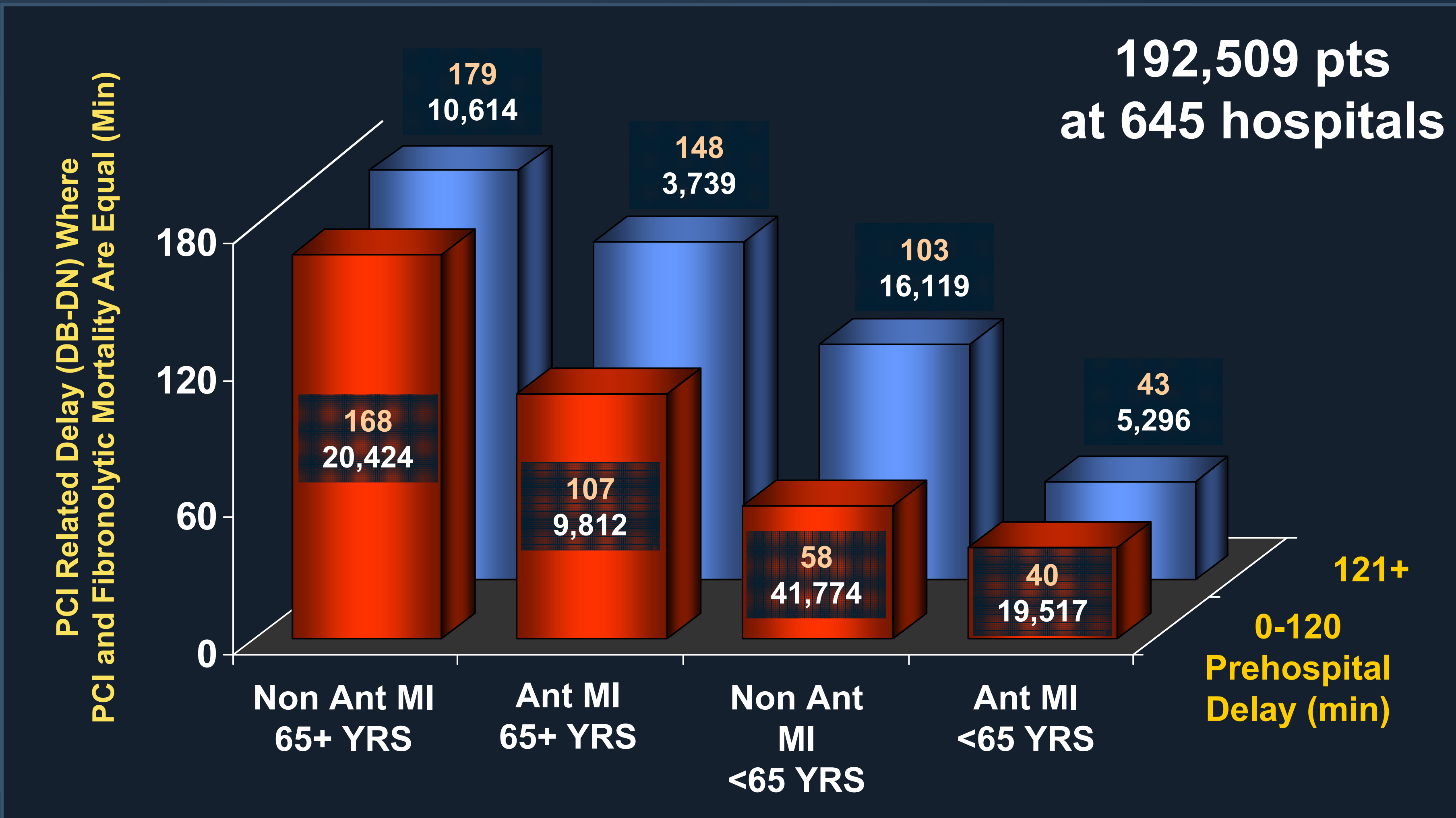


Low Risk Patients (n=993)



Brodie BR et al. *JACC* 2006;47:289–95

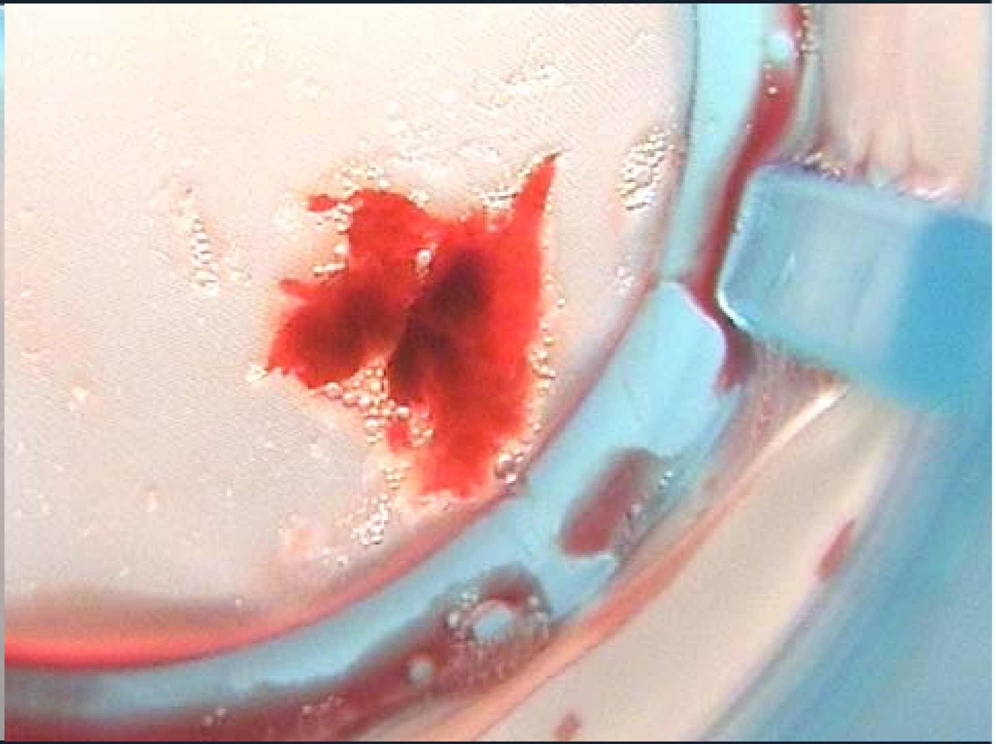
NRMI: Multivariate Adjusted Impact of Incremental PCI Delay Stratified by Age, MI Location and Presentation Delay



Pinto DS et al. *Circulation* 2006;114:2019-2025

Distal Protection and Thrombectomy in AMI

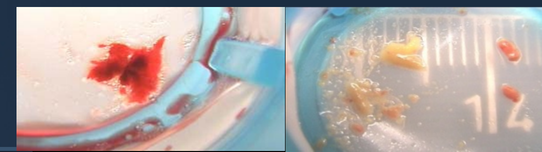
Macroscopic embolic debris can be retrieved from >75% of cases

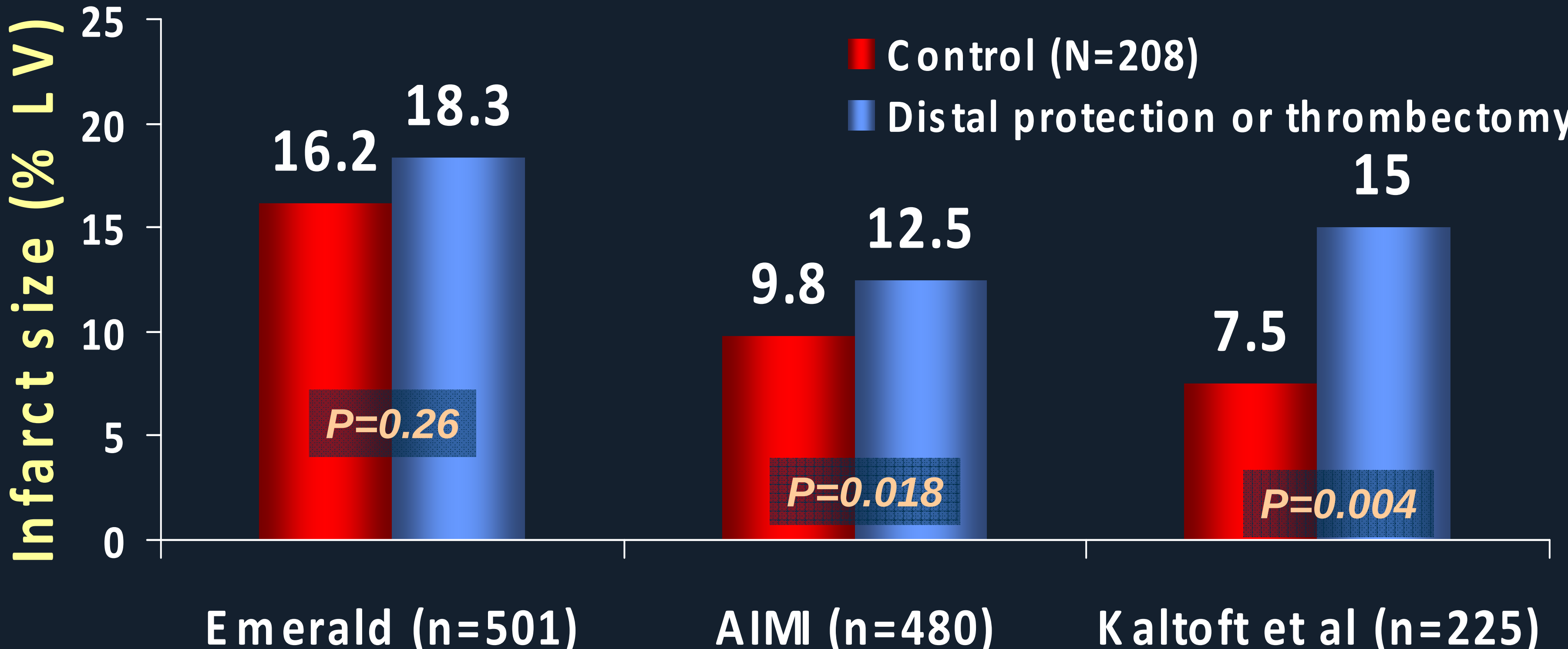


AMI: Attempts to Decrease Infarct Size

Have been mostly met with frustration

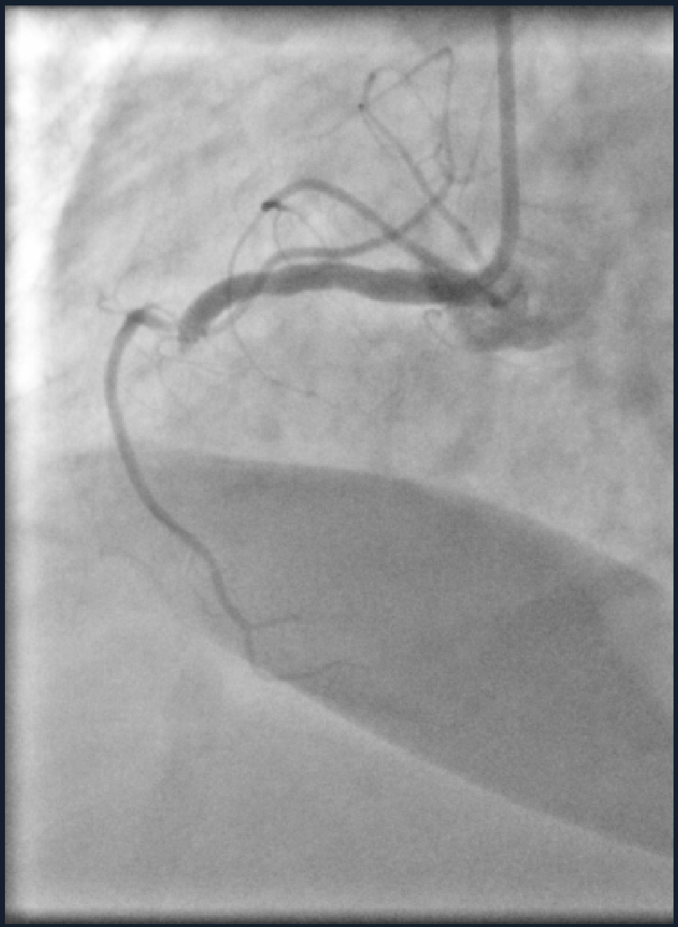
The concept of reducing embolic load

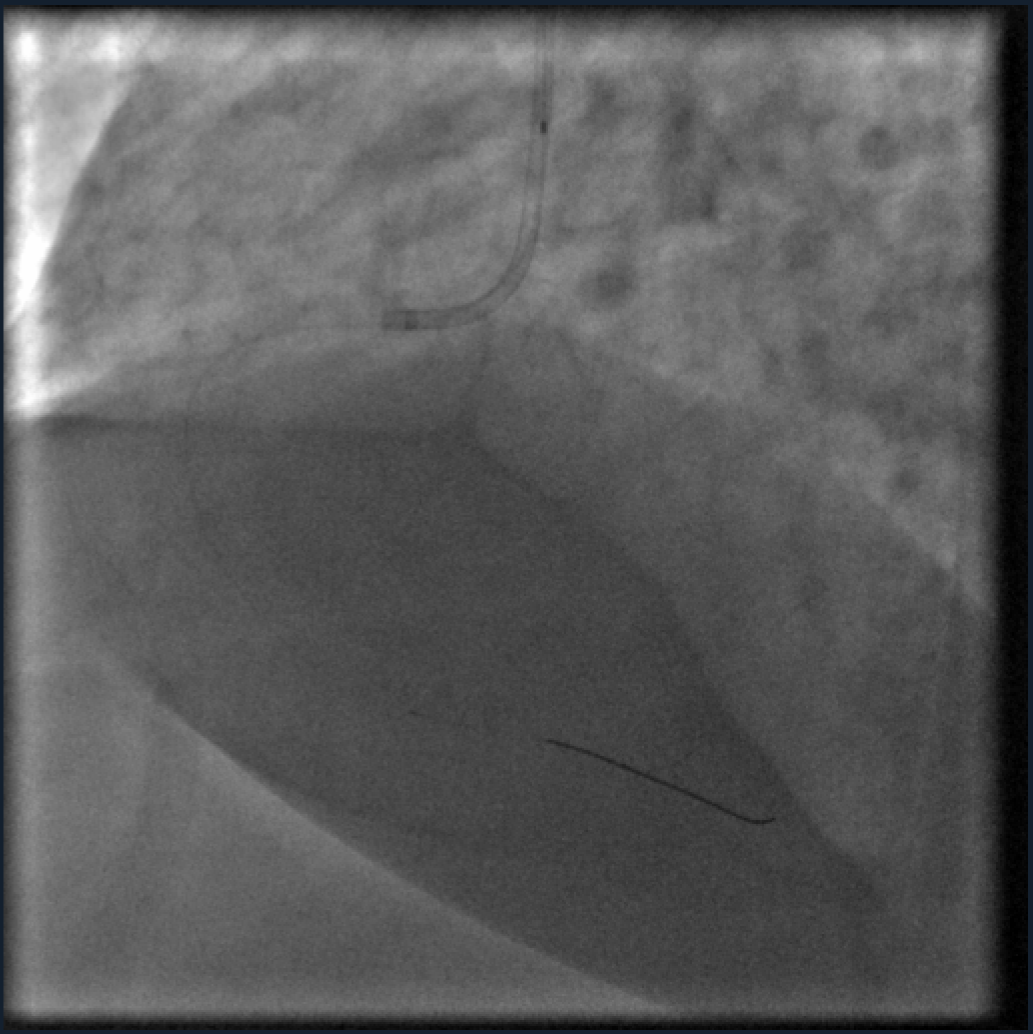




Distal protection (GuardWire Plus)	**Active thrombectomy (AngioJet)**	**Passive thrombus aspiration (Rescue)**
Stone GW et al. *JAMA* 2005	Ali A et al. *JACC* 2006	Kaltoft A et al. *JAMA* 2005

RCA Occlusion (Inferior STEMI)





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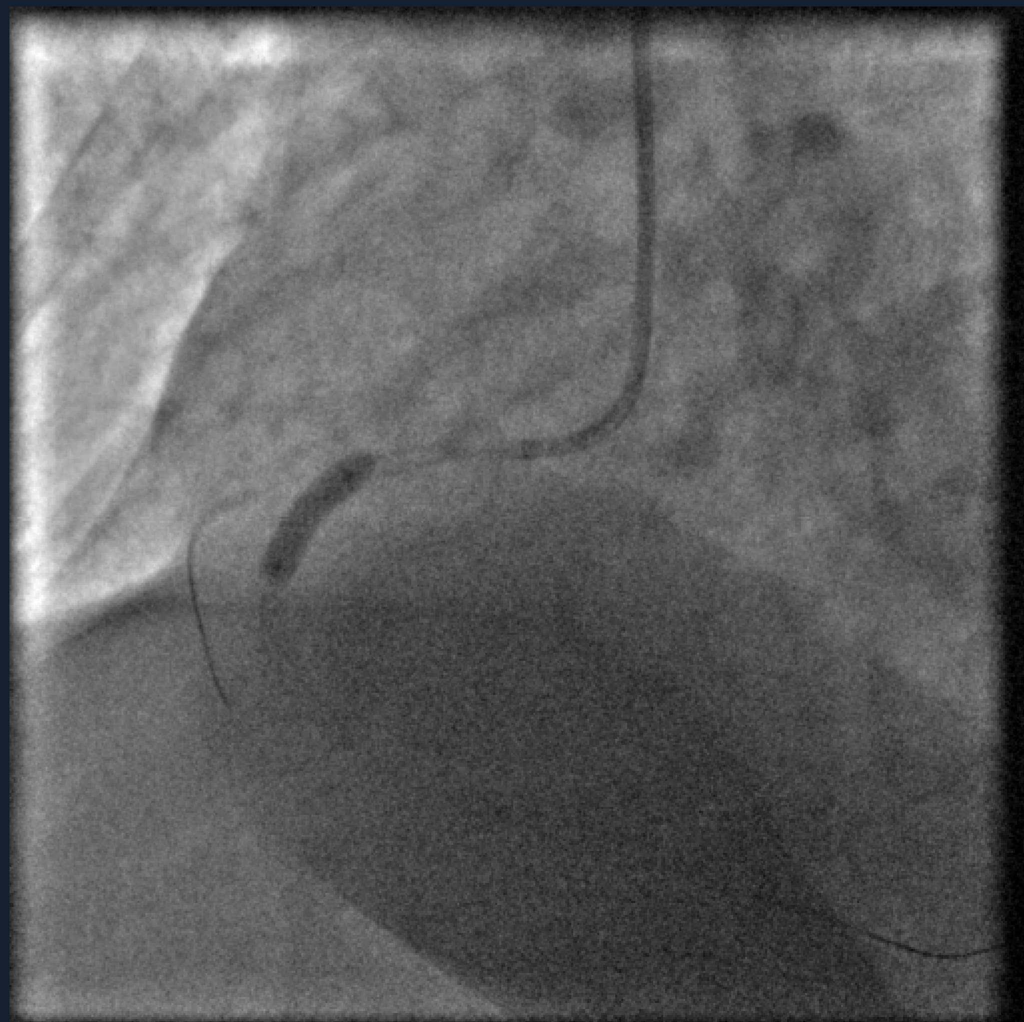
Direct Stent Implantation



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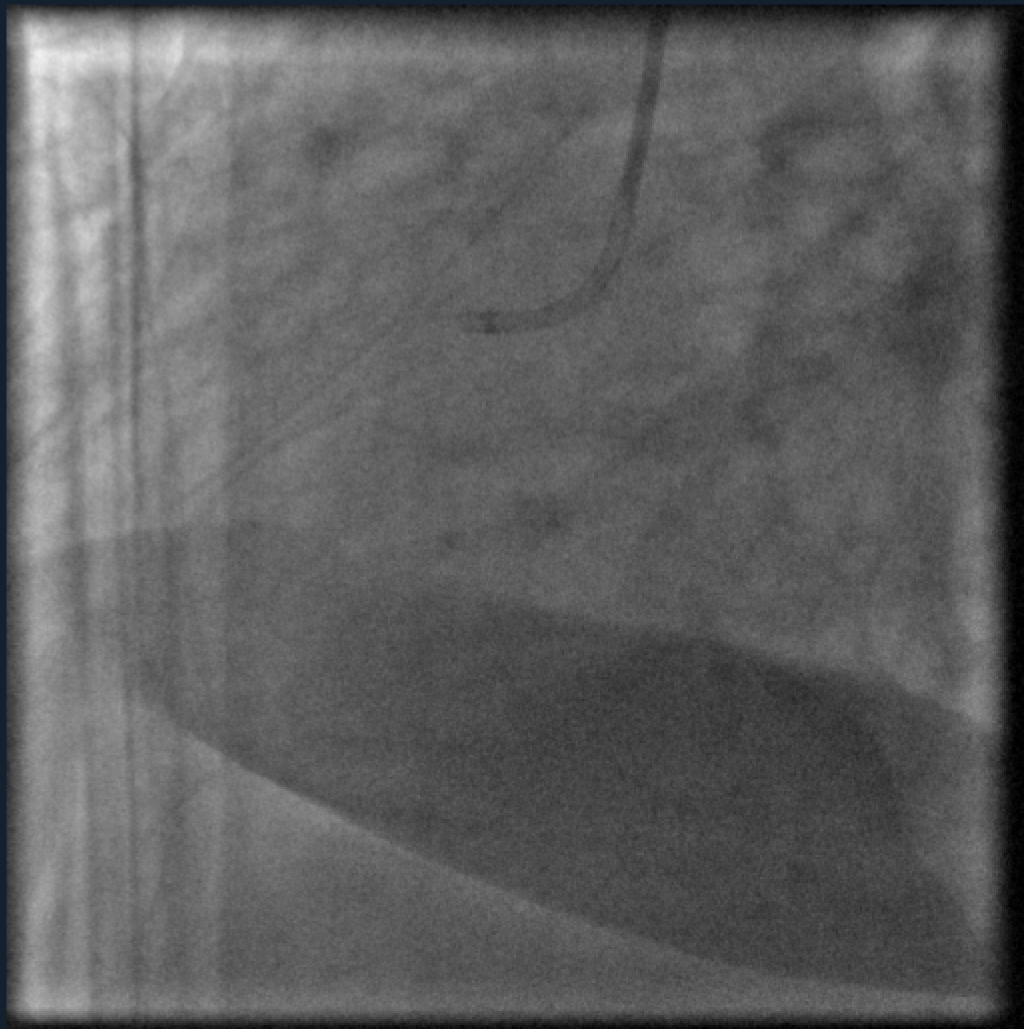
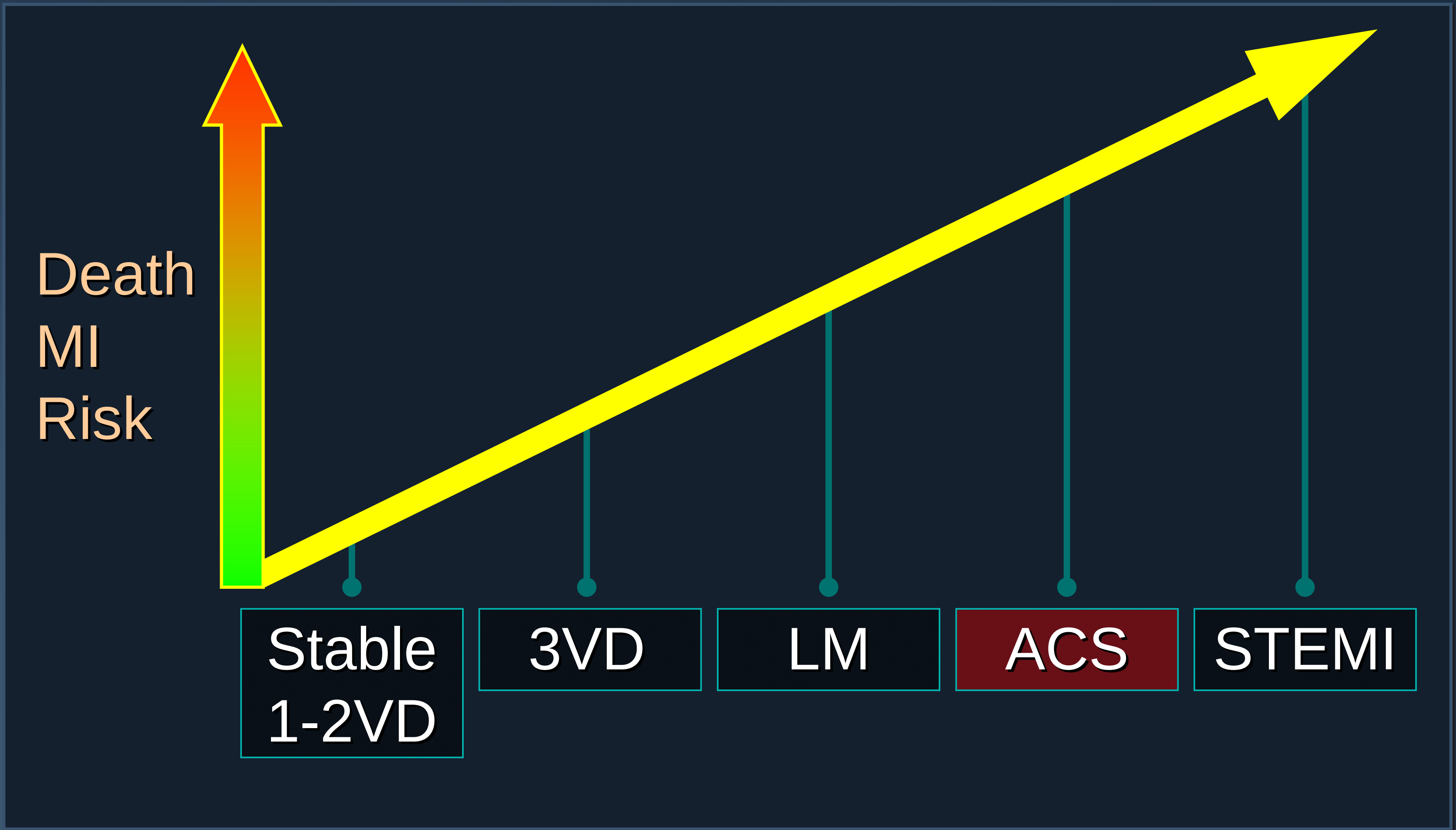
Final Angiogram



The Spectrum of CAD

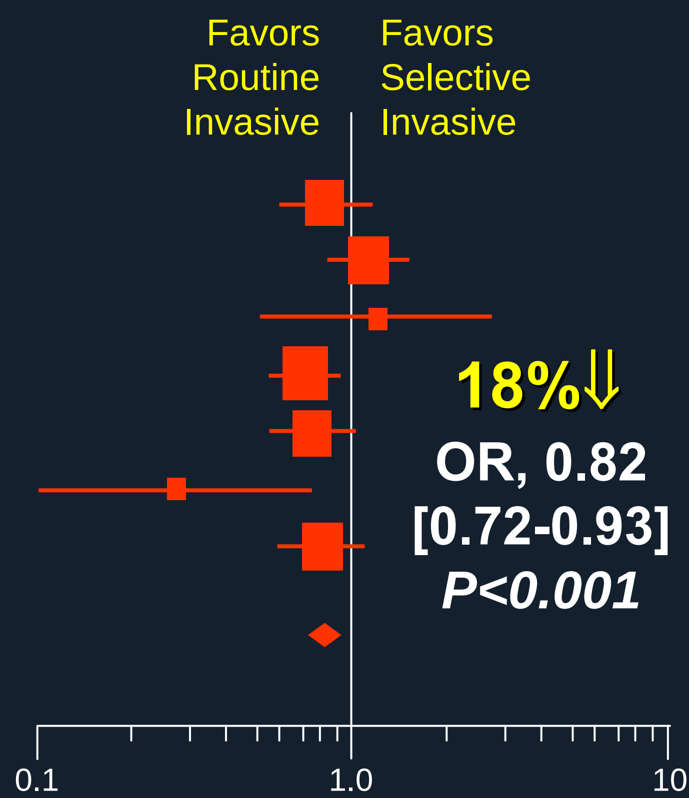


Meta-analysis of Conservative vs. Invasive Strategies in ACS

9,212 randomized pts in 7 trials

Composite death or MI from rand to latest FU

Source	Routine invasive	Selective invasive
TIMI IIIB	86/740 (11.6)	101/733 (13.8)
VANQWISH	152/462 (32.9)	139/458 (30.3)
MATE	16/111 (14.4)	11/90 (12.2)
FRISC II	127/1222 (10.4)	174/1235 (14.1)
TACTICS	81/1114 (7.3)	105/1106 (9.5)
VINO	4/64 (6.3)	15/67 (22.4)
RITA	95/895 (10.6)	118/915 (12.9)
Total	561/4608 (12.2)	663/4604 (14.4)



18%⇓
OR, 0.82
[0.72-0.93]
P<0.001

Mehta SR et al. *JAMA* 2005;293:2908-2917

Optimal Strategy for ACS

9 Randomized Trials
N=10,412

VANQWISH

ICTUS
MATE
TIMI IIIB

RITA-3
VINO
TRUCS
TACTICS-TIMI 18
FRISC II

Conservative (N=920)

N=2874

Invasive (N=6618)

TIMACS

Design, Eligibility Criteria and Protocol

UA or NSTEMI

2 of 3 Criteria: Age > 60, ischemic ECG or biomarker
AND suitable for revascularization

↓

RANDOMIZE* **Randomization ratio 1:1, 1:2 or 2:1*

↓

Early Invasive	**Delayed Invasive**
Cardiac Cath as soon as possible (<24 h)	***Cardiac Cath >36 hrs***

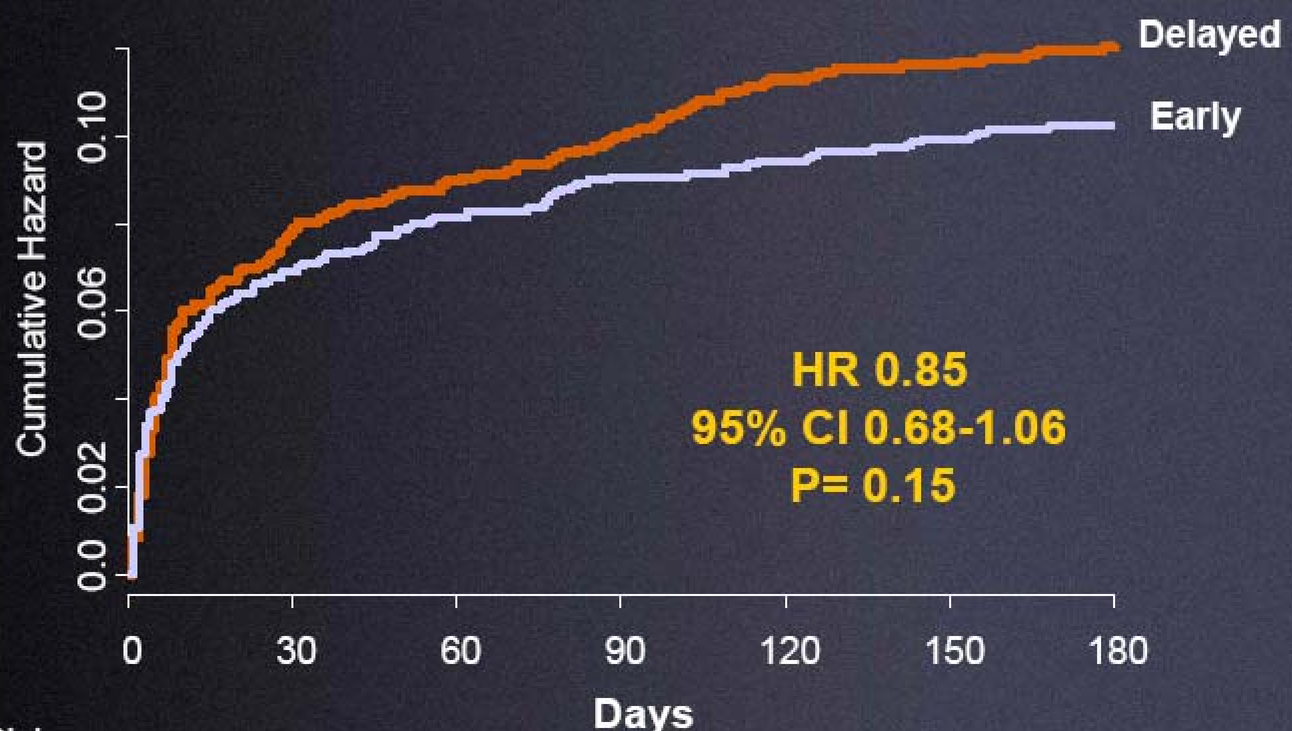
Follow-up 180 days

Mehta et al, NEJM 2009

TIMACS

Primary Outcome
Death, MI, or Stroke

Death/MI/Stroke at 180 days



No. at Risk							
Delayed	1438	1328	1269	1254	1234	1229	1211
Early	1593	1484	1413	1398	1391	1382	1363

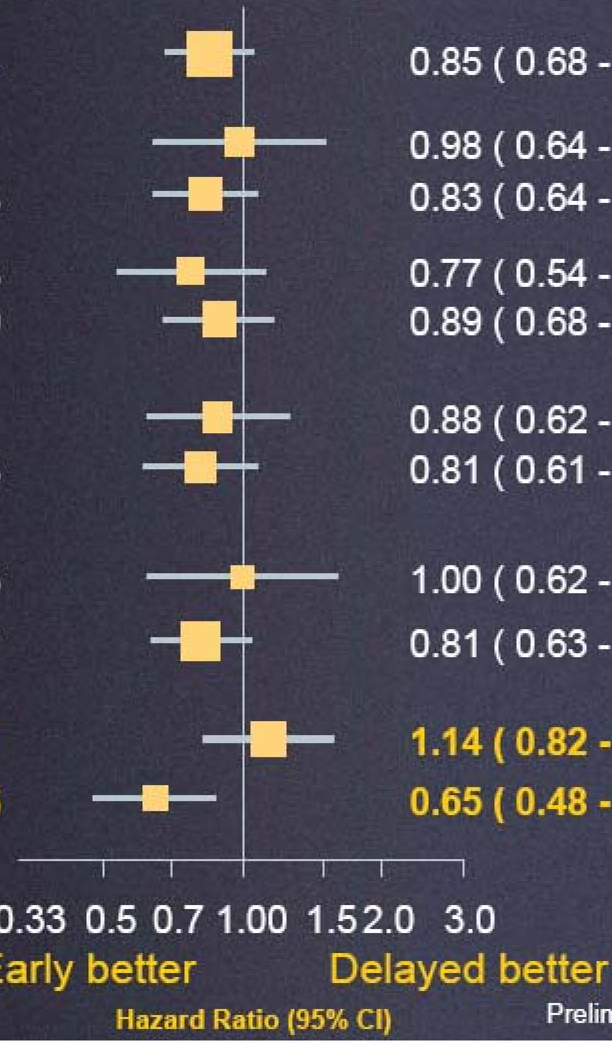
Mehta et al, NEJM 2009

Preliminary Results as of Nov 7, 2008

TIMACS

Pre-specified Subgroups

Characteristic	N	Early %	Delayed %	HR (95% CI)	Interaction p-Value
Overall	3031	9.7	11.4	0.85 (0.68 - 1.06)	
Age < 65	1293	6.5	6.5	0.98 (0.64 - 1.52)	
>=65	1736	12.3	14.8	0.83 (0.64 - 1.07)	0.463
Female	1052	9.7	12.3	0.77 (0.54 - 1.12)	
Male	1976	9.8	10.9	0.89 (0.68 - 1.18)	0.540
No ST deviation	1523	7.6	8.7	0.88 (0.62 - 1.26)	
ST deviation	1508	11.7	14.3	0.81 (0.61 - 1.07)	0.722
No elevated marker	668	10.5	10.5	1.00 (0.62 - 1.60)	
Elevated marker	2363	9.5	11.7	0.81 (0.63 - 1.04)	0.423
GRACE 0-140	**2070**	**7.7**	**6.7**	**1.14 (0.82 - 1.58)**	
GRACE >=141	**961**	**14.1**	**21.6**	**0.65 (0.48 - 0.88)**	**0.0097**



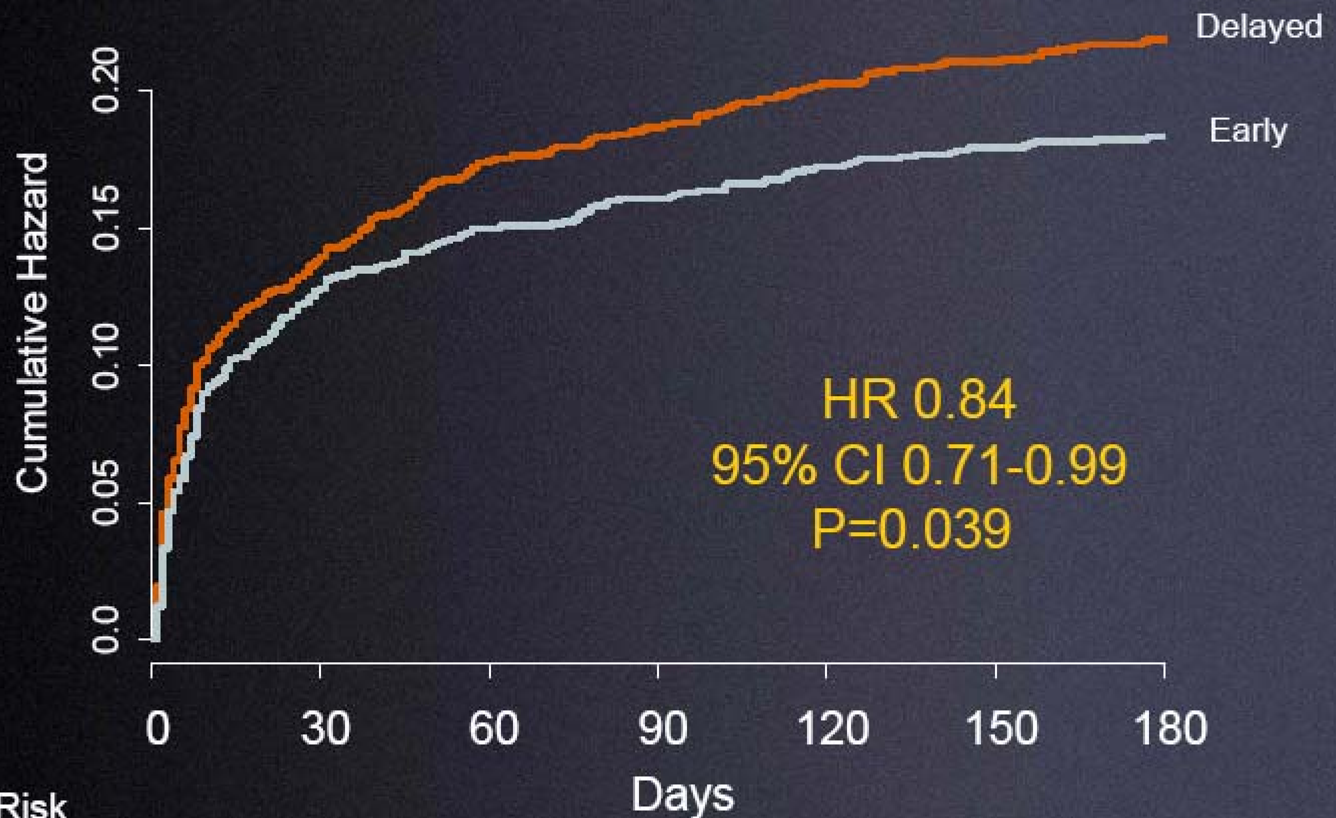
Mehta et al, NEJM 2009

Preliminary Results as of Nov 7, 2008

TIMACS

Secondary Outcome
Death, MI, Stroke, RFI or Rep Intervention

Death/MI/RI/Stroke/Rep Intervention at 180 days

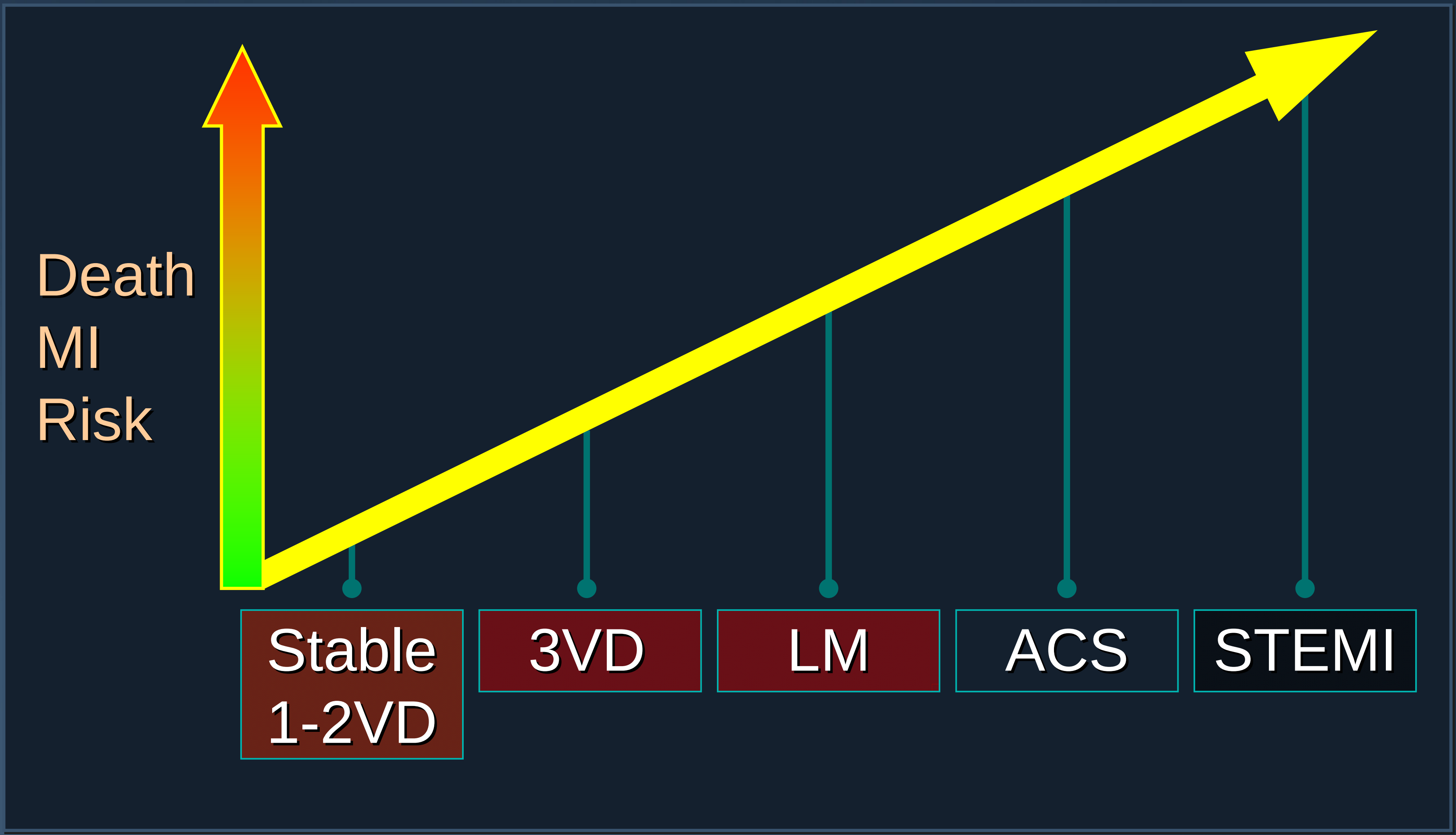


No. at Risk							
Delayed	1438	1250	1166	1150	1128	1118	1097
Early	1593	1400	1321	1304	1287	1276	1256

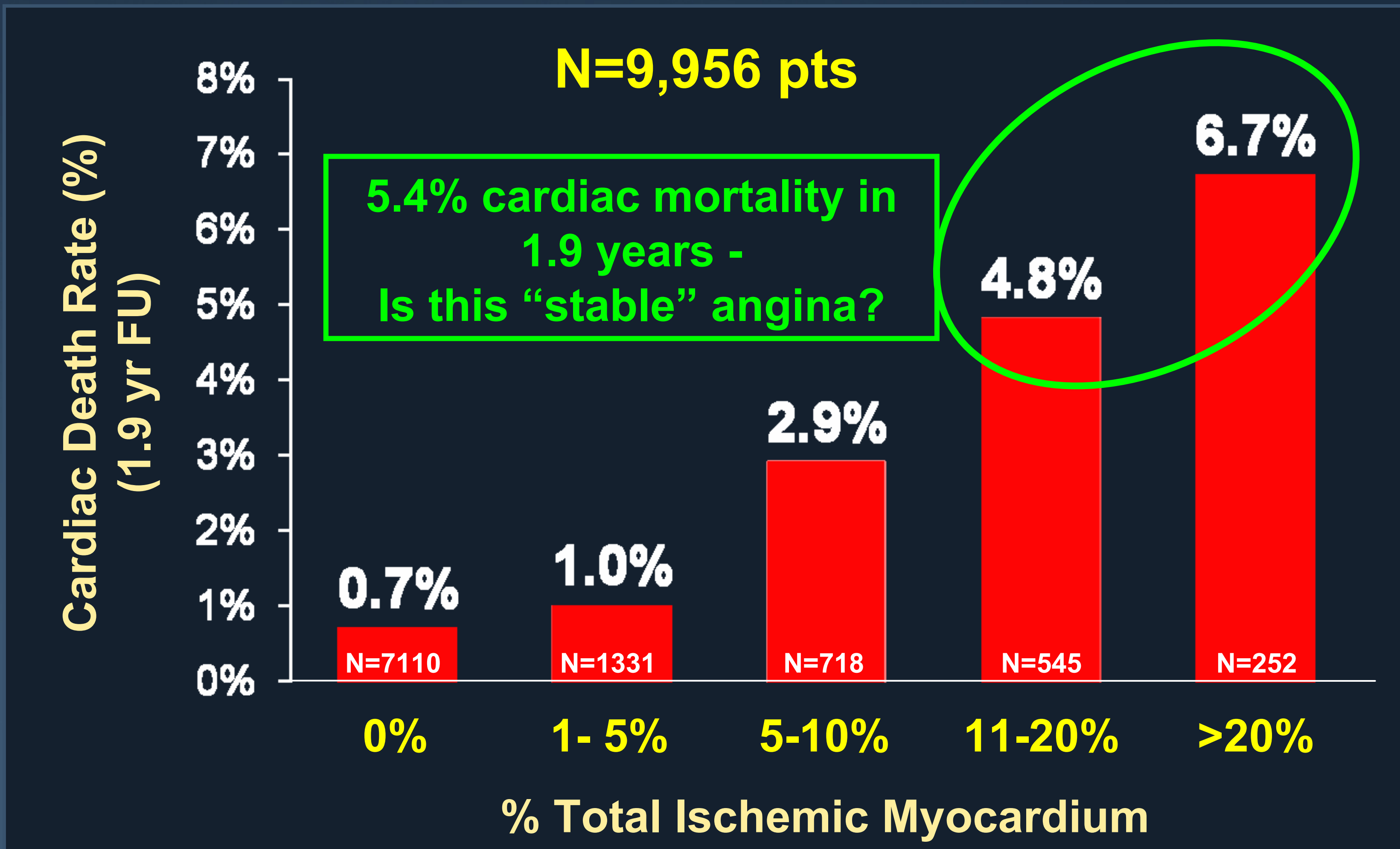
Mehta et al, NEJM 2009

Preliminary Results as of Nov 7, 2008

The Spectrum of CAD

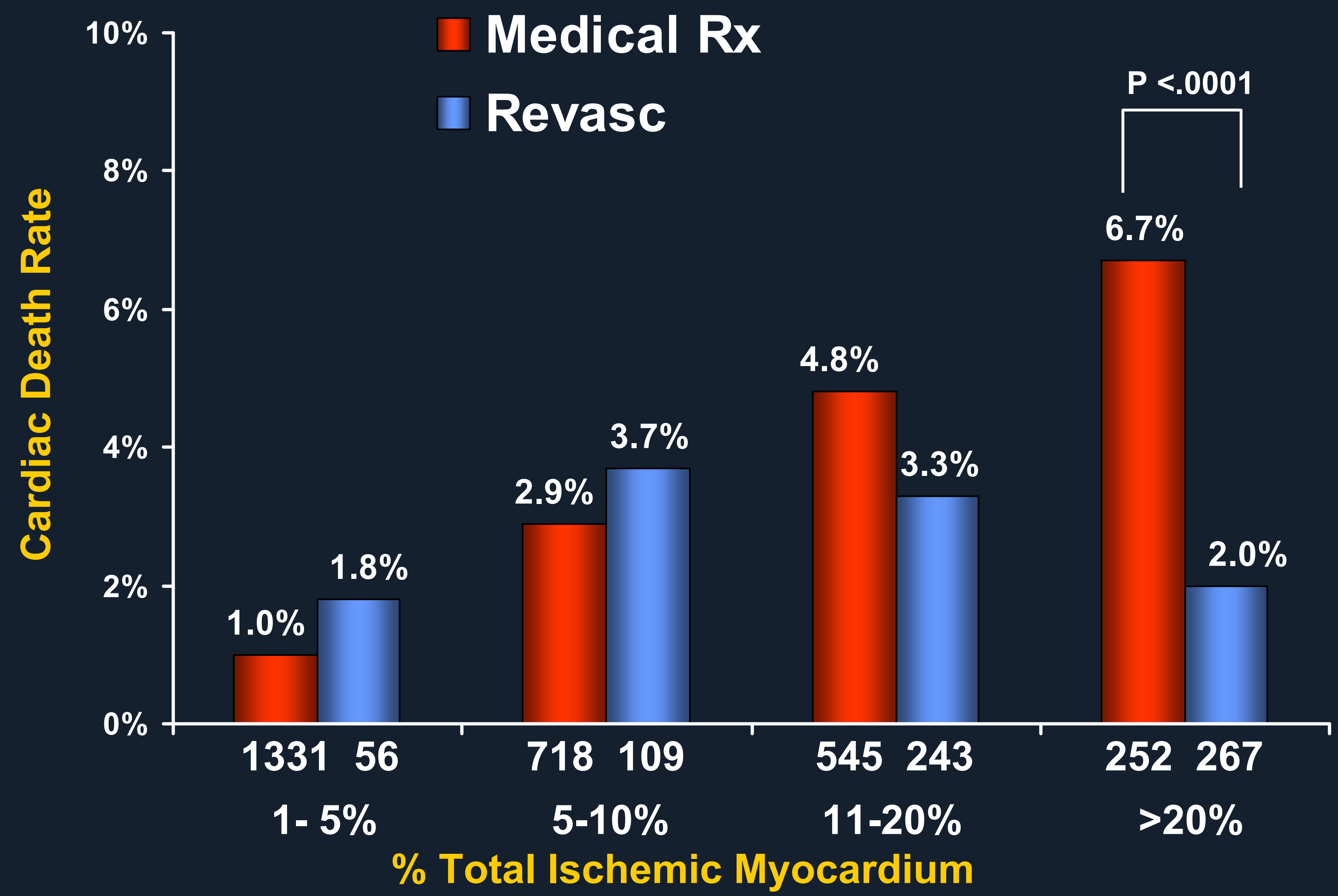


There is a Wide-Range of Morbidity/Mortality among "Stable Angina" Patients



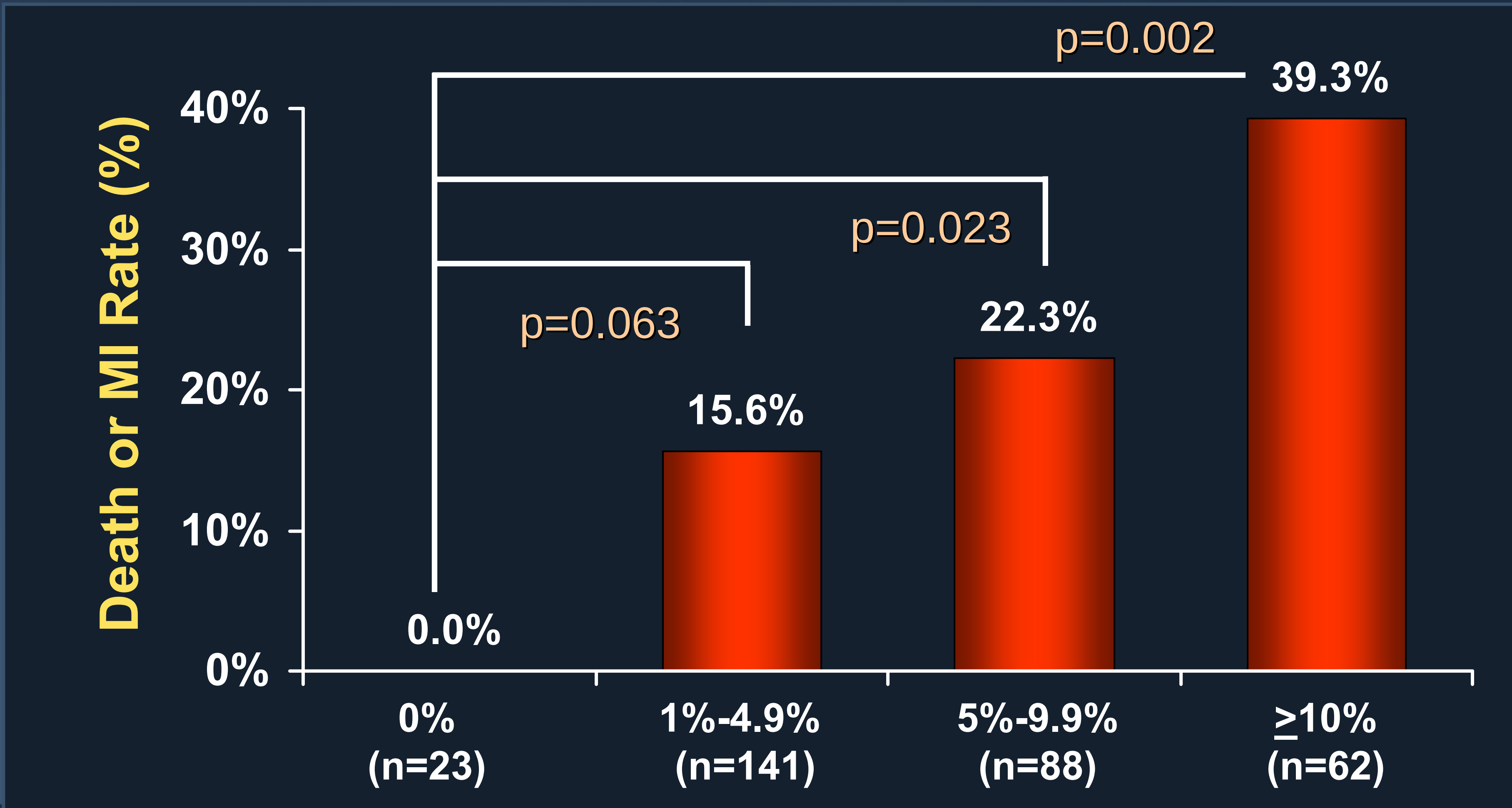
Hachamovitch et al, Circulation 2003;107:2900-07

Mitigated Gradient with Revascularization



Hachamovitch et al Circulation. 2003; 107:2900-2907.

Rates of Death or MI by Residual Ischemia on 6-18m MPS



Shaw, et al, AHA 2007 and Circulation 2008

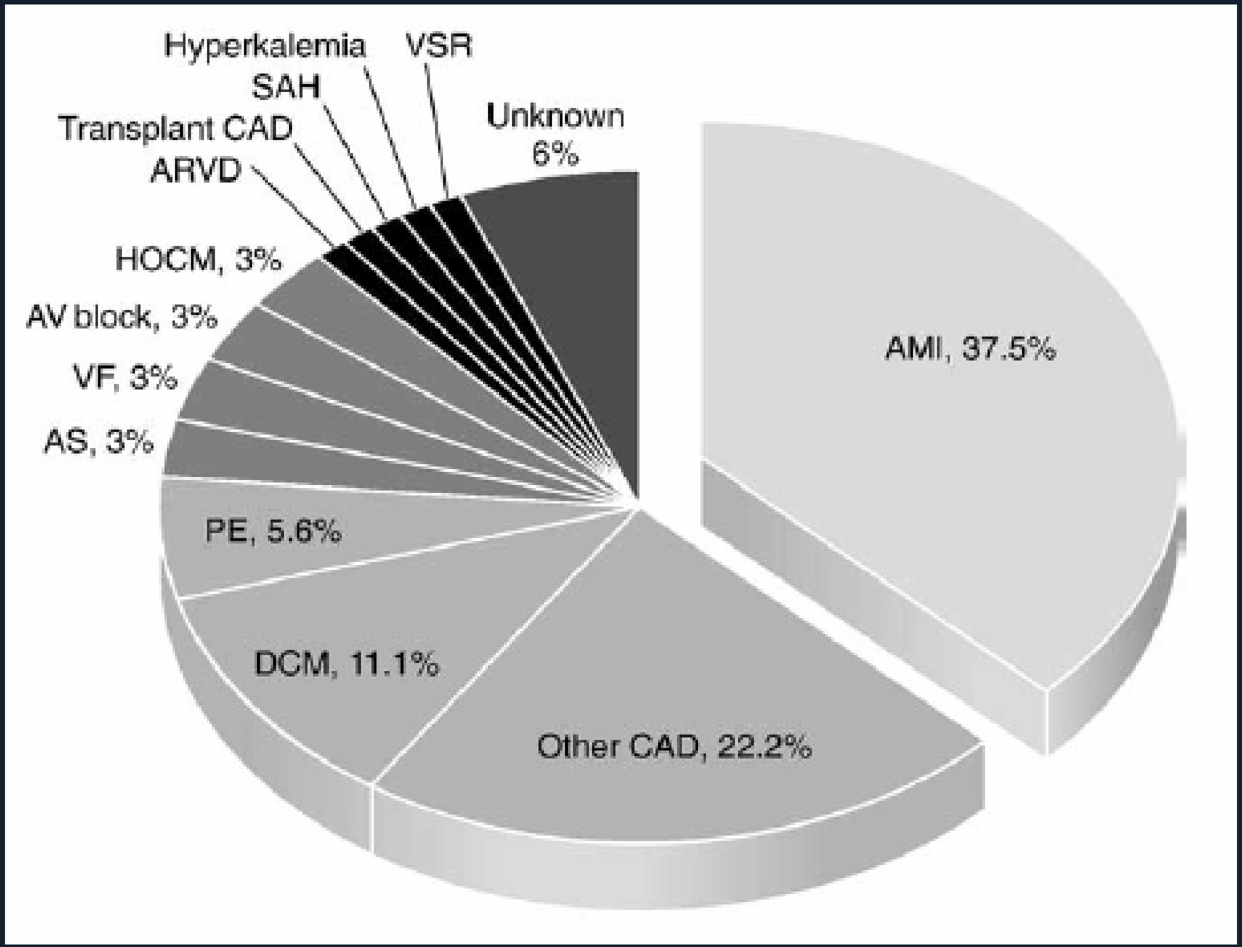
Revascularization: The Bottom Line

- **Revascularization improves prognosis (hard clinical endpoints) in:**
  - **STEMI (time-dependent)**
  - **NSTACS (moderately time-dependent)**
  - **Stable CAD with high ischemic burden (less time-dependent)**
- ***Prompt revascularization therefore has the potential to improve outcomes in appropriately selected patients with cardiac arrest!!***

Etiologies of Cardiac Arrest

- Coronary Heart Disease (>65%)
  - Coronary Occlusion (↑frequent on autopsy)
  - Arrhythmia
  - Pump Dysfunction
- Structural Heart Disease (10%)
  - Valvular Disease
  - HOCM
  - Coronary Anomalies
- Other: Takotsubo, Primary Arrhythmias, etc
- Non-cardiac / metabolic abnormalities (30%?)

Diagnoses in 72 Pts with Cardiac Arrest Undergoing Routine Catheterization



PCI performed in one-third of patients

Anyfantakis et al, Am Heart J 2009

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Use and Utility of Angiography after In-Hospital VF Arrest

- Of 110 patients with confirmed VF-arrest at a major US academic hospital, only 30 (27%) received angiography within 1 day of the arrest
  - Less than half had STEMI or new LBBB
  - More than half underwent PCI
- Performance of angiography has been associated with increased survival (but this association is quite confounded)

Merchant et al, Resuscitation 2008
Werling et al, Resuscitation 2007

A Case for Immediate Angiography for Survivors of Out-of-Hospital Arrest

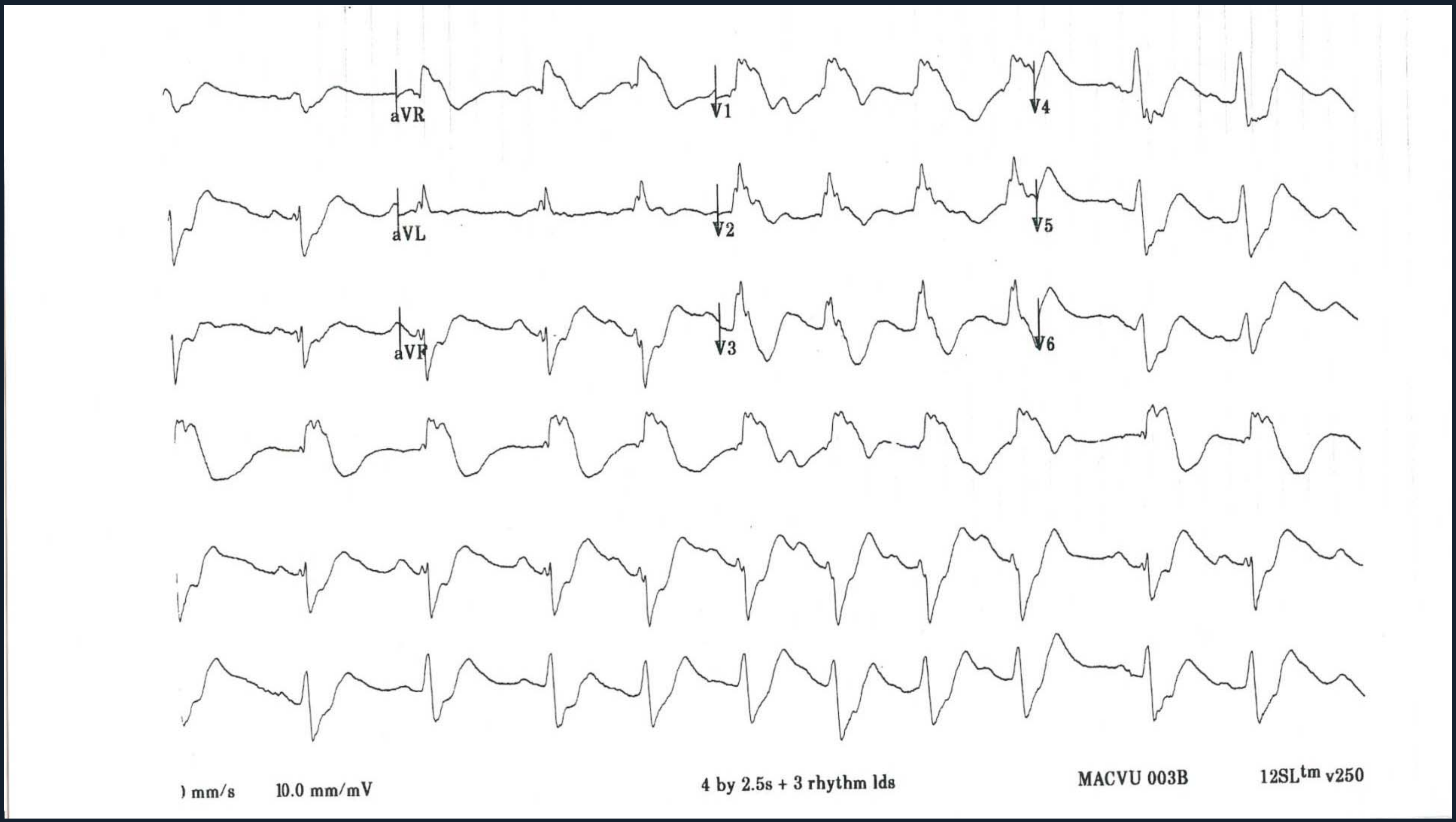
- 85 (selected) patients with no obvious non-cardiac cause of arrest
- Coronary occlusions seen in 48% of pts
- Clinically significant CAD in 71% of pts
- Mean LVEF 34%
- 38% Survival; predictors were:
  - No need for inotropes on transport
  - Successful angioplasty
  - Shorter time from arrest to presentation

Spaulding et al, NEJM 2007

Problems with the Diagnosis of Ischemic CAD in Arrest Patients

Diagnostic Dilemmas in Cardiac Arrest

Immediate post-arrest EKG



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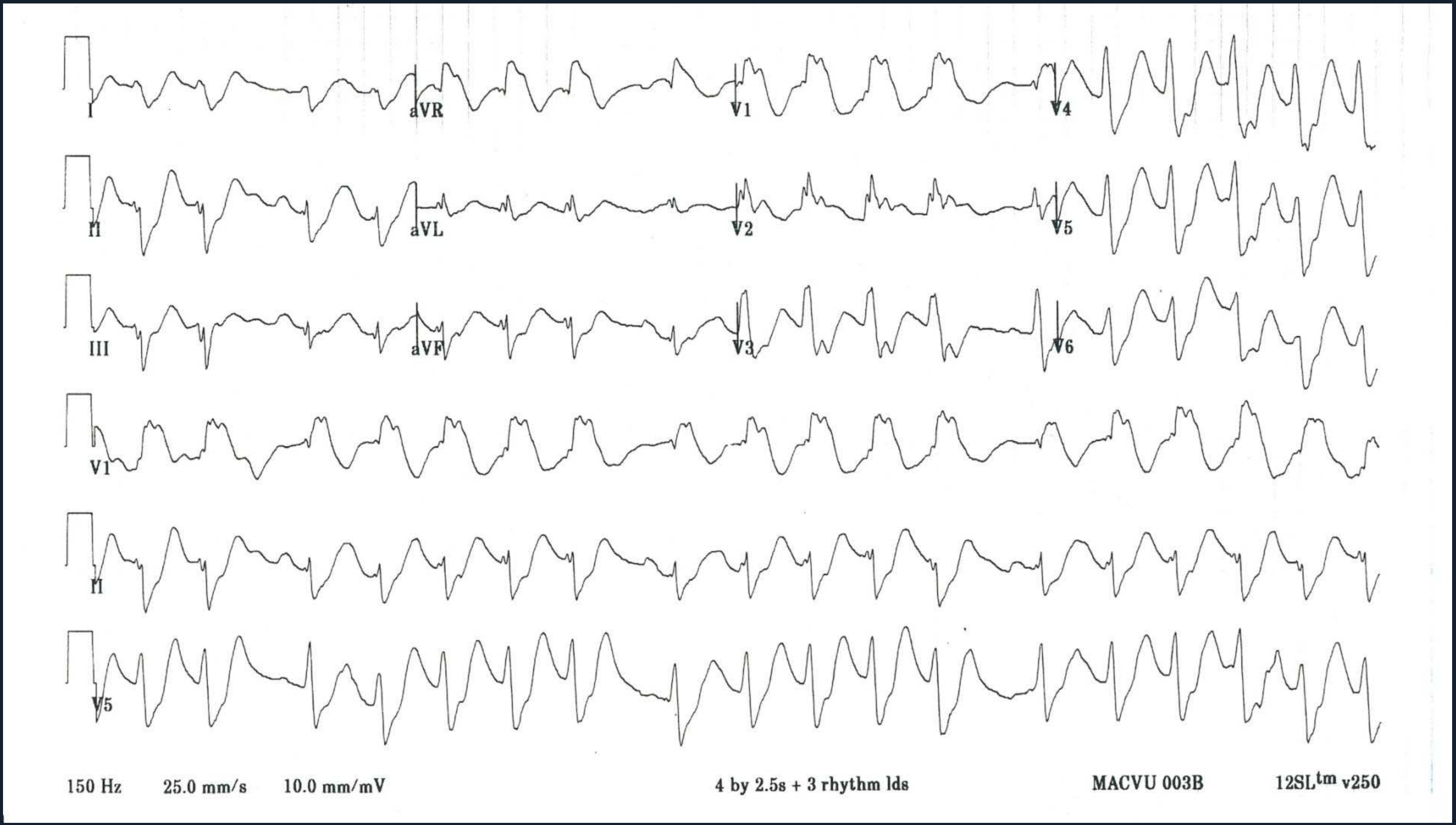
Diagnostic Dilemmas in Cardiac Arrest

After ventilation/sodium bicarbonate (3 min later)



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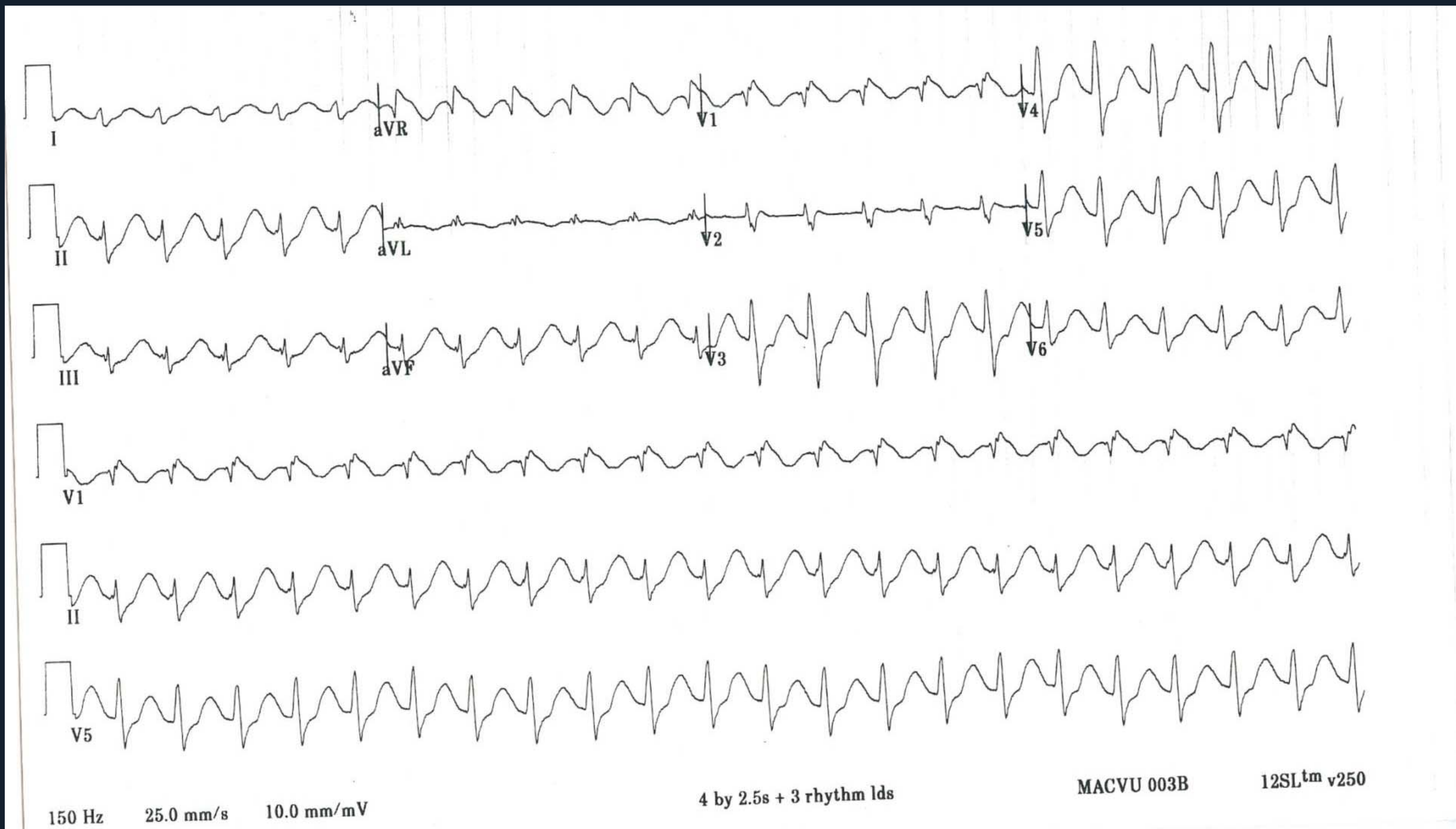
Diagnostic Dilemmas in Cardiac Arrest

35 minutes after initial EKG



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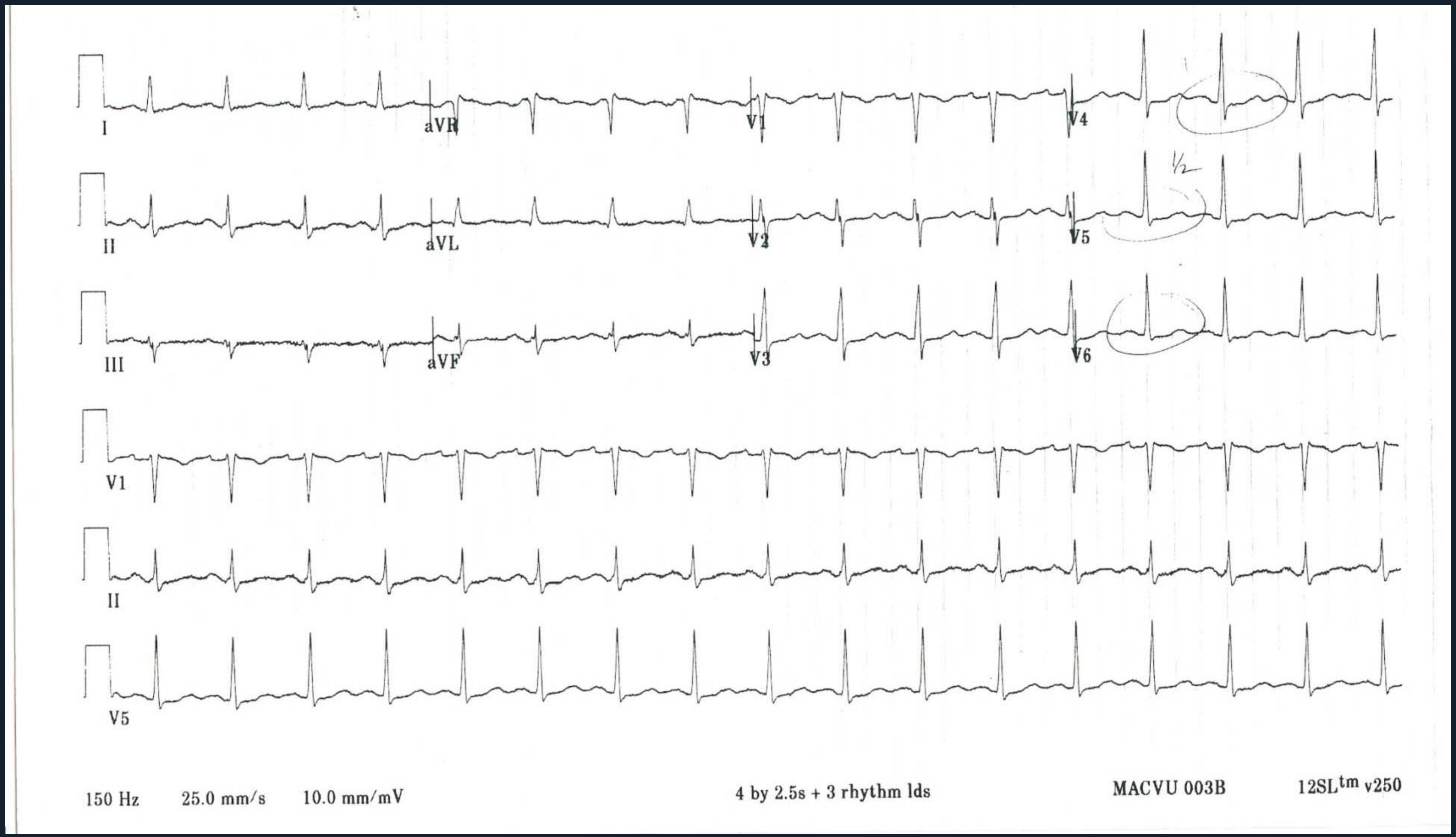
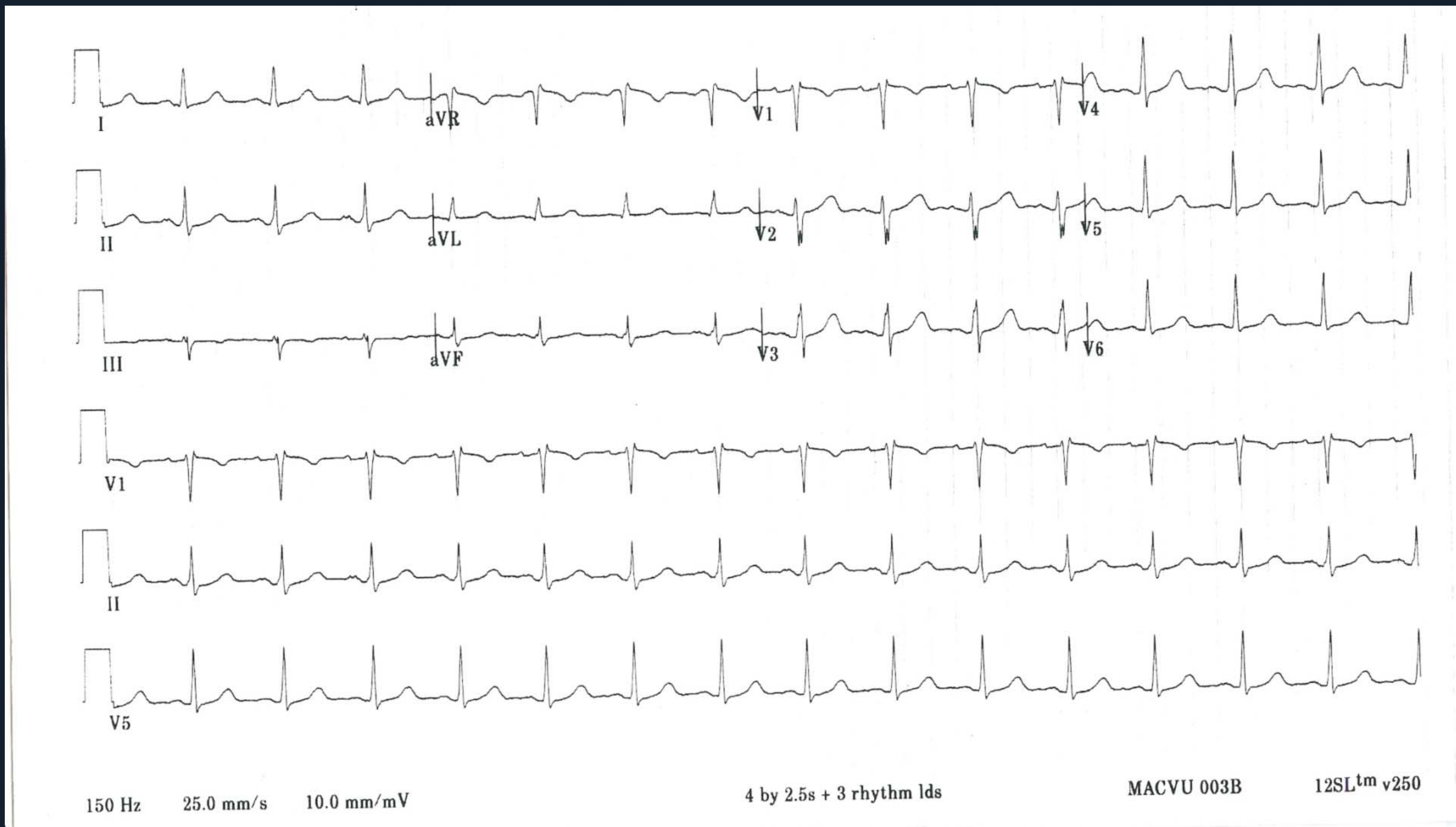
Diagnostic Dilemmas in Cardiac Arrest

4 hours post-arrest



Diagnostic Dilemmas in Cardiac Arrest

The next morning (12 hours post-arrest)



Ability of 12-lead EKG to Diagnose STEMI after Resuscitated Arrest

	MI at Discharge	No MI at Discharge	
ST Elevation on Admission EKG	37	3	40
No ST Elevation on EKG	11	24	35
	48	27	77

Out of hospital EKG: PPV 88% and NPV 69%
Sensitivity 77% and Specificity 83%

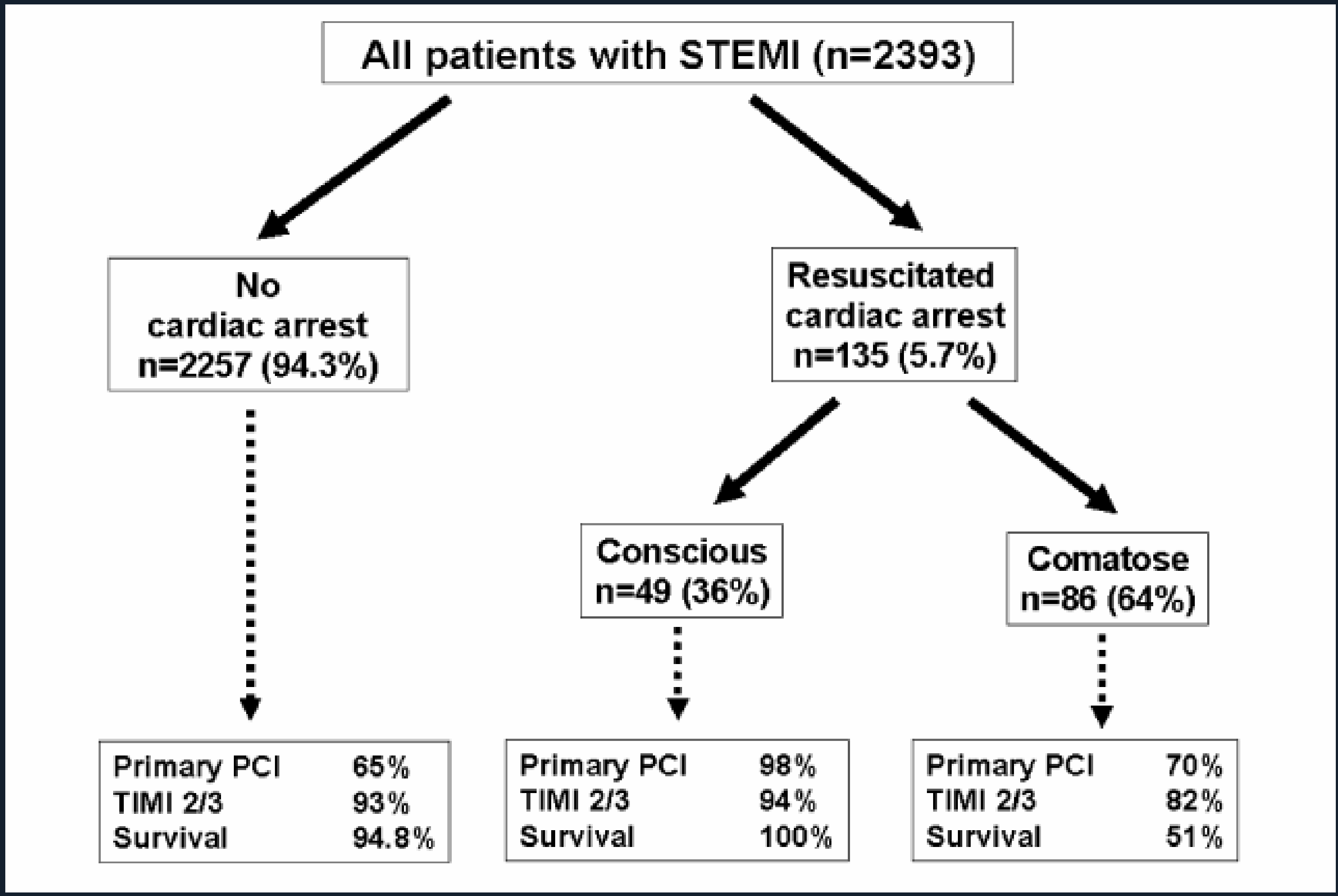
Müller et al, Ann Emerg Med 2008

Summary of PCI Outcomes Data

- Studies of primary PCI for STEMI after resuscitated cardiac arrest:
  - 7 studies, 458 patients; successful PCI in 89%
  - 66% survival, 58% neuro recovery
  - Lower survival / recovery in comatose patients
- PCI also performed in 34 patients undergoing active resuscitation
  - 88% success, 41% survival

Noc and Radsel, Curr Op Crit Care 2008

PCI for STEMI after Resuscitation



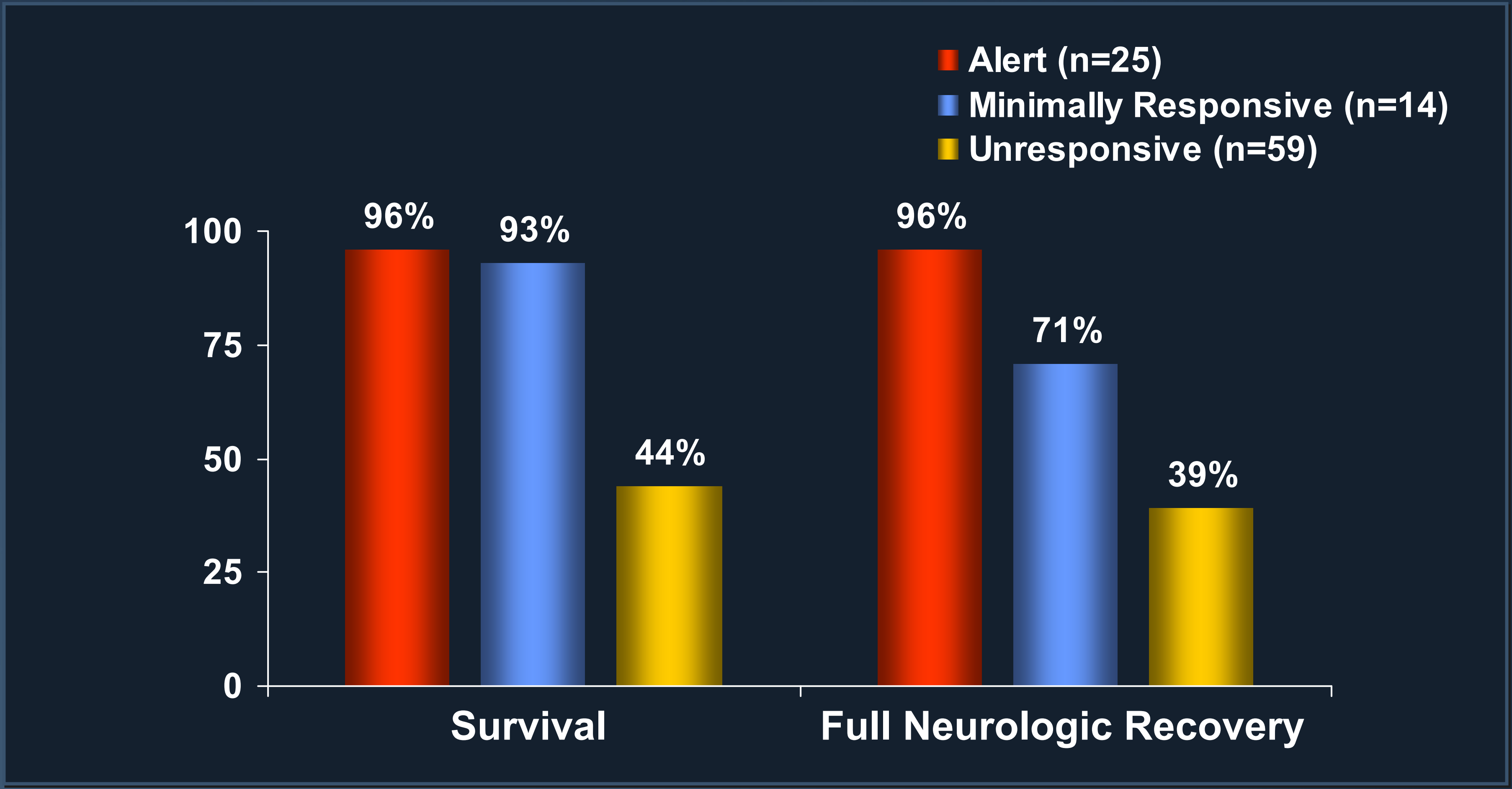
Correlates of 6-Month Survival in STEMI Patients With Cardiac Arrest

186 PCI patients; overall survival 54%

	OR	95% CI
Time from Arrest to 1st Responder (per min)	0.67	0.54-0.84
ROSC time (per 10 min)	0.43	0.25-0.66
Absence of Shock	12.66	3.39-47.62
Absence of Diabetes	7.30	1.80-29.41
Absence of prior PCI	10.99	1.65-71.43

Garot et al, Circulation 2007

Outcomes in STEMI Patients with Cardiac Arrest (n=98)



Hosmane et al, JACC 2009

Correlates of Death in STEMI Patients Following Cardiac Arrest (n=98)

	OR	95% CI	p
Neurologic Status			
Alert	-	-	-
Min Responsive	2.1	0.1-68.1	0.69
Unresponsive	47.8	3.3-549.1	0.004
ROSC time (per 10 min)	2.8	1.5-5.7	0.002
Age (per 5-yr)	1.3	1.1-1.7	0.009
Female Gender	5.9	1.2-30.1	0.034

Patients arresting in ED had better survival and neurologic recovery than out-of-hospital arrest patients

Hosmane et al, JACC 2009

Combining Hypothermia and PCI for Cardiac Arrest Patients with STEMI

- Can be accomplished with minimal increases in door-balloon times
- Requires regimented protocols and buy-in / cooperation between ED, Cath Lab, ICU units / staff
- No differences in in-hospital complications with a trend toward improved outcomes (vs. historical controls in 3 published studies)

Wolfrum et al, Crit Care Med 2008
Knafelj et al, Resuscitation 2007
Sunde et al, Resuscitation 2007

"COOL-IT" Outcomes

Alive at <u>hospital discharge</u> with favourable neurological recovery

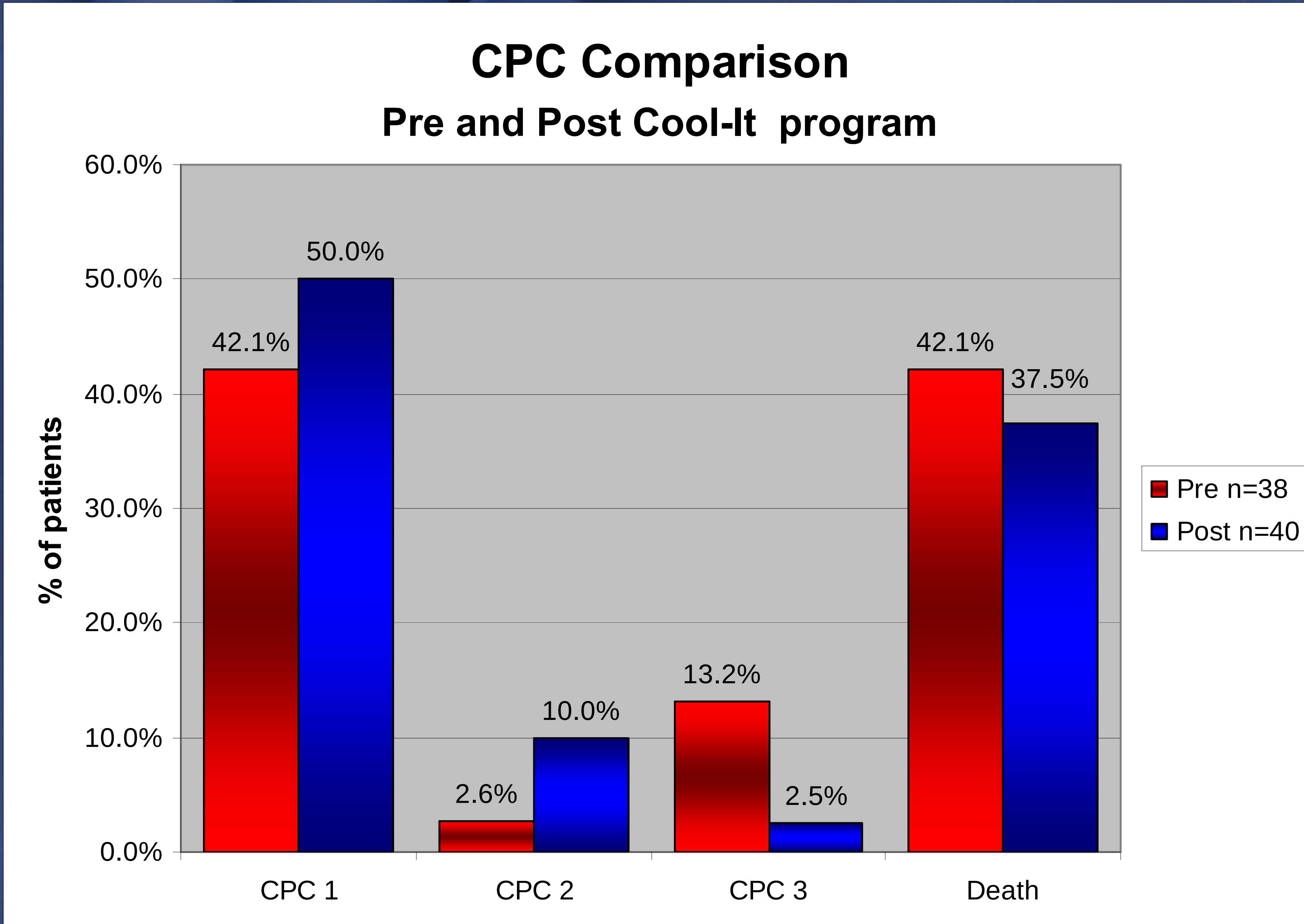
Abbott Northwestern Hospital	53/96	55.2%

- **<u>Survival by initial rhythm</u>**
  - **VF/VT: 47/75 62.6%**
  - **PEA/Asystole: 5/19 26.3%**

- **<u>Survival by diagnosis</u>**
  - **Other: 20/46 43.5%**
  - **STEMI: 33/50 66.0%**

Mooney, TCT 2008

Minneapolis Heart Institute



Mooney, TCT 2008

COOL-MI – A Negative Trial

- Preliminary data has suggested that systemic cooling has the potential to reduce infarct size (animal models of ischemia/reperfusion)
- Endovascular cooling to 33º for 3 hrs was tested in a 357 patient randomized trial
- 94% of patients tolerated the cooling
- No difference in SPECT-measured infarct size, ?possible trends in anterior infarction

O'Neill et al, TCT 2003

What About Fibrinolytic Therapy (post-TROICA)?

- Riskier to implement many successful hemodynamic diagnostic / therapeutic maneuvers after lytics are given
- Worries about use in cardiac arrest patients (particularly prolonged CPR)
- In a non-randomized study of 147 STEMI patients with VF arrest (101 treated with fibrinolysis and 47 treated wit primary PCI), there were similar outcomes with both strategies, which is reassuring

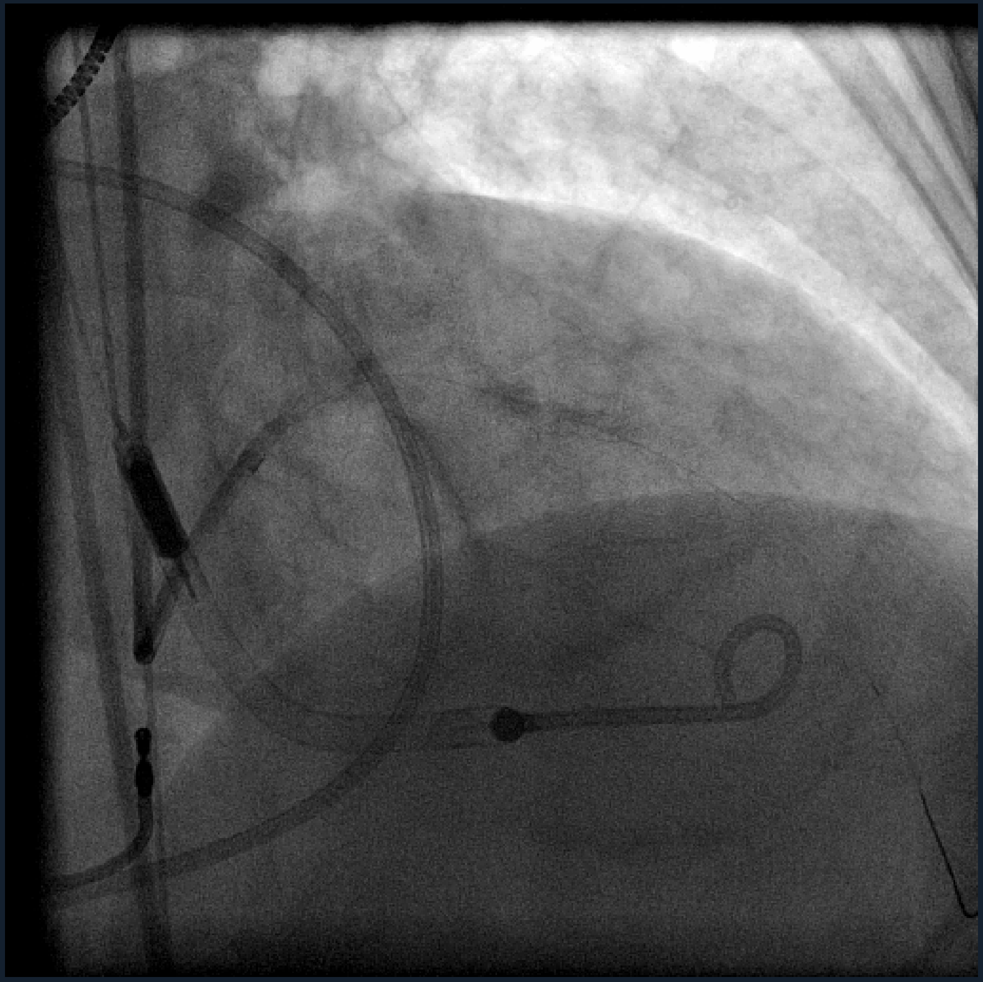
Richling et al, Am J Emerg Med 2007

PCI During Cardiac Arrest

- Gas-driven sternal compression device with suction cup (LUCAS)
- PCI feasible in 13 pts with arrest or severe hypotension / bradycardia; mean BP 81/34 mmHg

Larsen et al, Resuscitation 2007

PCI Using Hemodynamic Support



Impella 2.5 Device during LMCA Dissection

Cardiac Cath Lab ≠ Always a Stent!!!

- *Distinction between diagnostic and interventional cath procedures*
- Diagnostic:
  - Hemodynamic evaluation
    - Right heart catheterization / shunt evaluation
    - Left heart catheterization
    - Simultaneous LV/PCWP, LV/RV
  - Left ventriculography (ability to identify structural defects)
  - Coronary angiography
  - Aortography

Cardiac Cath Lab ≠ Always a Stent!!!

- Interventional Procedures:
  - Percutaneous coronary intervention
  - IABP, hemodynamic support
    - TandemHeart
    - Impella
  - Pressor/Vasodilator titration
  - Temporary pacemaker (Ventricular, CS/Ventricular)
  - Pericardiocentesis
  - Pulmonary Embolectomy
  - *Rapid access to other subspecialties*
    - *EP, CHF Team, CT Surgery*

Summary

- A significant proportion of patients with cardiac arrest (especially VT/VF) have coronary occlusion or significant coronary artery disease
- There are clear data supporting primary PCI for STEMI (acute coronary occlusion), a major cause of VT/VF
- Cardiac catheterization has other benefits, including making a diagnosis / further triage / hemodynamic support

Summary (2)

- An early invasive strategy is preferred for patients with non-ST-elevation acute coronary syndromes, but the timing may be less urgent
- Patients with significant “stable ischemic CAD” can benefit from revascularization, typically on an urgent / elective basis
- *The key question is whether all (or selected) cardiac arrest patients should undergo emergent angiography and/or PCI if indicated*

Conclusions

- Integrated systems of care are being implemented with success for patients with STEMI (primary PCI) as well as for cardiac arrest patients (hypothermia protocols)
- The overlap between these two areas is significant, and it makes sense to coordinate efforts
- Angiography / catheterization is likely underutilized in arrest patients and ought to be considered 1st line care for VT/VF