Primary PCI in Patients With Sustained VT/VF

Antonis S. Manolis, MD

ASM

Primary PCI & Ventricular Tachyarrhythmias: Current Management

Πρωτογενής Αγγειοπλαστική & Κοιλιακές Ταχυαρρυθμίες: Τρέχουσα Αντιμετώπιση

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MI & PCI

- CAD : leading cause of death in US. In 2006, ~1.2 m Americans sustained a MI. Of these, ¼ to 1/3 had a STEMI
- Of all pts having a MI, 25-35% will die before receiving medical attention, most often from VF
- For those who reach the hospital, prognosis is considerably better & has improved over the years:
- In-hospital MR fell from 11.2% in 1990 to 9.4% in 1999
- Most of decline: due to decreasing MR among pts with STEMI as a consequence of fibrinolysis & PCI
- Analysis by National Registry of MI: in-hospital MR was 5.7% among those receiving reperfusion Rx, as c/w 14.8% among those who eligible for but did not receive such Rx
- In a meta-analysis (23 studies of 1º PCI (3872 pts) & fibrinolytic Rx (3867 pts), MR at 4-6 w after Rx was significantly lower among those who underwent 1º PCI (7% vs 9%)

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VTAs in AMI

- VAs, ranging from isolated VPCs to VF, are common in immediate post-MI period
- In prethrombolytic era, following range of incidence : VPCs – 10-93%, VT – 3-39%, VF – 4-20%
- Early series underestimated the incidence of unstable VT & VF, because they did not include pts whose MI resulted in out-of-hospital SCD
- With thrombolysis & 1º PCI, a much lower incidence of serious VTAs (VT &/or VF) has been noted (2.3-10.2%)
- Data also underestimate, as did the earlier series, the true incidence of arrhythmias because pts with pre-hospital SCD would not have been included in studies of thrombolysis or 1º PCI

VTAs in AMI

- The incidence of VTAs appears to be higher with STEMI than NSTEMI infarctions

- STEMI — The largest experience with acute STEMI comes from the GUSTO-1 trial of 40,895 pts who were treated with thrombolytic therapy

- Overall incidence of sustained VT or VF was 10.2% :
- 3.5% developed VT, 4.1% VF, and 2.7% both VT & VF

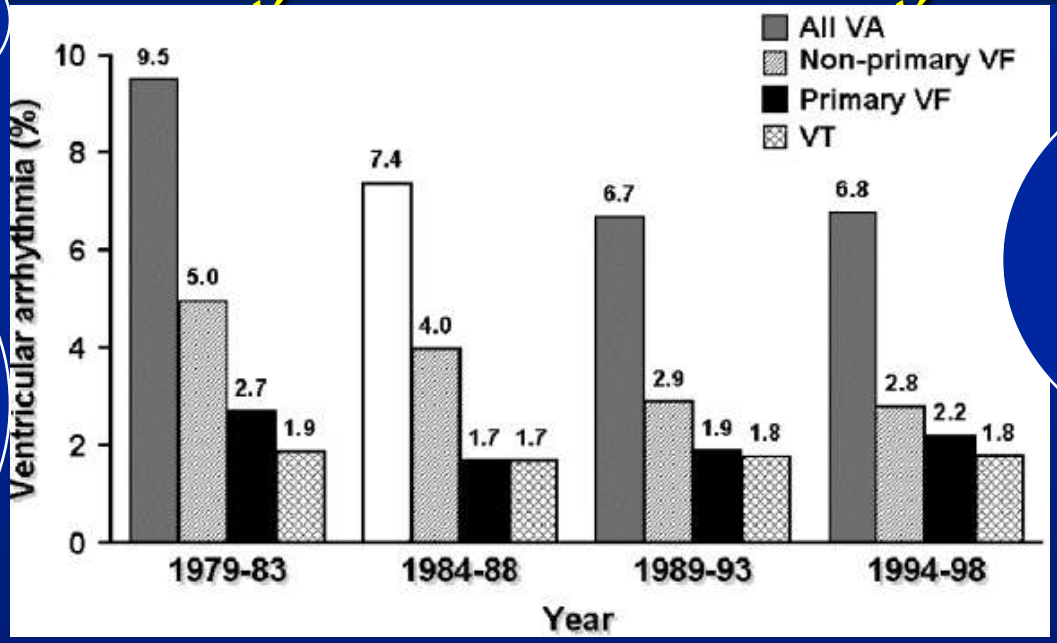
- Approximately 80 - 85% of these arrhythmias occurred in the first 48 hours

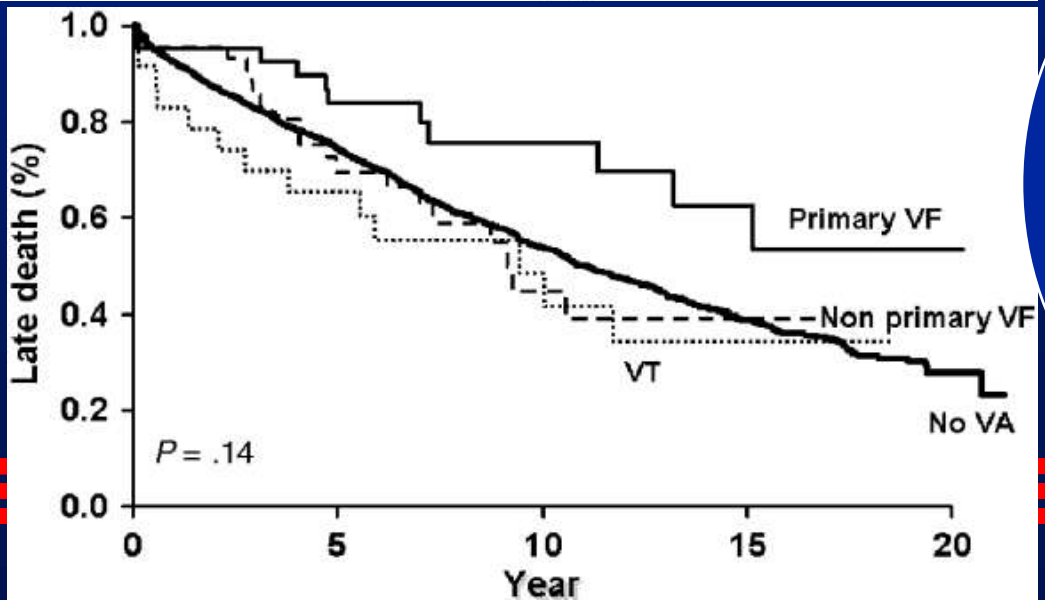
Ventricular arrhythmias after AMI: A 20-year community study

Henkel et al, Am Heart J 2006; 151:806

Among 2317 pts, 7.5% VAs

3.6% non-1º VF, 2.1% 1º VF, 1.8% VT





VA factors : younger age, female sex, ↑ er Killip class, STEMI, AF

VAs are a/w ↑ MR at 30 d

Over time, VF ↓, but VT did not.

VAs p-MI: a/w a 6-fold ↑ in MR

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European Heart Journal (2006) 27, 2499–2510
doi:10.1093/eurheartj/ehl218

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Rev

Risk factors for primary ventricular fibrillation during acute myocardial infarction: a systematic review and meta-analysis

Peter J. Gheeraert[1]*, Marc L. De Buyzere[1], Yves M. Taeymans[1], Thierry C. Gillebert[1],

- **ST-segment elevation** & the **first hours of symptoms** dramatically elevate the risk of PVF
- **"Time is muscle"**: it is important to reduce the final infarct size
- **"Time is life"** would better incorporate the strong & important association between PVF & time

21 cohort studies describing 57 158 pts with AMI were analyzed

Initial Conservative Versus Initial Invasive Strategies (UA/NSTEMI)

I IIaIIbIII

A

An early invasive PCI strategy is indicated for patients with UA/NSTEMI who have no serious comorbidity and who have coronary lesions amenable to PCI and who have characteristics for invasive therapy

MODIFIED

I IIaIIbIII

B

An **early invasive strategy** (i.e., diagnostic angiography with intent to perform revascularization) is indicated in UA/NSTEMI patients who have refractory angina or hemodynamic or **electrical instability** (without serious comorbidities or contraindications to such procedures)

NEW

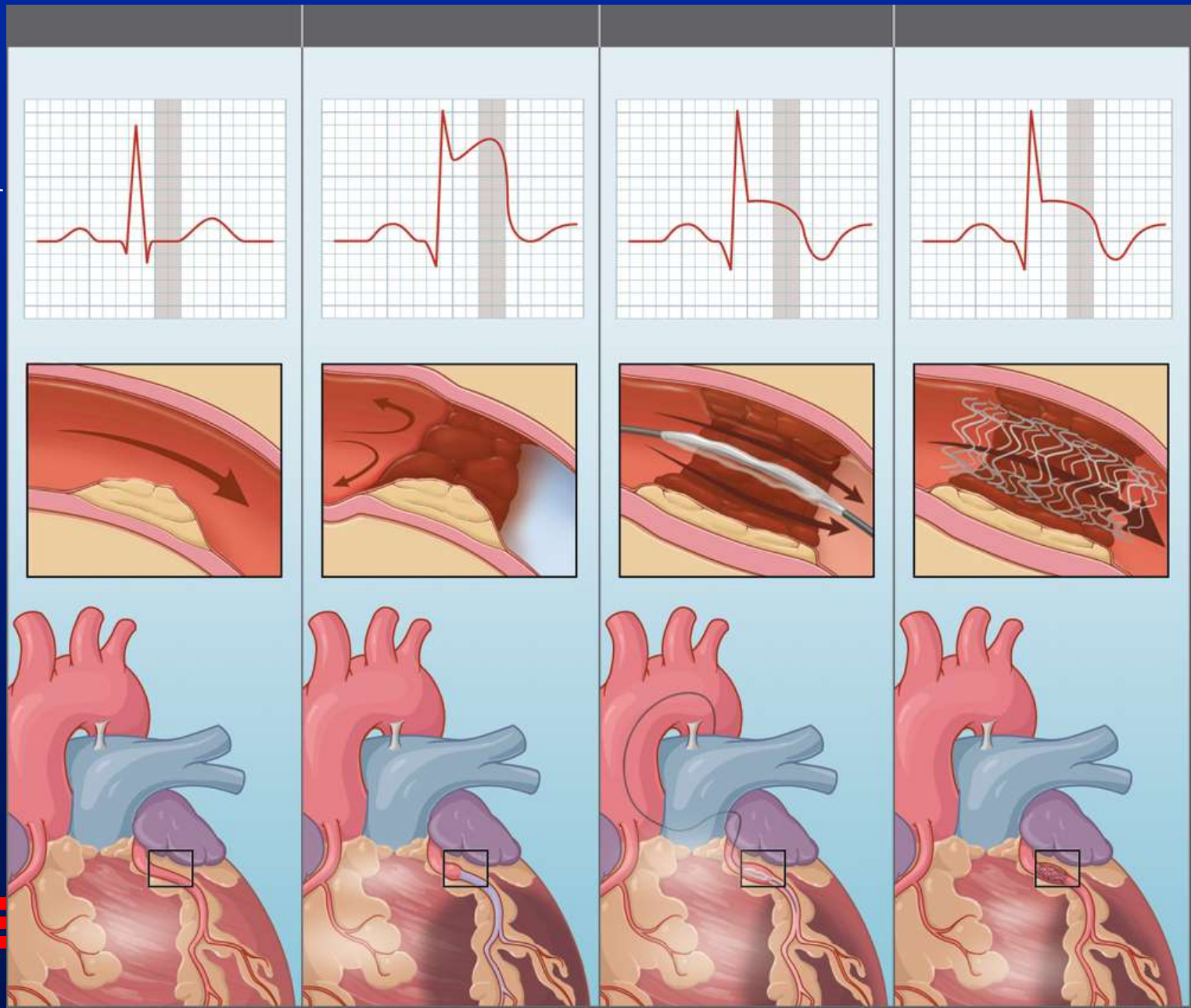
Selection of Initial Treatment Strategy: Invasive vs. Conservative

Preferred Strategy	Patient Characteristics
Invasive	Recurrent angina or ischemia at rest or with low-level activities despite intensive medical therapy
	Elevated cardiac biomarkers (TnT or TnI)
	New or presumably new ST-segment depression
	Signs or symptoms of HF or new or worsening mitral regurgitation
	High-risk findings from noninvasive testing
	Hemodynamic instability
	Sustained ventricular tachycardia
	PCI within 6 months
	Prior CABG
	High-risk score (e.g., TIMI, GRACE)
	Reduced LV function (LVEF less than 40%)
Conservative	Low-risk score (e.g., TIMI, GRACE)
	Patient or physician preference in absence of high-risk features

Anderson JL, et al. J Am Coll Cardiol, 2007; 50:e1-157. Table 11.

STEMI Before, During, & After PCI

Primary PCI restores angiographically normal flow in the previously occluded artery in >90% of pts, whereas fibrinolytic therapy does so in only 50-60% of such pts



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STEMI / Rescue PCI

A strategy of coronary angiography with intent to perform PCI (or emergency CABG) is recommended in pts who have received fibrinolytic therapy and have:

a. Cardiogenic shock in pts < 75 years who are suitable candidates for revascularization

b. Severe congestive heart failure and/or pulmonary edema (Killip class III)

c. Hemodynamically compromising ventricular arrhythmias

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ACC/AHA 2007 STEMI Guidelines Focused Update

PCI After Failed Fibrinolysis

MODIFIED

A strategy of coronary angiography with intent to perform PCI (or emergency CABG) is recommended for patients who have received fibrinolytic therapy and have any of the following:

I IIa IIb III
B

a) Cardiogenic shock in patients less than 75 years who are suitable candidates for revascularization.

I IIa IIb III
B

b) Severe congestive heart failure and/or pulmonary edema (Killip class III).

I IIa IIb III
C

c) Hemodynamically compromising ventricular arrhythmias

MODIFIED

A strategy of coronary angiography with intent to perform PCI (or emergency CABG) is reasonable in pts ≥75 years of age who have received fibrinolytic therapy and are in cardiogenic shock, provided that they are suitable candidates for revascularization

I IIaIIbIII
B

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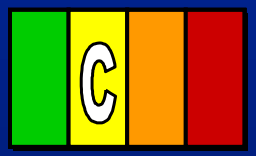
ACC/AHA/SCAI 2007 PCI Guidelines Focused Update

PCI After Successful Fibrinolysis or for Patients Not Undergoing Primary Reperfusion

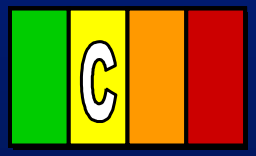
It is reasonable to perform routine PCI:

I IIaIIbIII



in patients with LVEF ≤ 40%, HF, or serious ventricular arrhythmias

I IIaIIbIII



when there is documented clinical heart failure during the acute episode, even though subsequent evaluation shows preserved LV function (LVEF >40%)

LVEF=Left Ventricular Ejection Fraction

ESC Guidelines

Transient arrhythmias of reversible cause

Class I

1. Myocardial revascularization should be performed, when appropriate, to reduce the risk of SCD in patients experiencing cardiac arrest due to VF or polymorphic VT in the setting of acute ischaemia or MI (LEVEL C)
2. Unless electrolyte abnormalities are proven to be the cause, survivors of cardiac arrest due to VF or polymorphic VT in whom electrolyte abnormalities are discovered, in general should be evaluated and treated in a similar manner as survivors of cardiac arrest without electrolyte abnormalities (LEVEL C)
3. Patients who experience sustained monomorphic VT in the presence of antiarrhythmic drugs or electrolyte abnormalities should be evaluated and treated in a manner similar to that of patients with VT without electrolyte abnormalities or antiarrhythmic drugs present. Antiarrhythmic drugs or electrolyte abnormalities should not be assumed to be the sole cause of sustained monomorphic VT (LEVEL B)
4. Patients who experience polymorphic VT in association with prolonged QT interval due to antiarrhythmic medications or other drugs should be advised to avoid exposure to all agents associated with QT prolongation (LEVEL B)

VA & SCD Guidelines Slide-Set © 2006 European Society of Cardiology

Primary PCI & VT VF

- VT or VF is reported in 4.3% of patients undergoing primary PCI

- Although these patients remain in the hospital longer than those who do not have ventricular tachyarrhythmias,
- the long-term prognosis for those with or without ventricular tachyarrhythmias is similar

Mehta et al, JACC 2004; 43(10): 1765

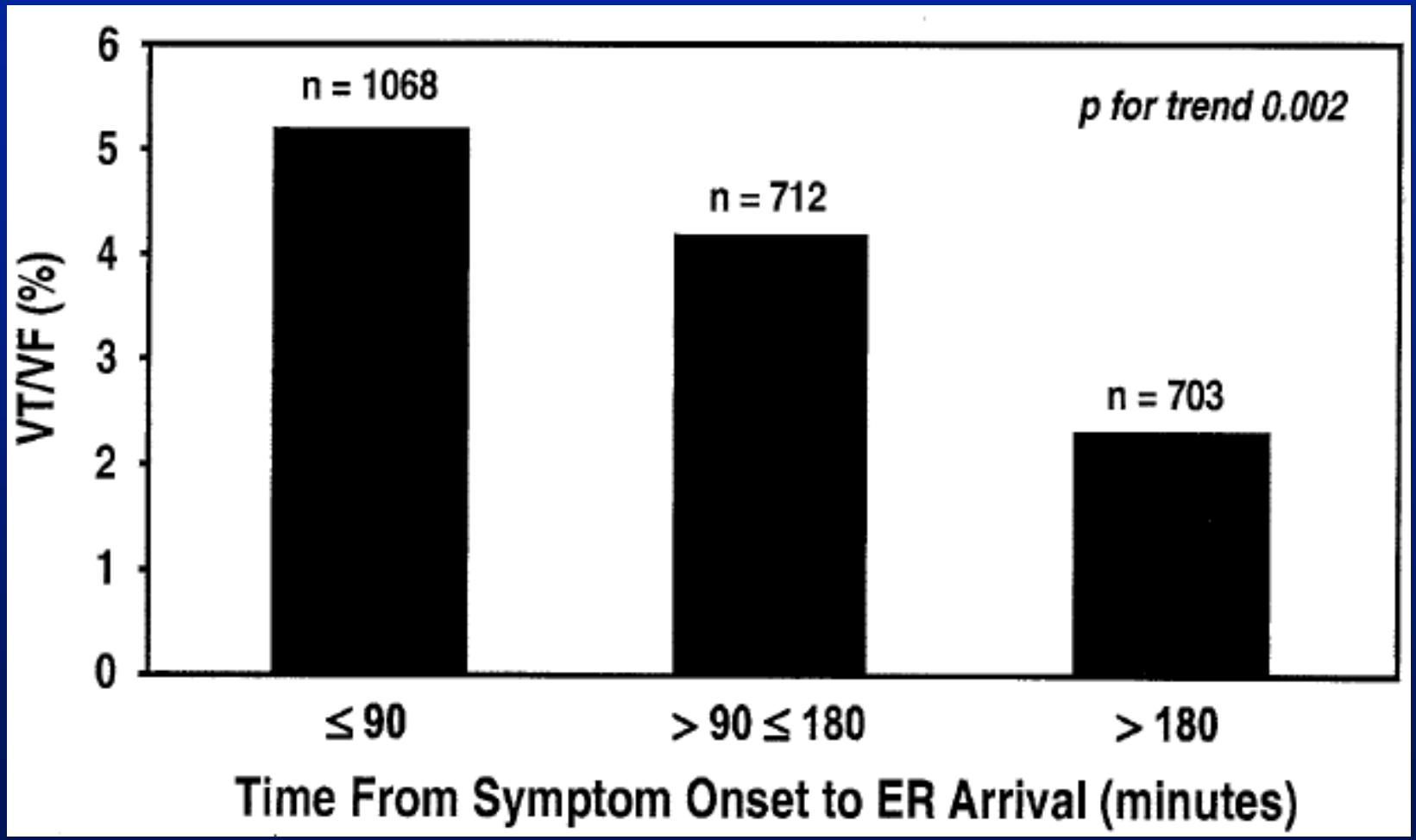
VTAs in Patients Undergoing Primary PCI

- In pts undergoing 1º PCI, VT/VF occurred in 133 /3065 (4.3%)
- Multivariate analysis identified the following as independent correlates of VT/VF:
- smoking (odds ratio [OR] 1.95)
- lack of preprocedural β-blockers (OR 2.34)
- time from symptom onset to ER of ≤180 min (OR 2.63)
- initial TIMI flow grade 0 (OR 2.06), and
- RCA-related infarct (OR 1.93)
- Although pts with VT/VF had a higher incidence of bradyarrhythmias, hypotension, CPR, & endotracheal intubation in the cath lab,
- their in-hospital & one-year adverse outcomes were similar to those of the cohort without these arrhythmias

Mehta et al, JACC 2004; 43(10): 1765

PAMI trial

Time from symptom onset to ER arrival and frequency of VT/VF



Mehta et al, JACC 2004; 43(10): 1765

Adjusted Odds Ratios of Clinical Variables Associated With the Risk of VT or VF During Primary PCI

Outcome	Odds Ratio	95% Confidence Interval	p Value
Current smoker	1.95	1.26–3.02	0.0027
No beta-blocker in the ER	2.34	1.35–4.07	0.0026
RCA as infarct artery	1.93	1.25–2.99	0.0033
Time from symptom onset to ER ≤180 min	2.63	1.42–4.89	0.0022
Initial TIMI flow grade 0	2.06	1.23–3.47	0.0062

Mehta et al, JACC 2004; 43(10): 1765

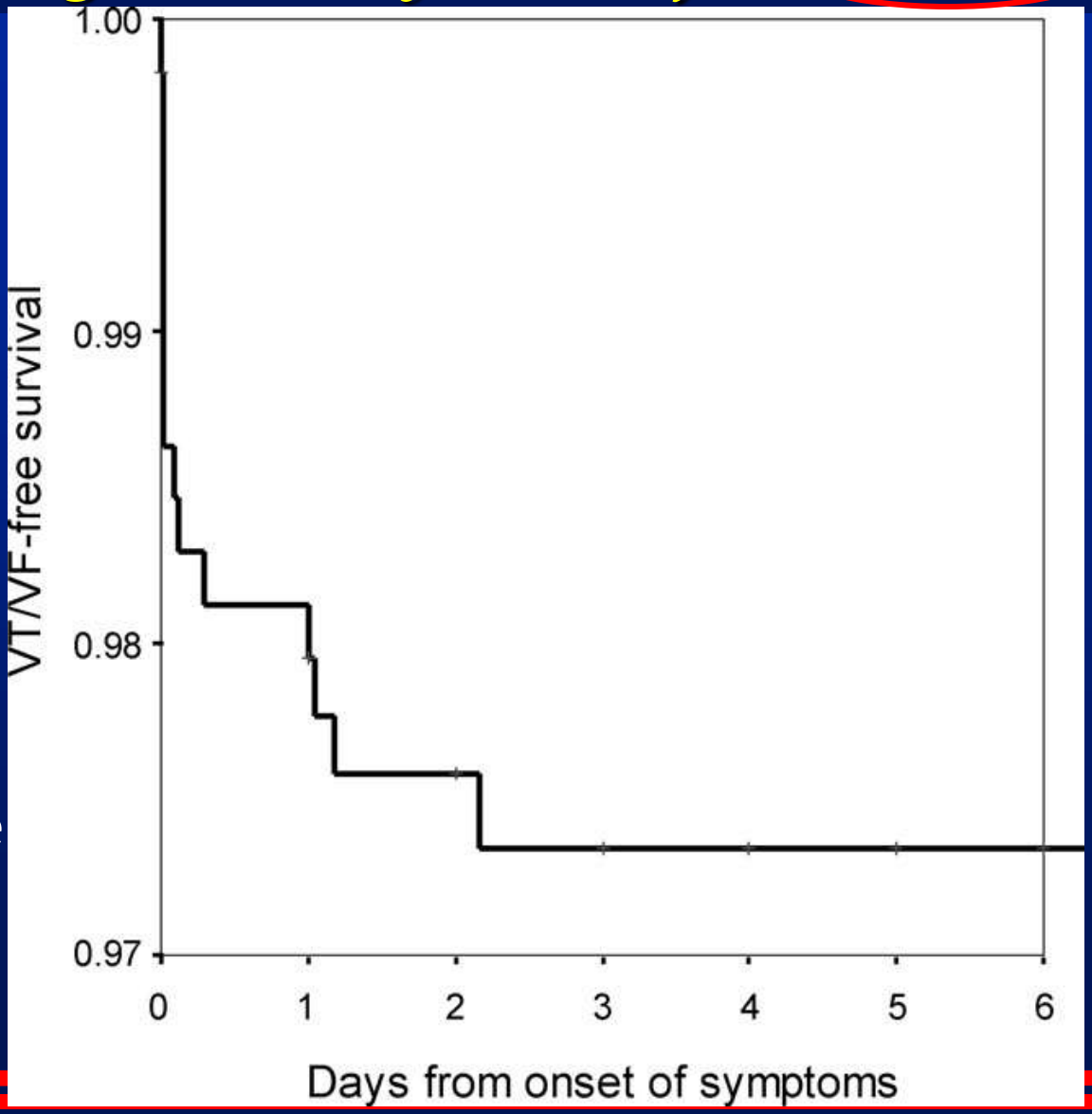
Complications during hospital stay after primary stenting

de Oliveira et al, Arq Bras Cardiol 2008; 90(4): 221

Variable	Patients (%)
Major Bleeding	15 (2.4%)
Minor Bleeding	5 (7.4%)
CHF	19 (9.4%)
MI	1 (0.5%)
AF	6 (2.9%)
VT/VF	12 (5.9%)
ARF	1 (0.5%)
CAVB	13 (6.4%)
Post-AMI angina	15 (7.4%)

The Kaplan–Meier survival curve for occurrence of malignant arrhythmia after NSTEMI

Cardiac monitoring after acute NSTEMI in pts with early invasive strategy identified only 2.6% of the pts having acute malignant VTAs with the majority of arrhythmias occurring during the first 12 h after onset of symptoms



Rahimi et al, Eur Heart J 2006; 27: 1706–1711

Safety & outcome of patients with an acute STEMI transferred for primary PCI: the Neuchatel experience

- **Safety of transfer**
- **No major complication such as VF, c. shock or death occurred during transport to PCI center**
- **1 pt developed a 2nd degree AVB but remained hemodynamically stable without intervention**
- **1 patient initially presented with an acute PEd & 1 with c. shock. Both were stabilized by medical Rx & then transferred without complications**
- **N.B.: *before departure*, *3 pts presented VTAs* (1 VT & 2 VF) that were successfully treated by DF. None of the 3 presented further problems during transport**

SWISS MED WKLY 2006;136:703

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STEMI, Primary PCI & VTAs

- Since 10/2000, ~700 pts c STEMI had 1º PCI within first 12 h
- Pts c STEMI & 1º PCI had a higher incidence of suVT & VF than quoted earlier & most occurred within first 12–24 h
- Uncertain whether these VTAs are caused by reperfusion or ischemia? Other causes: catheter manipulation, dye injection
- MI location, reperfusion achievement, & pain-to-balloon or door-to-balloon have no significant influence on appearance of VTAs
- Acc. to literature, in pts c STEMI & successful 1º PCI, only positive cTnT seems to be a/w a higher incidence of VT/VF
- Pts with STEMI & VT/VF after reperfusion have a higher MR, but the same frequency of other major adverse CV events
- VT/VF in MI pts reperfused via 1º PCI becomes of lesser significance after first 24 h, which is important from an economic point of view

Nkolic-Heitzler & Babic, EHJ 2006

VF in AMI Before or During PCI

- Fm Jan 1995-Dec 2001: 2826 pts treated for AMI / clinical records reviewed of pts who developed VF & pts classified according to first episode of VF: either before or during PCI
- VF developed in 219 (8%) pts
- Pts with VF during reperfusion therapy (n=74, 3%) were older (p=0.03), more frequently female (0.04), less often had HF (p=0.04), c/w pts with VF before PCI (n=145, 5%)
- Pts with VF during PCI experienced more often preinfarction angina (p=0.009) and suffered more often from inferior MI (p=0.001), c/w pts with VF before PCI
- Thus, pts with early VF before reperfusion have different characteristics c/w pts with VF during reperfusion.
- Infarct location is a major determinant of timing of VF, when both groups are compared (p<0.001)

Henriques et al, Intern J Cardiol 2005;105(3):262

CV complications in patients with AMI submitted to primary PCI

- 689 consecutive AMI pts undergoing PCI
- VF occurred in 11% of pts, and most episodes (94.7%) occurred before or during PCI
- 6.3% developed complete AVB / 86.3% of AVB occurred before or during PCI; in 94.5%, AVB resolved in the cath lab
- 31 pts (4.5%) had impending shock on admission to Cath Lab
- C. shock developed in 29 pts (4.2%), mostly in the prehospital phase or in the Cath Lab. Only 4 pts (<1%) developed CS later
- Circulatory & ventilatory support, & temp. pacing & cardiac DF, were used mostly in the prehospital phase or in Cath Lab
- In CCU, 45 pts (6.5%) had hemorrhagic or vasc. complications
- the incidence of post-PCI ischemia & early reocclusion of the culprit vessel were low (2.1% & 0.6%, respectively)

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Giglioli et al, Can J Cardiol 2006 Oct;22(12):1047

VF occurred in 11% of pts / most episodes (94.7%) before or during PCI

Giglioli et al, Can J Cardiol 2006;22:1047

Timing of major cardiac events in patients with acute myocardial infarction treated with primary percutaneous coronary intervention (n=689)

	Prehospital phase	Catheterization laboratory	CCU	Ward	Total, n (%)
Ventricular fibrillation	34	38	3	1	76 (11.0)
CAVB	22	16	0	6	44 (6.3)
Impending shock	NA	31	0	0	31 (4.5)
Pulmonary edema	23	14	9	0	46 (6.7)
Cardiogenic shock	18	7	4	0	29 (4.2)
Death	1	7	23	11	41 (5.9)

VTAs & TIMI Flow

- Arrhythmia rate: lower in pts with 1º PCI in AMI (46.2%) than in those receiving thrombolytic Rx (64%) ($p < 0.01$)
- Achieved mean TIMI flow with 1º PCI (2.46 ±0.21) is higher than mean flow achieved after thrombolytic Rx (2.12 ±0.16)
- The lowest arrhythmia rate is found in pts with TIMI 3 flow (17.2%) achieved with any procedure after AMI
- Arrhythmia rate is 84% in pts with TIMI 2 flow & 33.3% with TIMI 0—1 flow ($p < 0.001$)
- Arrhythmia rate is appreciably lower after 48 hours of MI
- Such finding suggests that the continuing myocardial ischemia represented by TIMI flow at the coronary angiography after AMI may have an important role in the pathogenesis of reperfusion arrhythmias

Heper, Angiology 2008;58 (6): 663-670

Residual flow to the infarct zone against lethal VTAs during the acute phase of MI

- 310 consecutive pts with AMI undergoing primary PCI
- Group 1 with (n = 40) & Group 2 without (n = 270) lethal VTAs
- Residual flow: anterograde (≥TIMI 2) flow or good angiographic collaterals (≥ grade 2) on a preintervention angiogram
- Multivariate analysis: card. shock (odds ratio= 4.79, p = 0.004), residual flow (OR = 0.34, p = 0.015), & RCA as the culprit artery (OR = 2.09, p = 0.040) were independent determinants of these arrhythmias
- In-hospital death occurred in 10 pts & was more common in Group 1 than in Gp 2 (12.5% vs. 1.9%, respectively, p < 0.001)
- CONCLUSION: The absence of residual flow was associated with greater risk of lethal VTAs during the acute phase of AMI, suggesting a protective role of residual flow against these arrhythmias in AMI

Yang et al, Clin Cardiol. 2003;26(8):373

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Reperfusion Arrhythmias

- Almost all subjects had VAs : 156/157 (99%)
- VA bursts during or after reperfusion occurred in 97/157 (62%)
- Majority of VA bursts(72%) arose within 20 min of reperfusion
- Onset: at a median of 4 min post-reperfusion
- Bursts comprised a median of 1290 VPCs & persisted for a median of 105 min; most occurred as single VPCs; bursts typically comprised runs of ≥3VPCs
- Subjects with bursts had higher absolute peak ST segments & more frequent worsening of ST elevation immediately after reperfusion
- Conclusion: Ventricular arrhythmia bursts temporally a/w TIMI 3 flow restoration & stable ST-segment recovery (reperfusion VA bursts) can be precisely defined in subjects with anterior STEMI and may constitute a unique electric biosignal of myocellular response to reperfusion

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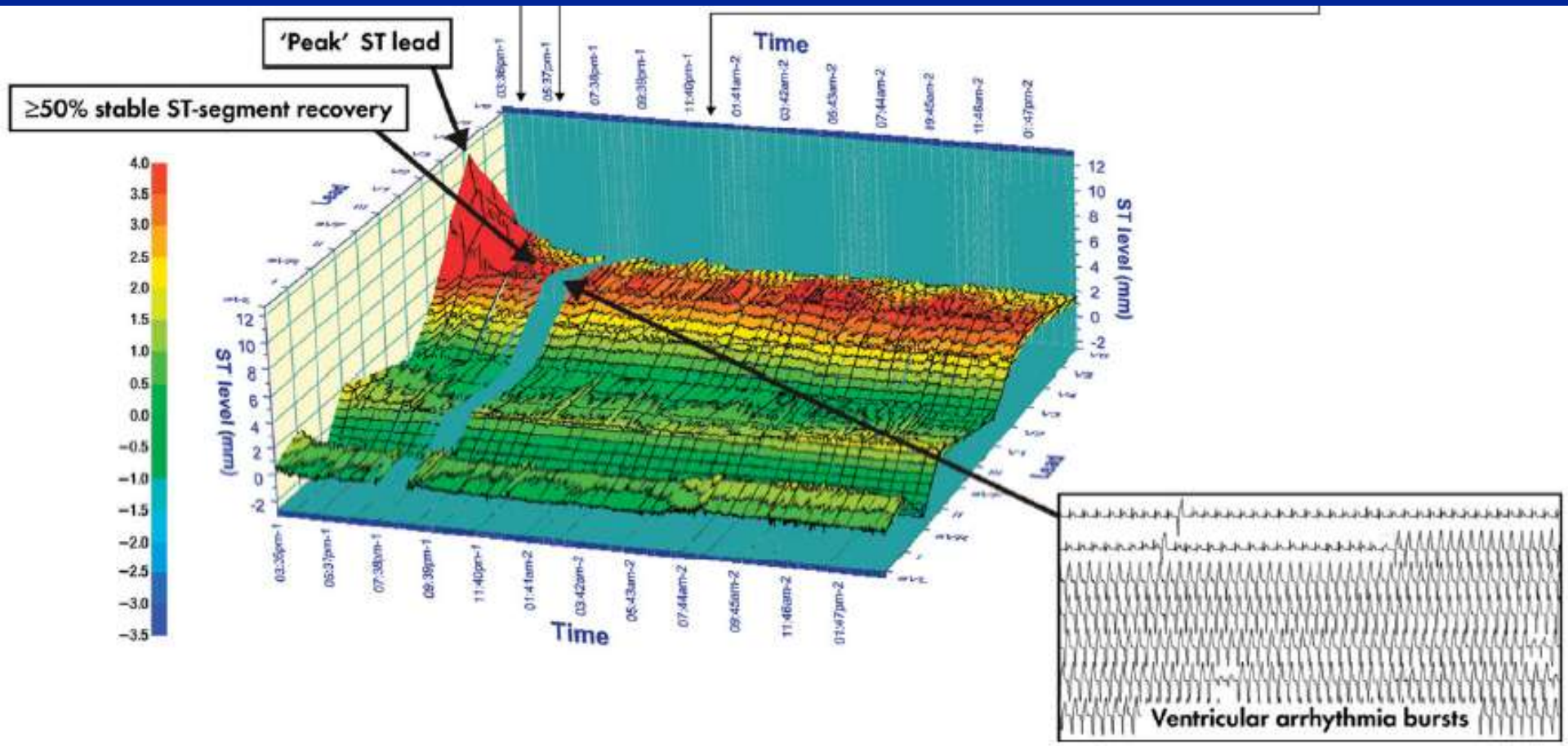
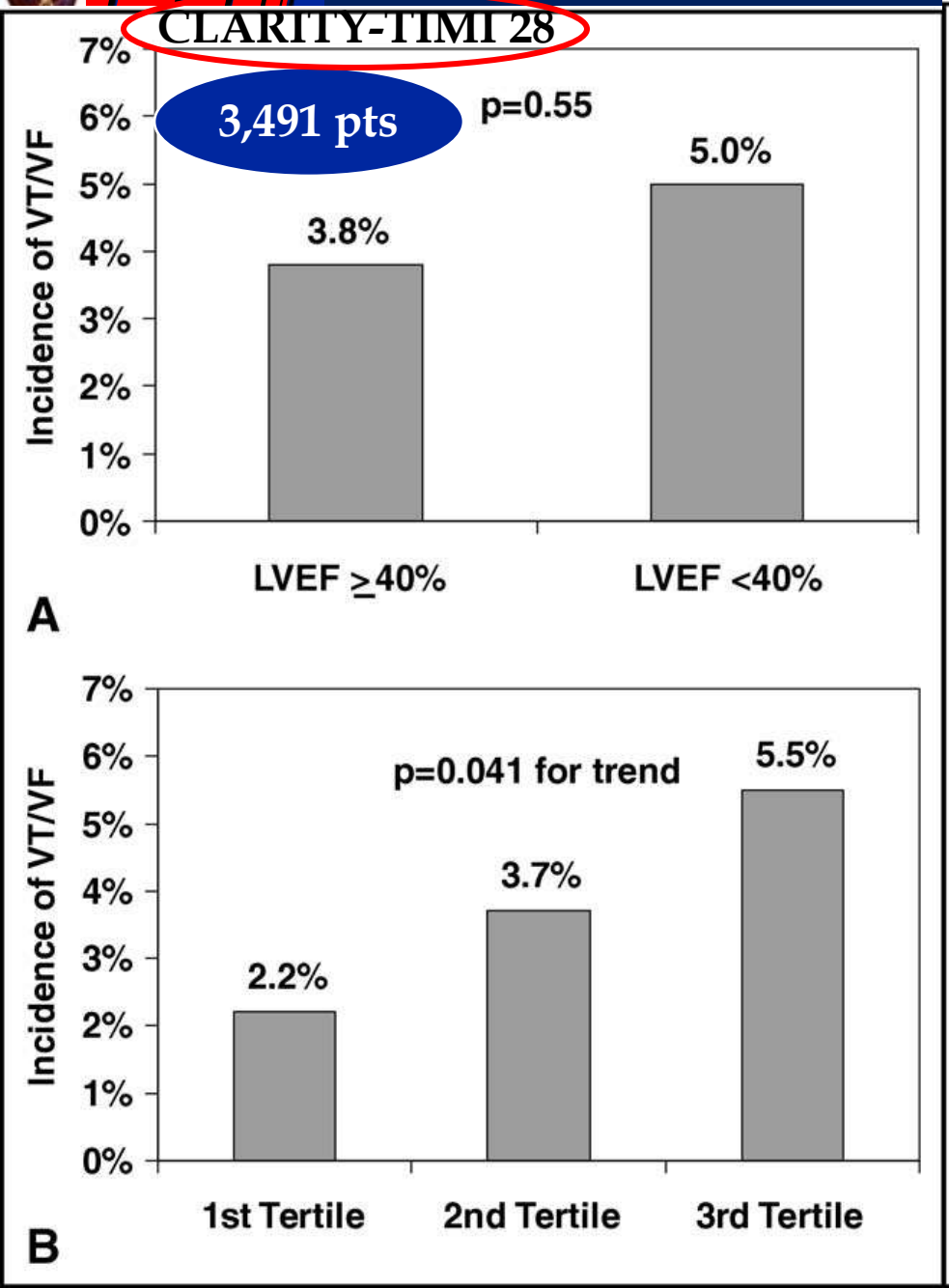
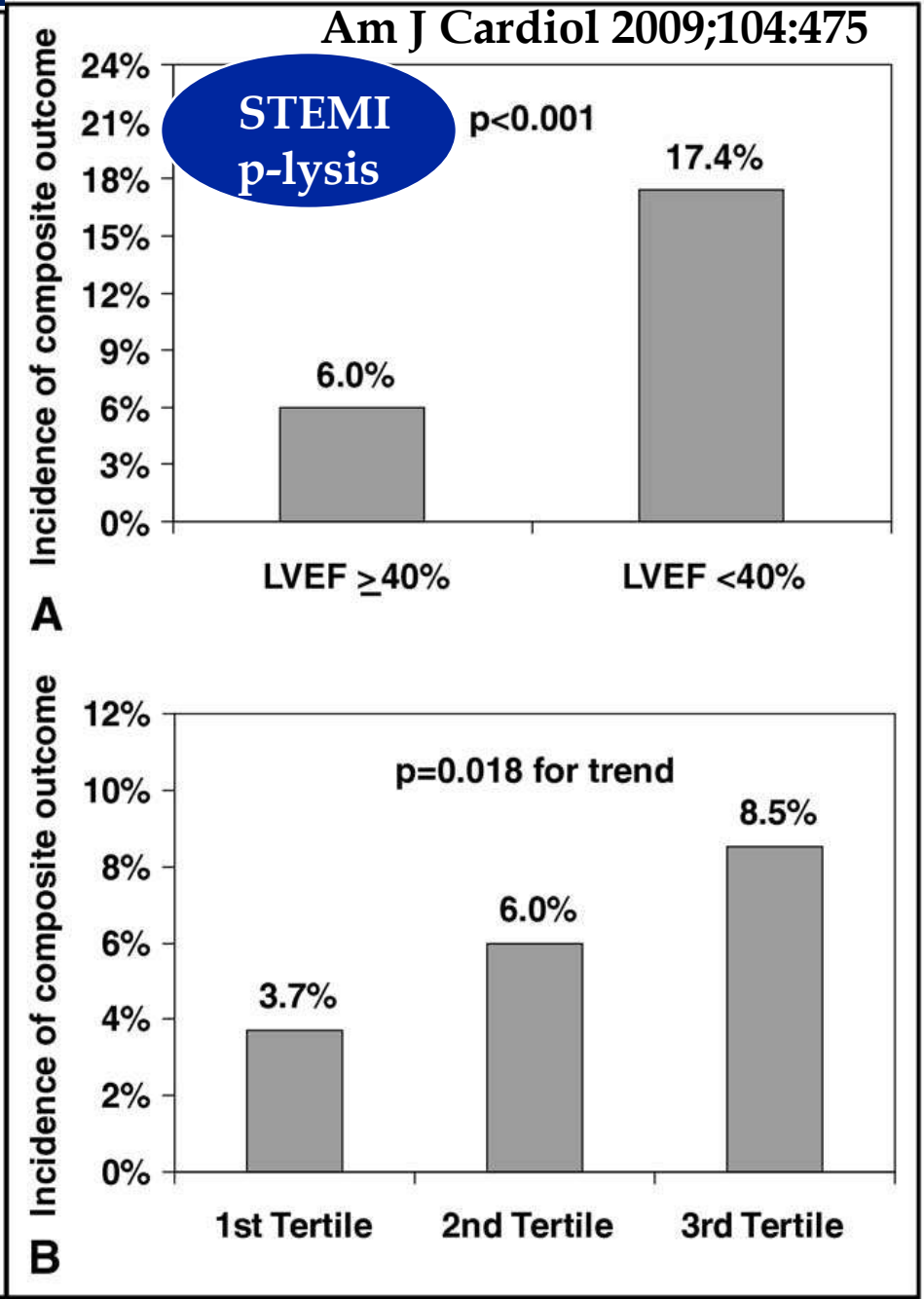
Majidi et al, Europace 2008; 10:98

Anterior STEMI treated with 1º PCI: at the time of ST-elevation resolution ➡ a sudden increase ('bursts') of VAs



VTAs & Infarct Size





Incidence of & Outcomes a/w VT or VF in Pts Undergoing 1º PCI

- 5745 STEMI pts c 1º PCI (13/7/2004-11/5/2006, APEX AMI trial)
- 4 gps: no VT/VF; VT/VF any time; **early** VT/VF, before the end of cardiac cath; & **late** VT/VF, after the end of cardiac cath
- **VT/VF**: 329 STEMI pts (**5.7%**); majority before end of cath (n = 205, 64%), & **90% occurred within 48 h** of Sx of STEMI
- Clinical outcomes were worse in pts with vs those without **VT/VF (90-day mortality, 23.2% vs 3.6%; adjusted HR, 3.63)**
- **outcomes worse if VT/VF occurred late** vs early (90-d MR, 33.3% [adj. HR, 5.59 vs 17.2% [adj. HR, 2.34]; for no VT/VF, 3.6%
- Factors a/w **early VT/VF**: pre-PCI TIMI 0 (HR, 2.94), IMI (HR, 2.16), total STE (HR, 1.39), crea clearance (HR, 0.88), Killip > I (HR, 1.88), baseline SBP (HR, 0.92), Wt (HR, 1.16), & HR> 70/min (HR, 1.10)
- Factors a/w **late VT/VF** : SBP (HR, 0.83), ST resolution < 70% (HR, 3.17), baseline HR> 70/min (HR, 1.20), total STE (HR, 1.43), post-PCI TIMI <3 (HR, 2.09), pre-PCI TIMI 0 (HR, 2.12), & β-blockers <24 h (HR, 0.52)

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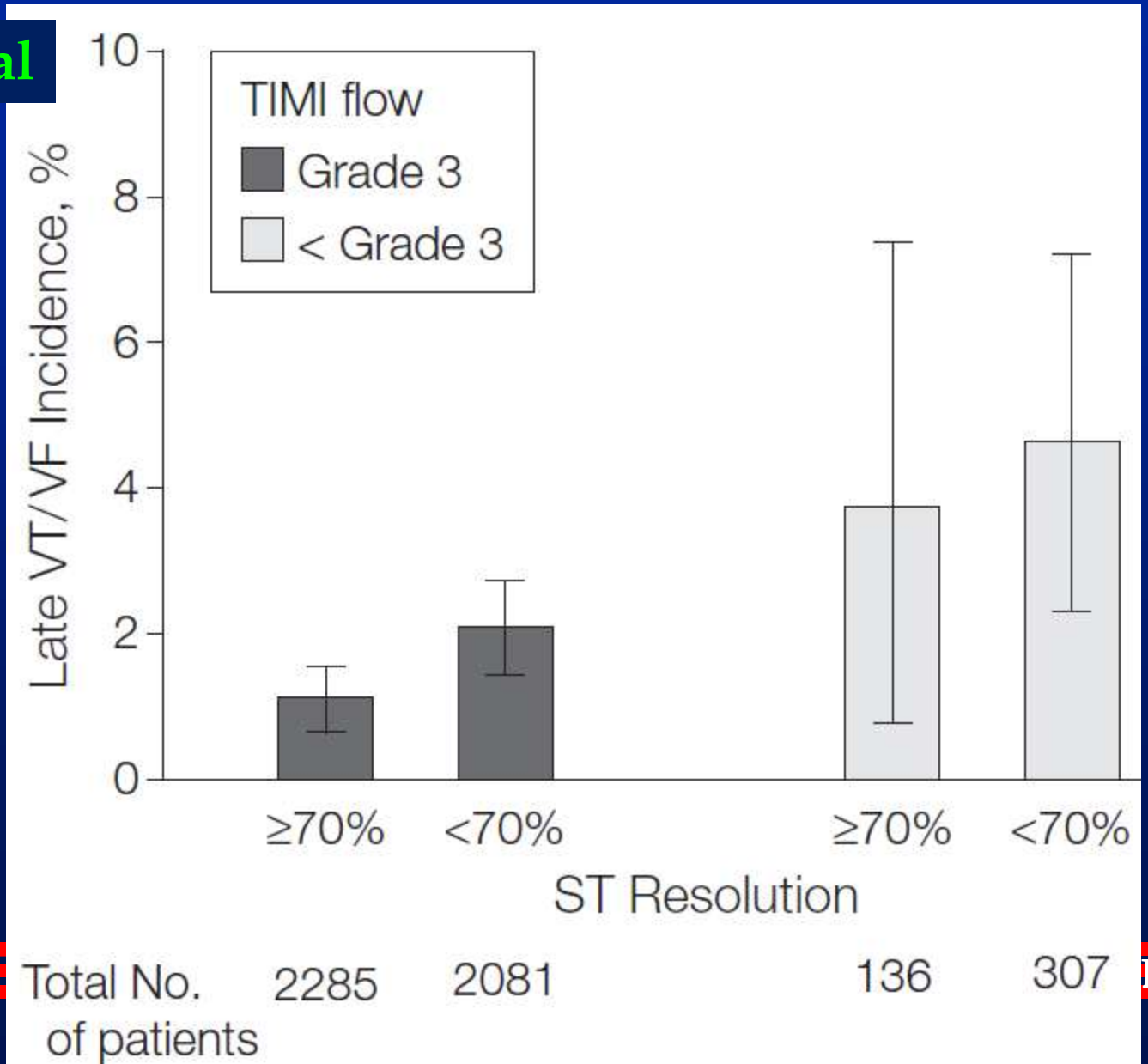
Mehta et al, for the APEX AMI Investigators, *JAMA* 2009;301(17):1779

Postprocedural TIMI Flow & ST Resolution & Incidence of Late VT/VF

APEX AMI trial

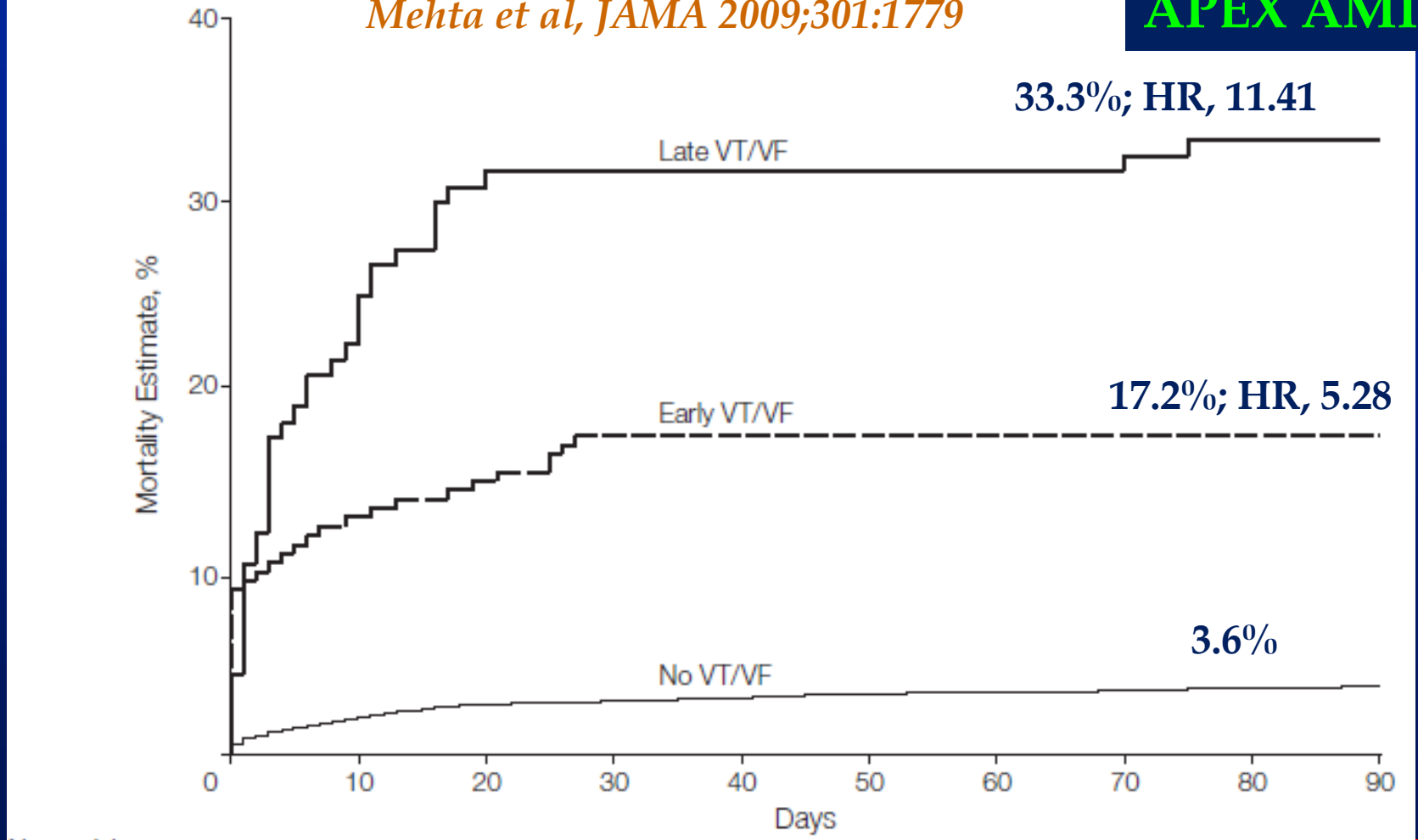


JAMA 2009;301:1779

90-day mortality for early VT/VF, 17.2%; HR, 5.28; & for late VT/VF, 33.3%; HR, 11.41; vs 3.6% for patient s with no VT/VF)

Mehta et al, JAMA 2009;301:1779

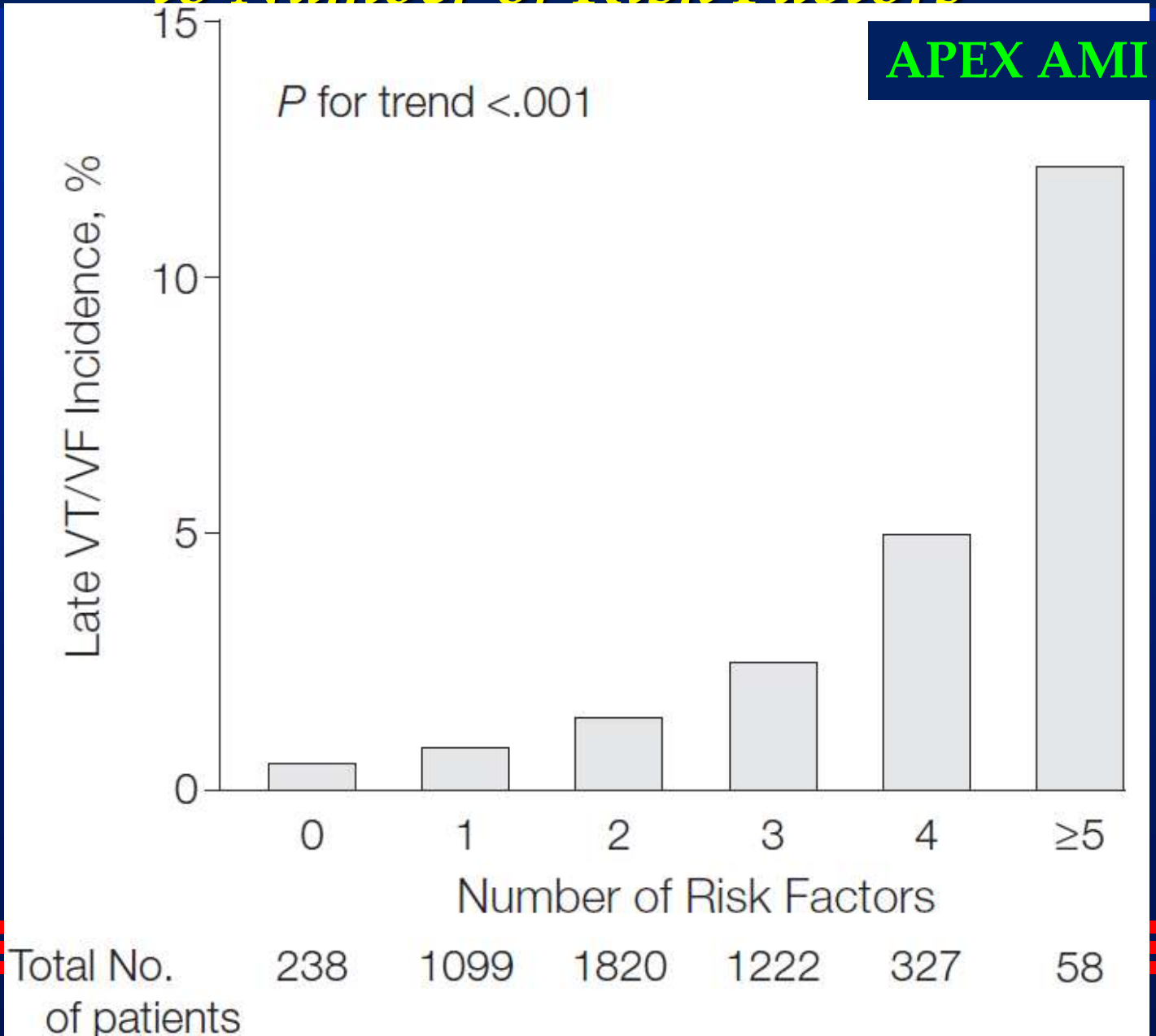
APEX AMI trial



No. at risk										
Late VT/VF	117	91	81	80	80	80	80	80	78	76
Early VT/VF	203	177	173	168	168	168	168	168	168	163
No VT/VF	5405	5307	5264	5254	5245	5231	5224	5219	5212	5119

Incidence of Late VT/VF for All Pts According to Number of Risk Factors

APEX AMI trial



JAMA 2009;301:1779

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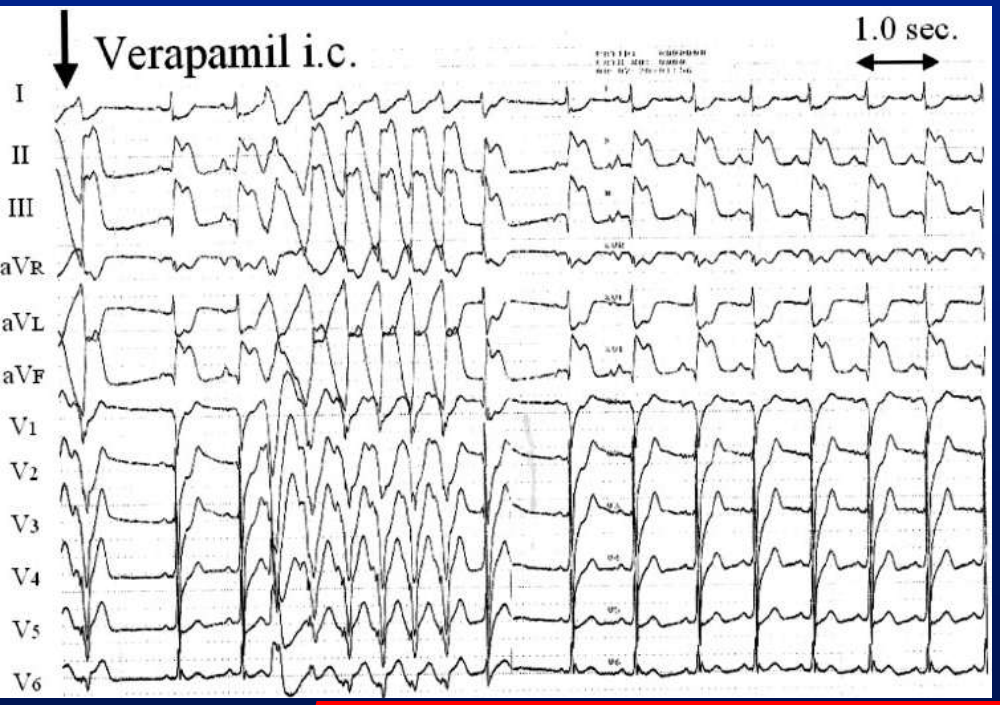
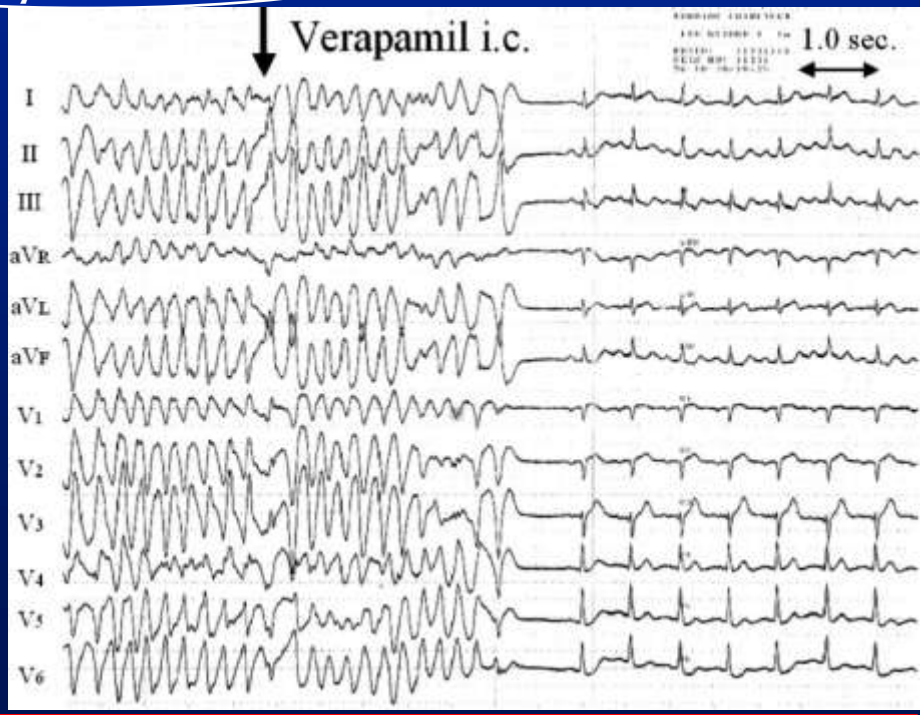
IC Verapamil in Reperfusion VTAs

ECG of a 63-y-old pt with an inferior AMI reveals repetitive VT just after stent placement in the middle RCA lesion. VT was successfully terminated with 0.25 mg IC verapamil (arrow)



ECG of a 71-y-old pt with an anterior AMI reveals TdP just after stent placement in the proximal LAD lesion. TdP was successfully terminated with 0.5 mg IC verapamil (arrow)

31/109/390 1º PCI



Kato et al, Chest 2004; 126:702

x for VF

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Patients undergoing emergent PCI for cardiac arrest secondary to AMI

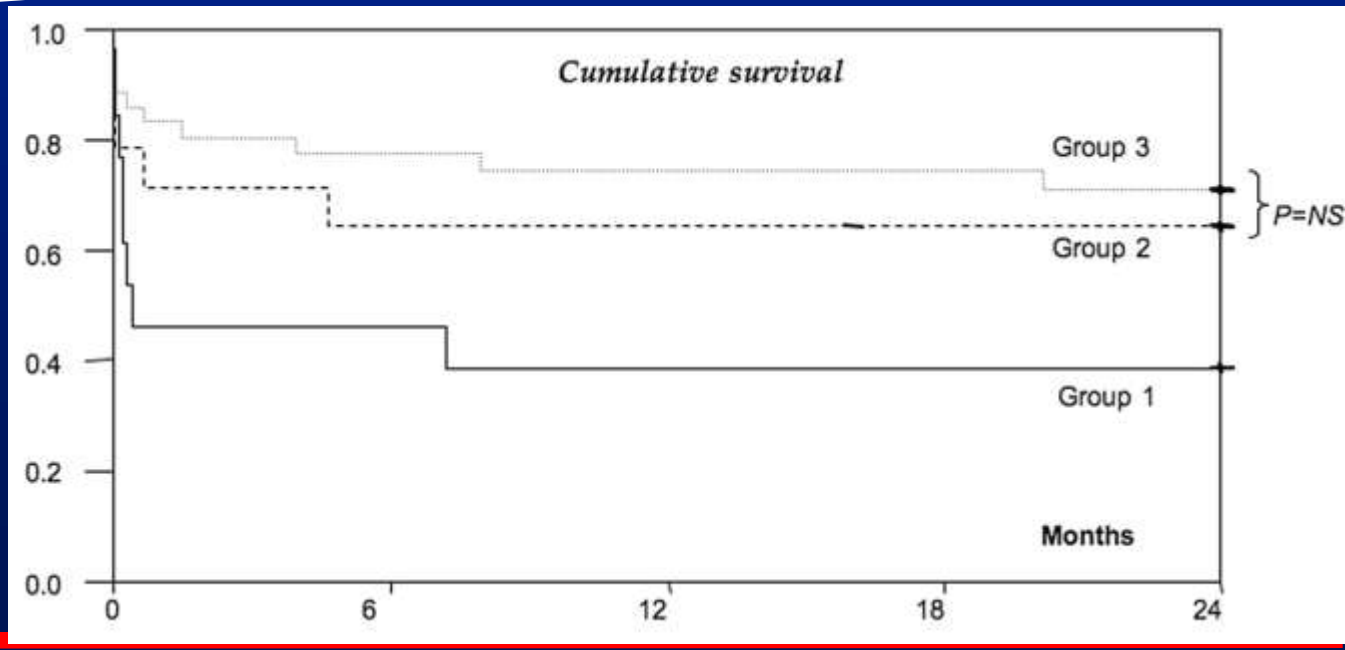
63/630(10%)

- Group 1: out-of-hospital cardiac arrest (OOHCA) without immediate medical or paramedical assistance (≤1 min from CA until initiation of resuscitation; *n* = 13);
- Group 2: OOHCA with medical or paramedical immediate assistance; (*n* = 14); and
- Group 3: CA before PCI, but after hospital admission; (*n* = 36).

VTAs: 77-83%

Angio success: 86-93%

Clinical outcomes were significantly worse in Group 1 than in Groups 2 or 3, and were rather similar between Groups 2 and 3. The mean FU period for the study population was 21 ± 19 mos



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Quintero-Moran et al, J Invas Cardiol 2006 Jun;18(6):269

Six-Month Outcome of Emergency Percutaneous Coronary Intervention in Resuscitated Patients After Cardiac Arrest Complicating ST-Elevation Myocardial Infarction

Philippe Garot, MD; Thierry Lefevre, MD; Hélène Eltchaninoff, MD, PhD; Marie-Claude Morice, MD;

- *186 pts:PCI* after resuscitation for CA complicating AMI
- 154 of 186 pts had OOHCA, whereas 32 had in-hospital CA
- MI was anterior in 105 pts (56%), and 96 (52%) were in shock
- PCI (stenting 90%) was successful in 161 of 186 pts (87%)
- 6-mo survival was 100 of 186 (54%), and 6-mo survival free of neurological sequelae was 46%
- By multivariate analysis, predictors of 6-mo survival were
  - shorter interval between onset of CA & arrival of a first responder (odds ratio/OR, 0.67),
  - shorter interval between the onset of CA & return of spontaneous circulation (OR, 0.91), and
  - absence of diabetes (OR, 7.30)

Circulation 2007;115:1354

EGHA

Primary PCI After OOHCA

- From 3/1998 to 6/2006, 25 STEMI pts (21 men, age 56 ± 11y, 13 pts c anterior MI) after OHCA were treated with 1º PCI
- OOHCA: witnessed in 23 pts (92%), but bystander resuscitation was performed in only 2 pts (8%)
- 18 pts (72%) were unconscious on admission, & Glasgow Coma Scale > 5 was noted in 2 pts (8%)
- C. shock on admission was diagnosed in 4 pts (16%)
- PCI procedure was successful in 22 pts (88%)
- In-hosp, 30-d, 6-mo & 1-y survival was 76%, 76%, 76% & 72%
- In-hospital, 30-day, 6-mo & 1-y survival without severe neurological disability was 68%, 68%, 68% & 64%, respectively
- Conclusions: In a selected group of STEMI pts after OOHCA, 1º PCI can be performed with a high success rate & provides reasonably good results in short and longer term survival

Markusohn et al, IMAJ 2007;9:257–259

ASM

Primary PCI & mild induced hypothermia (MIH) in comatose survivors of VF with acute STEMI

- **40 pts undergoing 1º PCI & mild induced hypothermia (MIH) were compared to 32 pts who had 1º PCI but no MIH**
- **No signif. differences between MIH & no MIH gps in general characteristics, CA circumstances & angiographic features**
- **Also, except for ↓ in HR during hypothermia, there was no difference in BP, peak arterial lactate, need for vasopressors, inotropes, IABP, repeat CV/DF (30% vs 34%; p=.89) & use of antiarrhythmics**
- **There was also no difference in FIO2 requirements during mechanical ventilation and in renal function**
- **Hospital survival with cerebral performance category 1 & 2 was significantly better in MIH group (55% vs 16%; p=.001) ****

EGHA

Knafeldj et al, Resuscitation 2007 Aug;74(2):227

ASM

Electrical Storm

Electrical storm is defined as recurrent, hemodynamically destabilizing VT or VF occurring ≥2-3 times in a 24 h period, and usually requiring electrical CV or DF

- **Clinical syndromes of electrical storm**

- **Electrical storm in acute MI or ischemia**
- **High density monomorphic VT in patients without structural heart disease**
- **Arrhythmias with delayed repolarization (QT-U prolongation)**
- **Recurrent VT/ VF or cardiac arrest**

EGHA

ASM

Electrical storm in acute myocardial ischemia or MI

- The specific arrhythmia in these cases is almost always polymorphic VT or VF arising from s-tach, with a short coupling interval of the first beat (the PVC) to the last normal beat (~250 - 350 ms). SuMVT is relatively uncommon in acute MI or ischemia & should be treated as any other monomorphic VT
- Because the primary abnormality is ischemia or infarction, the focus of treatment should be anti-ischemic or anti-adrenergic interventions, rather than simply antiarrhythmic drugs
- Thrombolysis, or either ASA or heparin therapy, is usually appropriate
- Primary angioplasty or surgical revascularization needs to be carefully considered in such pts.
- Intravenous beta-blocking agents may be useful
- In most cases, high density VT or VF dissipates quickly following acute infarction

EGHA

Electrical Storm

Characteristics of patients enrolled in trials of treatment for electrical storm

Patient characteristic	Authors (reference)		
	Levine et al (2)	Kowey et al (1)	Scheinman et al (3)
Age (mean years ± SD)	63 ± 11	65 ± 12	63 ± 12
Sex (% male)	73	76	77
History of acute or past MI (%)	86	82	80
Mean ejection fraction (%)	32	30	31

Electrical Storm: Recurrent VT/VF with syncope or cardiac arrest

Dosage regimens in a trial of intravenous amiodarone versus bretylium in the management of electrical storm

Regimen	Drug and Dosage	
	Amiodarone high dose (1000 mg/24 h)	Bretylium (2500 mg/24 h)
Initial rapid infusion	150 mg over 10 min	350 mg over 10 min
Loading infusion	1 mg/min for 6 h	1.5 mg/min for 6 h
Maintenance infusion	0.52 mg/min for the remainder of 48 h	1.5 mg/min for the remainder of 48 h
Day 1 total dose	1071.6 mg	2510 mg
Day 2 total dose	748.8 mg	2160 mg

ASM

TdP: Possible Causes

- Drugs that lengthen the QT:
  - Quinidine
  - Procainamide
  - Sotalol
  - Ibutilide
- Physical
  - Ischemia
  - Electrolyte abnormalities

EGHA

Arrhythmia Storm in ICD Patients

- As with most arrhythmias there is substantial variation in the relative contribution of the components of the triad of
  - substrate,
  - trigger and
  - modulating factors and
- every patient presenting with ES should be evaluated thoroughly with a careful search for trigger factors such as
  - electrolyte imbalance or
  - recurrent ischemia
- If these are present and treated appropriately, the ES may subside without a need for specific AAD therapy
- Unfortunately, reversible triggers are found only in a minority of patients who present with ES

Treatment of Arrhythmia Storm

Krivan et al, Med Sci Monit, 2005; 11(9): CR426

	n	%
Antiarrhythmic therapy (onset + change)	15	78
Anti-ischemic + heart failure therapy	11	58
Sedation	10	52
VVI, DDD stimulation	10	52
Correction of the ionic disorders	8	42
Revascularisation	3	16
Radiofrequency ablation of VT	2	10

Management of the 294 episodes of ES

ICD reprogramming, *n* (%)	67 (23)
Antiarrhythmic drugs adjustment, *n* (%)	142 (48)
Radiofrequency ablation of VT, *n* (%)	22 (7)
Hyperthyroidism treatment, *n* (%)	8 (3)
Acute cardiac failure treatment, *n* (%)	46 (16)
Angioplasty procedures, *n* (%)	9 (3)
No specific action, *n* (%)	85 (29)

ASM

Role of Reperfusion (open IRA)

- ↑electrical instability (↑ VEA/LPs/inducible VAs)
- Major factor: patency of IRA
- Reperfusion and IRA patency: ↓ LPs independently of global LV function
- Also favorable effect on HRV
- Mechanisms? : ↓border zone ischemia, favorable effects on EP properties of surviving cells & LV remodelling, prevention of non-uniform responsiveness during sympathetic stimulation
- Prevents development of arrhythmogenic substrate

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ASM

Reperfusion & VT/VF After AMI

- **Lower rate of inducible VT:** Kersschot et al, JACC 1986; Sager et al, JACC 1988; Bourke et al, JACC 1990 ; Pedretti et al, JACC 1994 **but no difference:** Treese et al, IJC 1987; McComb et al, AJC 1988
- **Lower rate of clinical VT/VF:** 13% vs 43% (p=0.04) @ 23 mos (Pedretti et al, JACC 1994)
- **Reduction of risk markers** for arrhythmic events (LP/HRV/EPS)
- effect of **patent IRA!** rather than lytic or PCI Rx
- **LVEF** potent predictor of VT/VF

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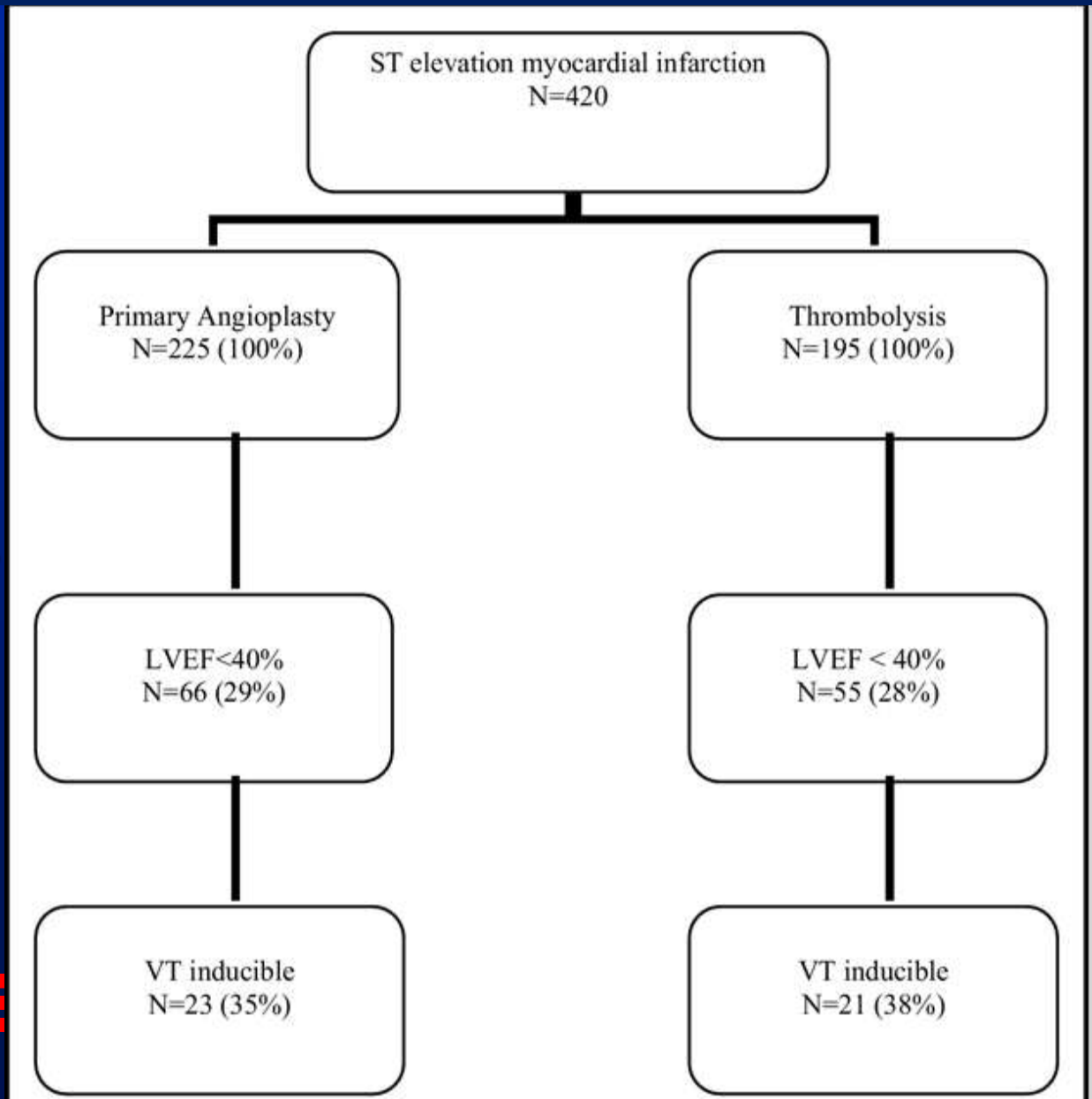
Comparison of LVEF & Inducible VT in STEMI Treated by Primary Angioplasty vs Thrombolysis

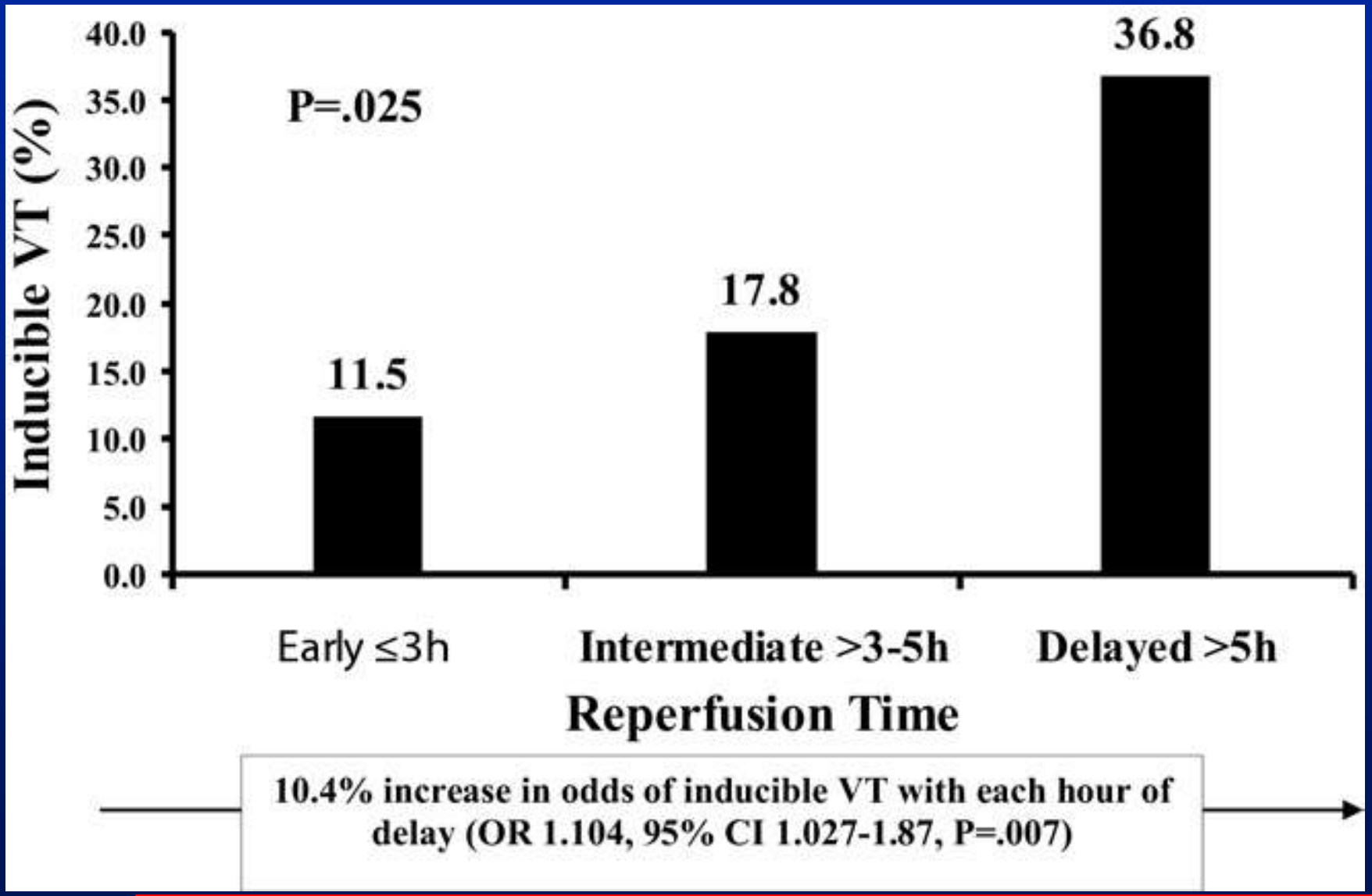
The mean LVEF was 48±12% for the 1º PCI gp & 46±13% for the thrombolysis gp. The proportion of pts with LVEFs <40% was 30% in the 1º PCI gp & in the thrombolysis gp

Pts treated with thrombolysis (& rescue PCI if indicated) achieve similar preservation of LVEF & susceptibility to inducible VT c/w pts treated with 1º PCI

Chong et al, AJC 2008;101:153



Reperfusion time & inducible VT

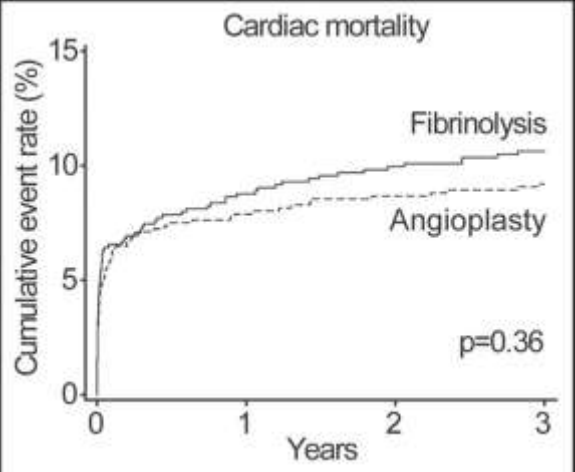


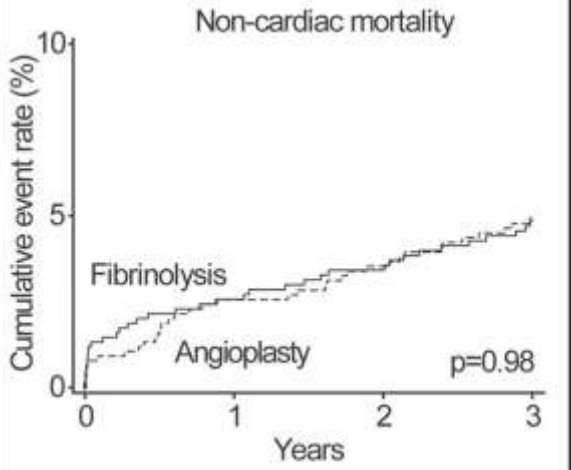
Kumar et al, HR 2011;8:493

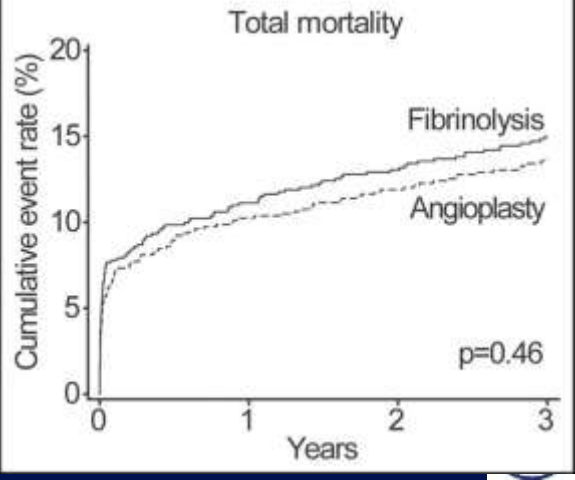
DANAMI-2:Cardiac, noncardiac, & total mortality after fibrinolysis vs 1º PCI

- 1,572 pts c STEMI randomized to 1º angioplasty or alteplase & followed for 3 y
- A total of 225 pts (14.3%) died, 113 within first 30 d & 112 between 31 d & 3 y
- Mortality & causes of death did not differ between the 2 treatments
- Causes of death: CS/CHF (41%), SD (17%), other CD (10%), cancer (12%), & other NCD (20%)
- CD was predominant during the first month only (86% of early deaths), &
- NCD & CD were equally frequent after 30 d (49% & 51% of late deaths, respectively)
- Independent predictors of death after D/C: age, LVEF, DM, Killip class, & a lack of Rx with a β-blocker or statin

- In conclusion, the causes of death did not differ between alteplase Rx & 1º PCI with stent implantation
- One half of the deaths within 3 y after STEMI occurred during the first 30 d, & CD was predominant during the first 30 d only





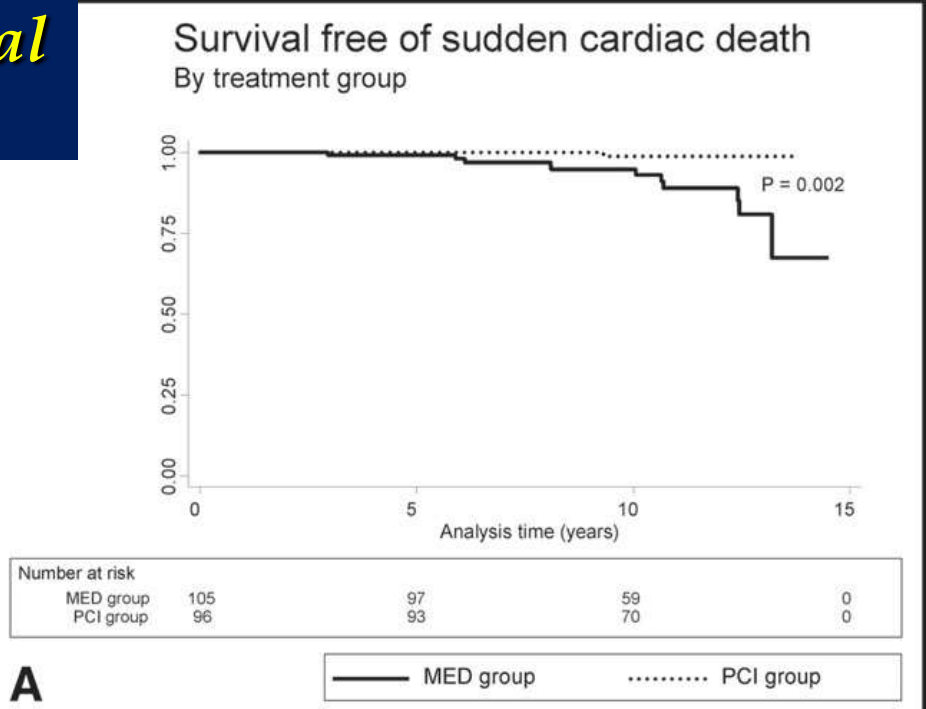


Busk et al, Am J Cardiol 2009;104:210

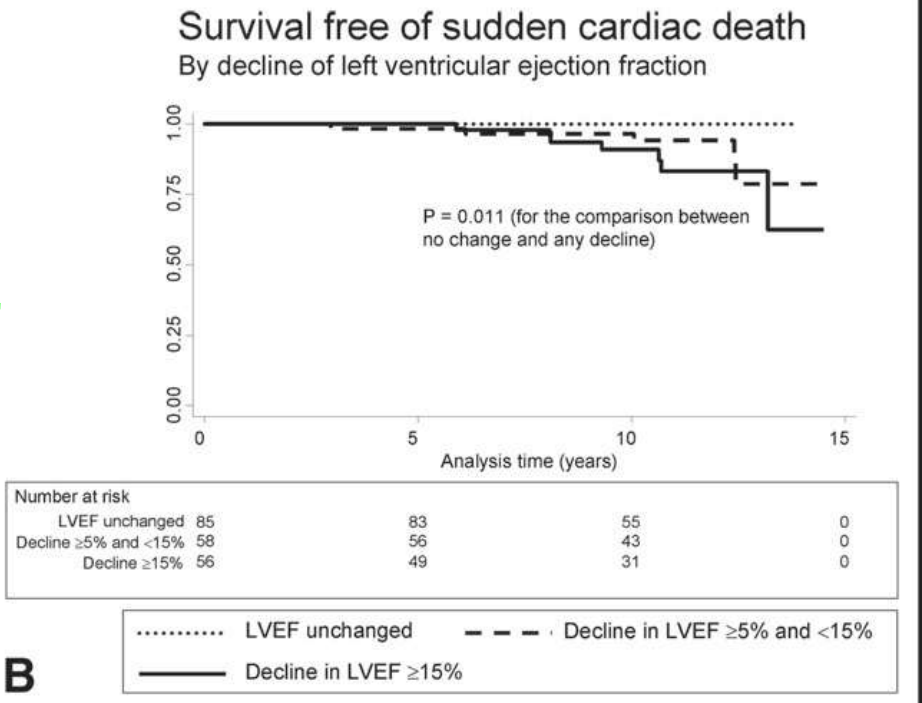
SCD in Pts With Silent Myocardial Ischemia After MI (SWISSI II])

- 201 pts c silent ischemia after MI were randomized to PCI or medical Rx
- @ a mean FU of 10 y, 12 SCDs occurred, c average annual event rate of 0.6%
- Decline in LVEF during FU was the only independent predictor of SCD other than age; however, baseline LVEF was not.
- LVEF decline was greater in pts receiving medical Rx than PCI ($p < 0.001$), & in pts with residual myocardial ischemia or recurrent MI c/w pts without these findings ($p = 0.038$ & $p < 0.001$, respectively).
- C/w medical Rx, PCI reduced the rate of residual myocardial ischemia ($p < 0.001$) & recurrent MI ($p = 0.001$) during FU
- In conclusion, pts with silent ischemia after MI are at a substantial risk of SCD
- Prevention of residual myocardial ischemia & recurrent MI using PCI resulted in better long-term LVEF & a reduced SCD incidence

Am J Cardiol 2009;104:158



A

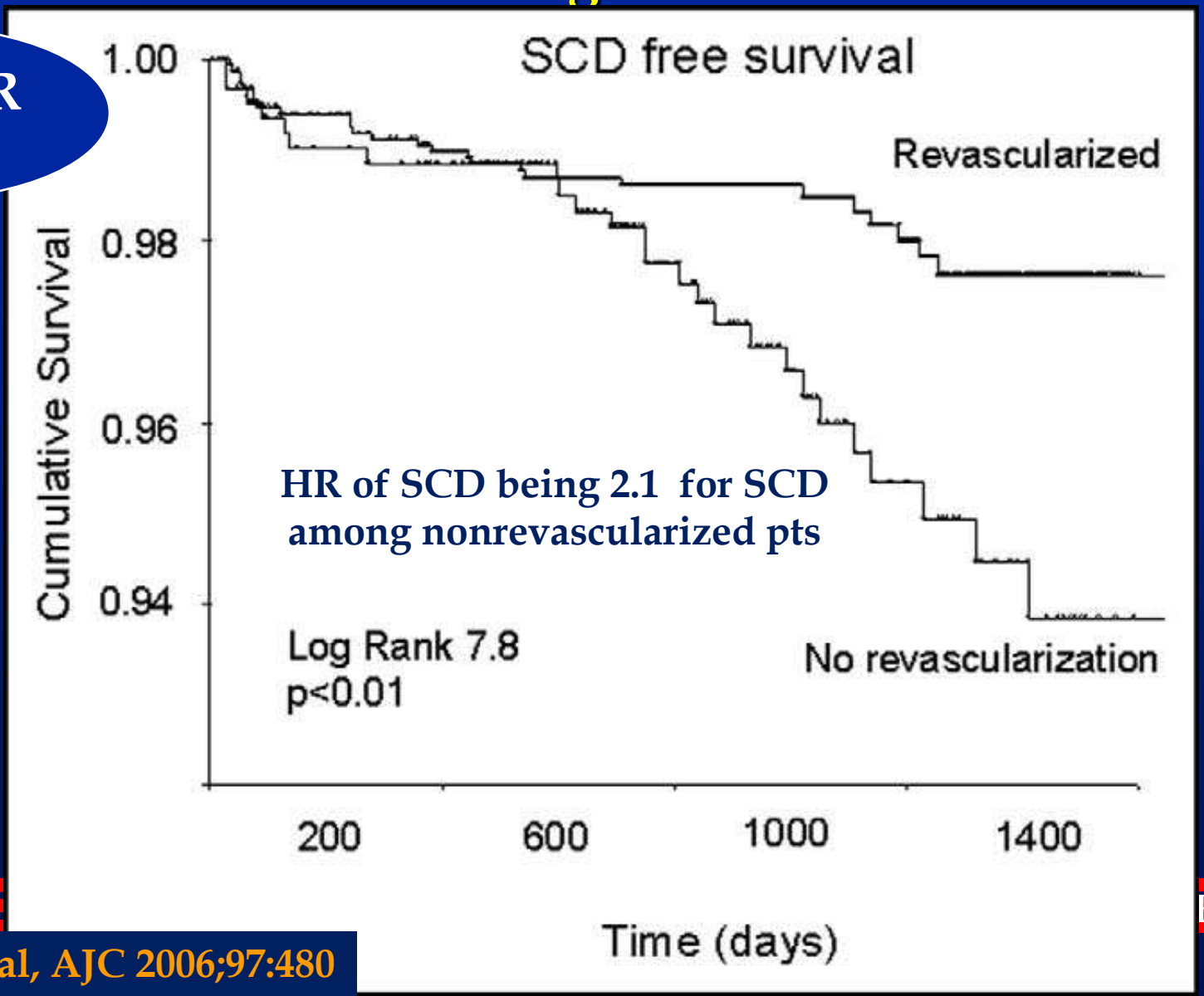


B

Pts who underwent coronary revascularization after AMI had a significantly lower rate of SCD than did pts who did not undergo revascularization

FINGER study

N = 2130



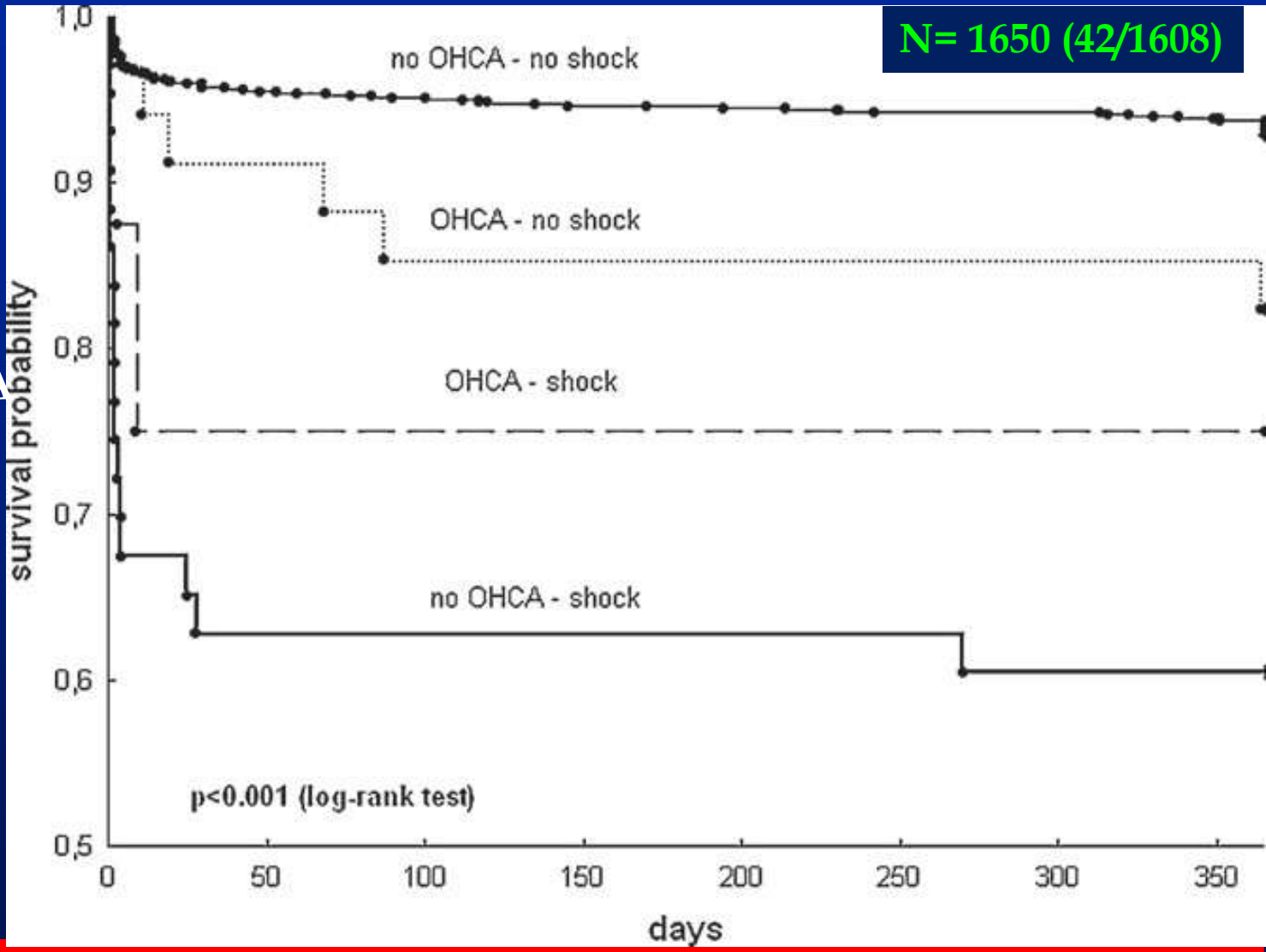
Mäkikallio et al, AJC 2006;97:480

OHCA in pts treated with 1º PCI for STEMI
Long-term FU data from EUROTRANSFER registry

1-year mortality was 19.1% in the OHCA group

vs

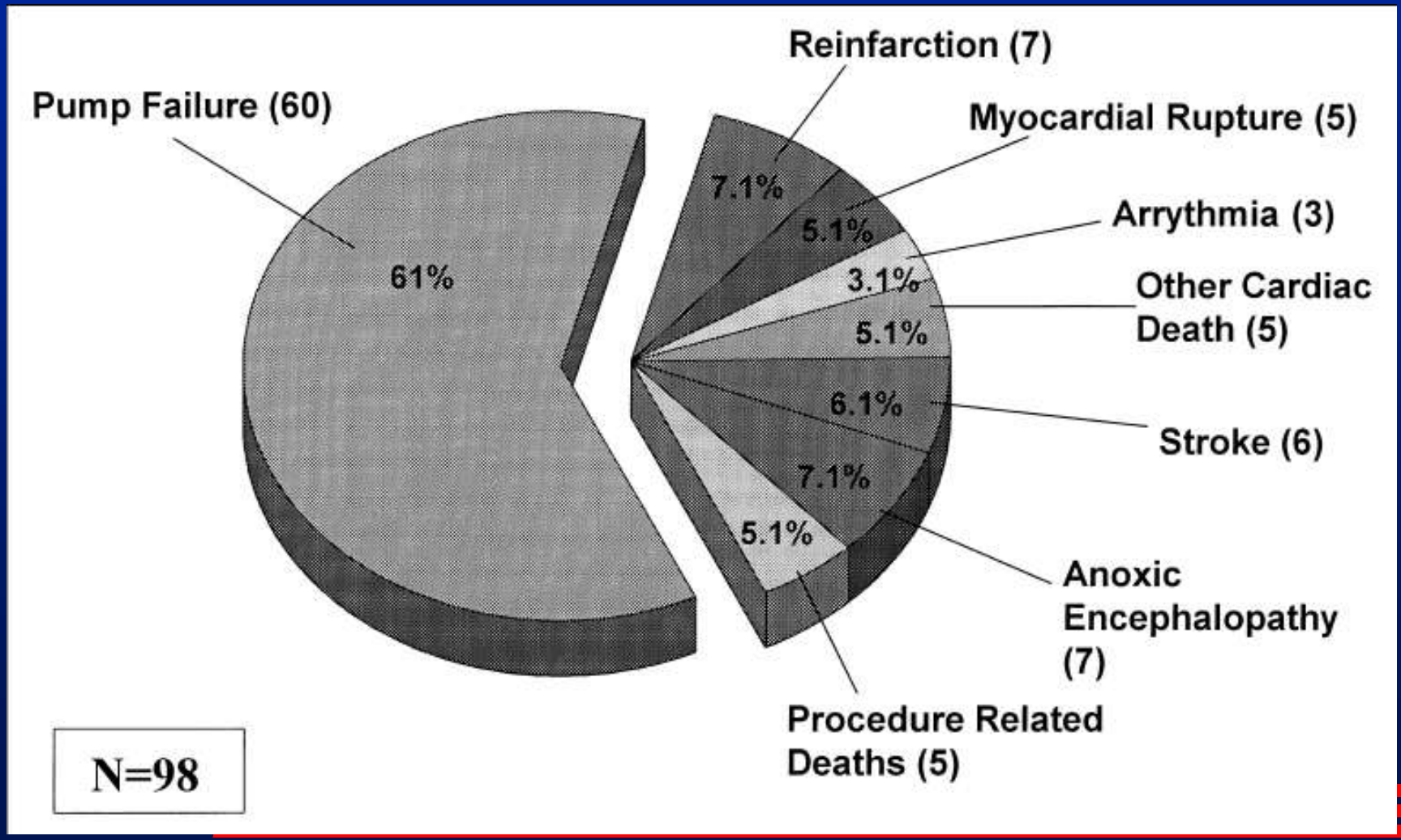
8.1% in no OHCA group (p = 0.011)



EGHA

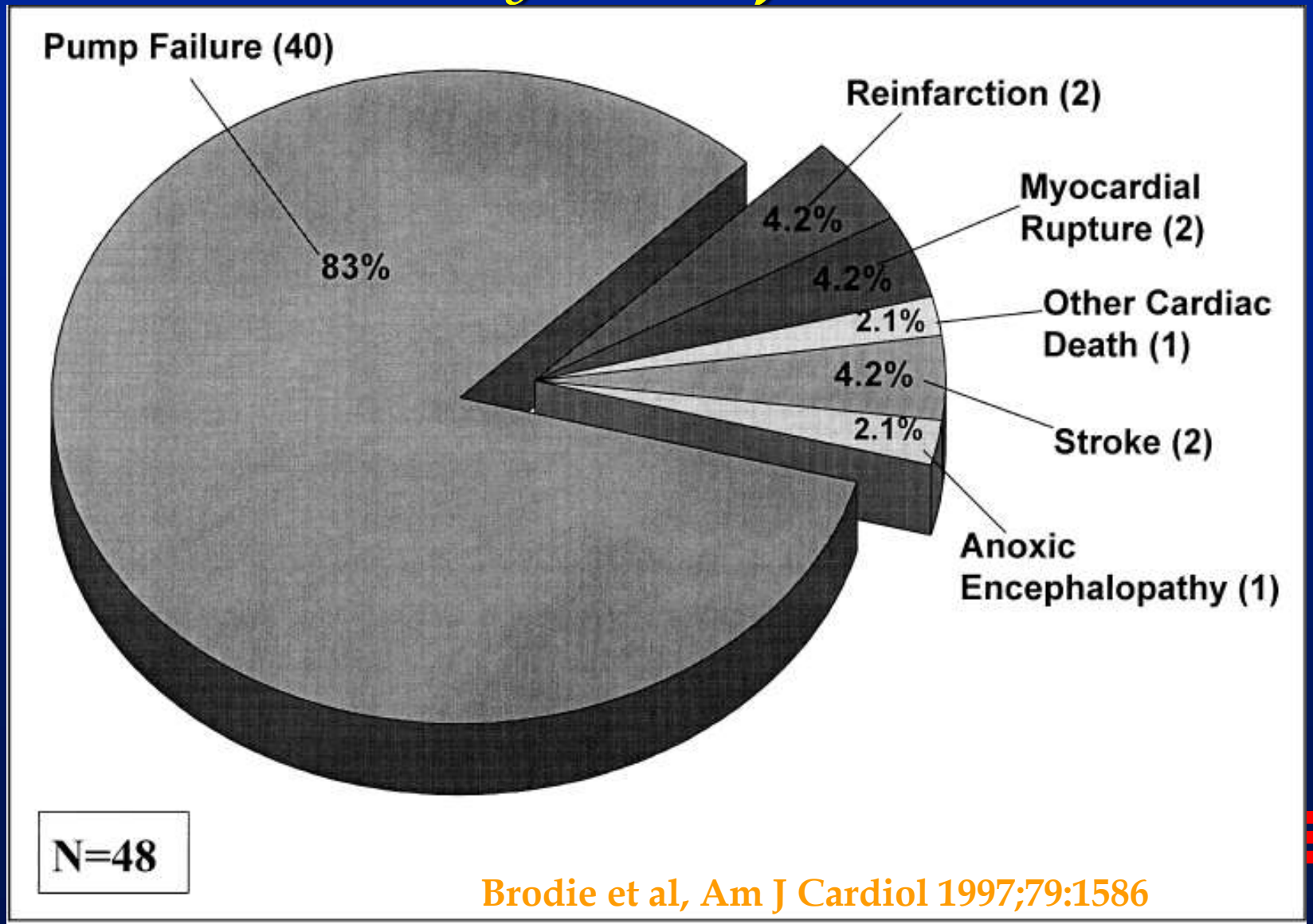
Siudak et al, Resuscitation xxx (2011) xxx– xxx

Mechanism of death in 98 pts who died within 30 days after 1º angioplasty for AMI



Brodie et al, Am J Cardiol 1997;79:1586

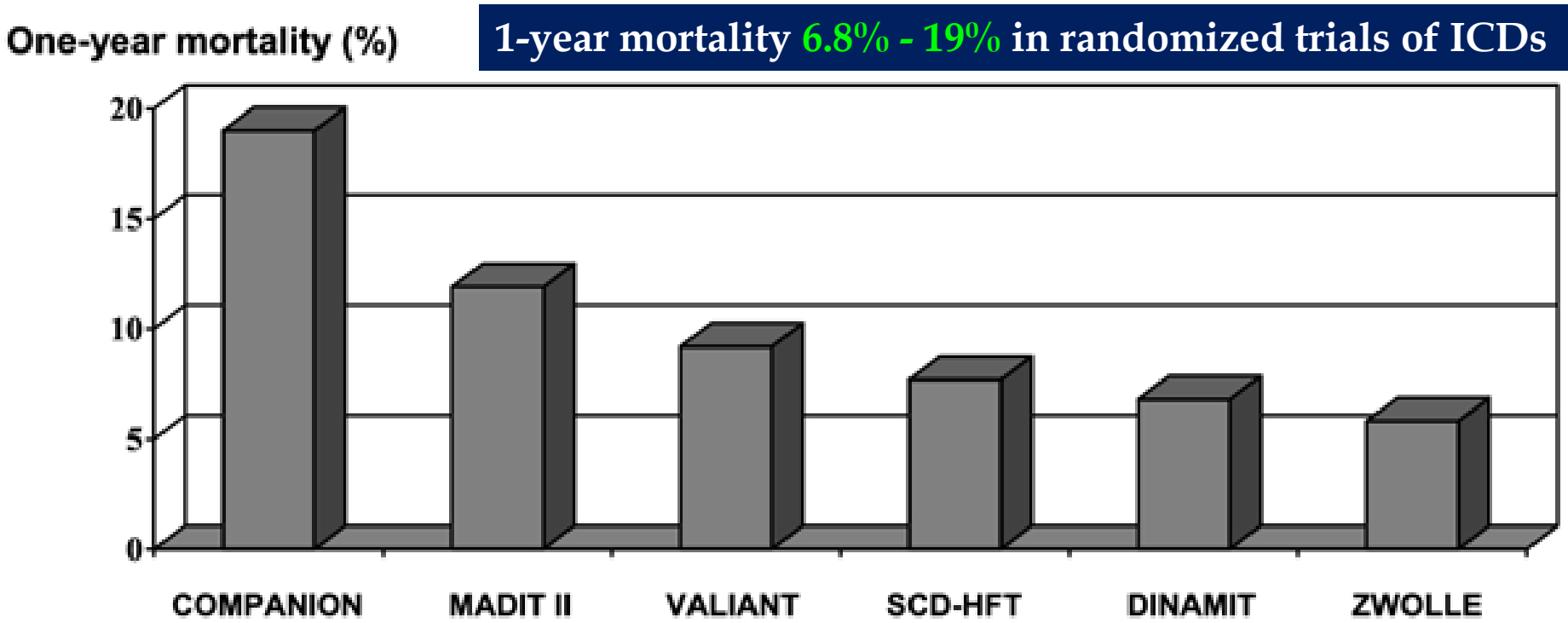
Mechanisms of early death in 48 pts who died the day of or the day following 1º angioplasty (day 0 or 1) for AMI



Brodie et al, Am J Cardiol 1997;79:1586

Mortality in Pts With LVEF <30% After Primary PCI for STEMI

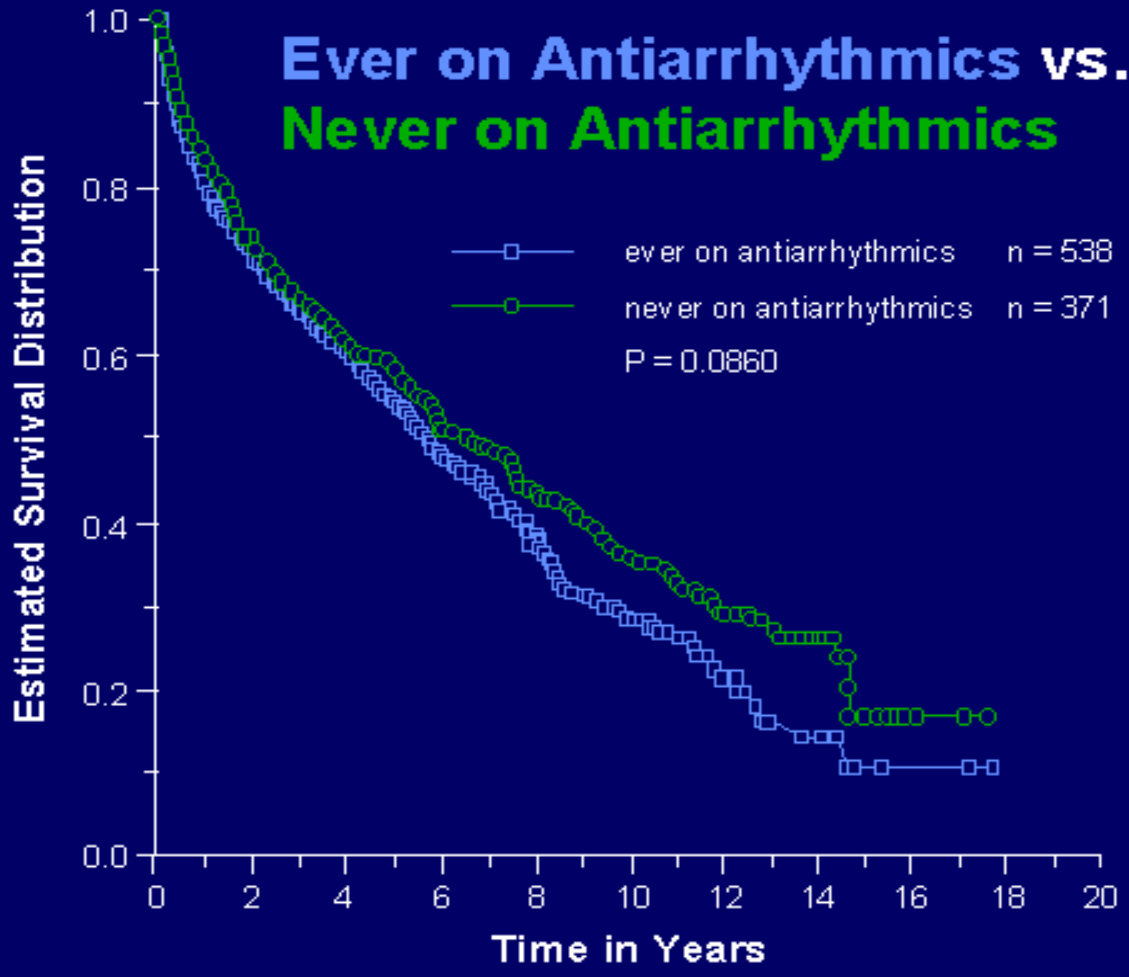
One-year mortality of 30-day survivors in several trials and in the present (Zwolle) analysis



Of 2,544 pts, 342 (13%) had LVEF <30%. 1-year mortality was 5.8%. SCD was the most common cause of death (40%). Pts who died more often had MVD and a higher incidence of recurrent MI within 1 year

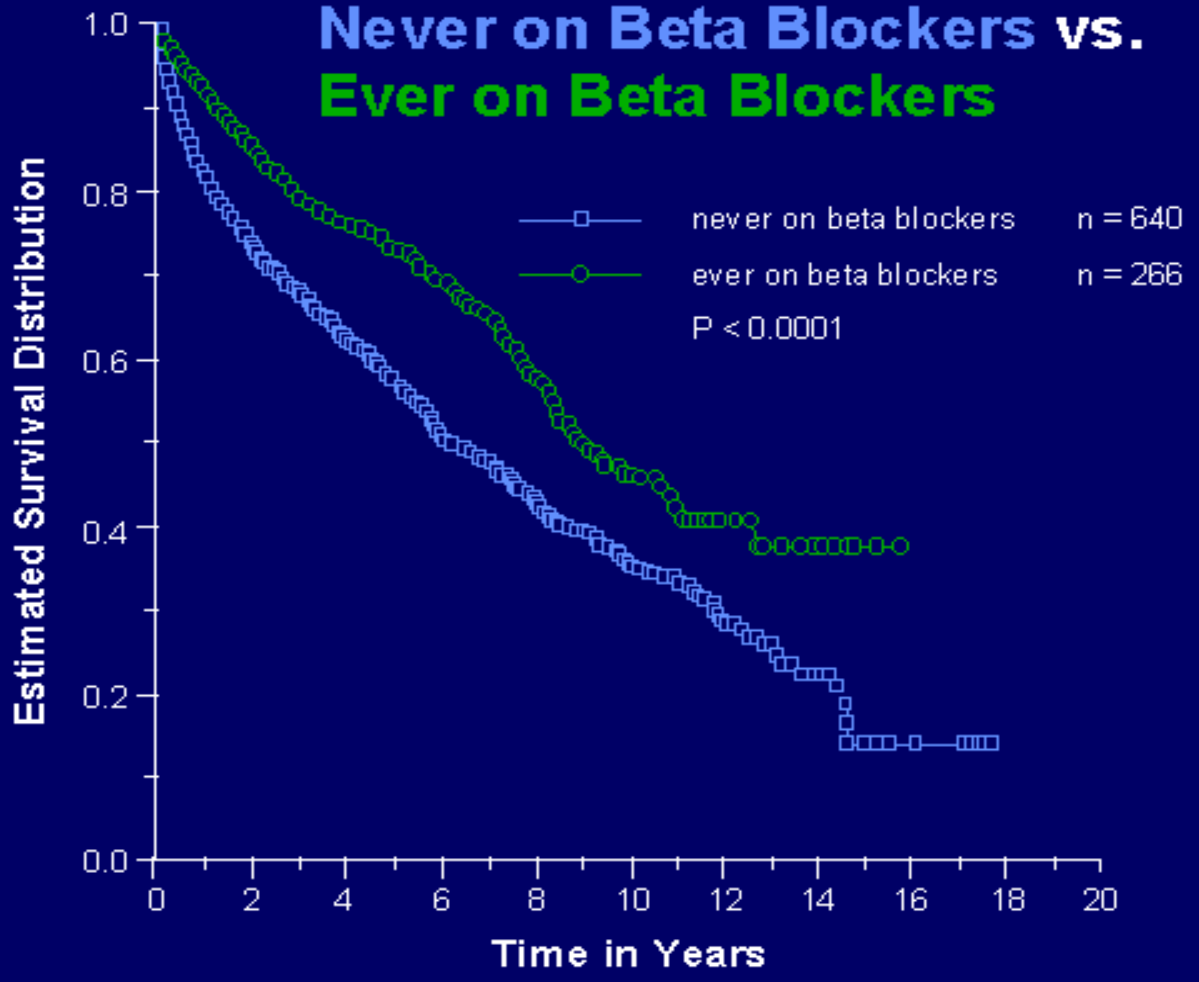
Ottervanger et al, AJC 2007;100:793

Antiarrhythmic Experience After Cardiac Arrest



Hallstrom AP. Am J Cardiol. 1991;68:1025-1031.

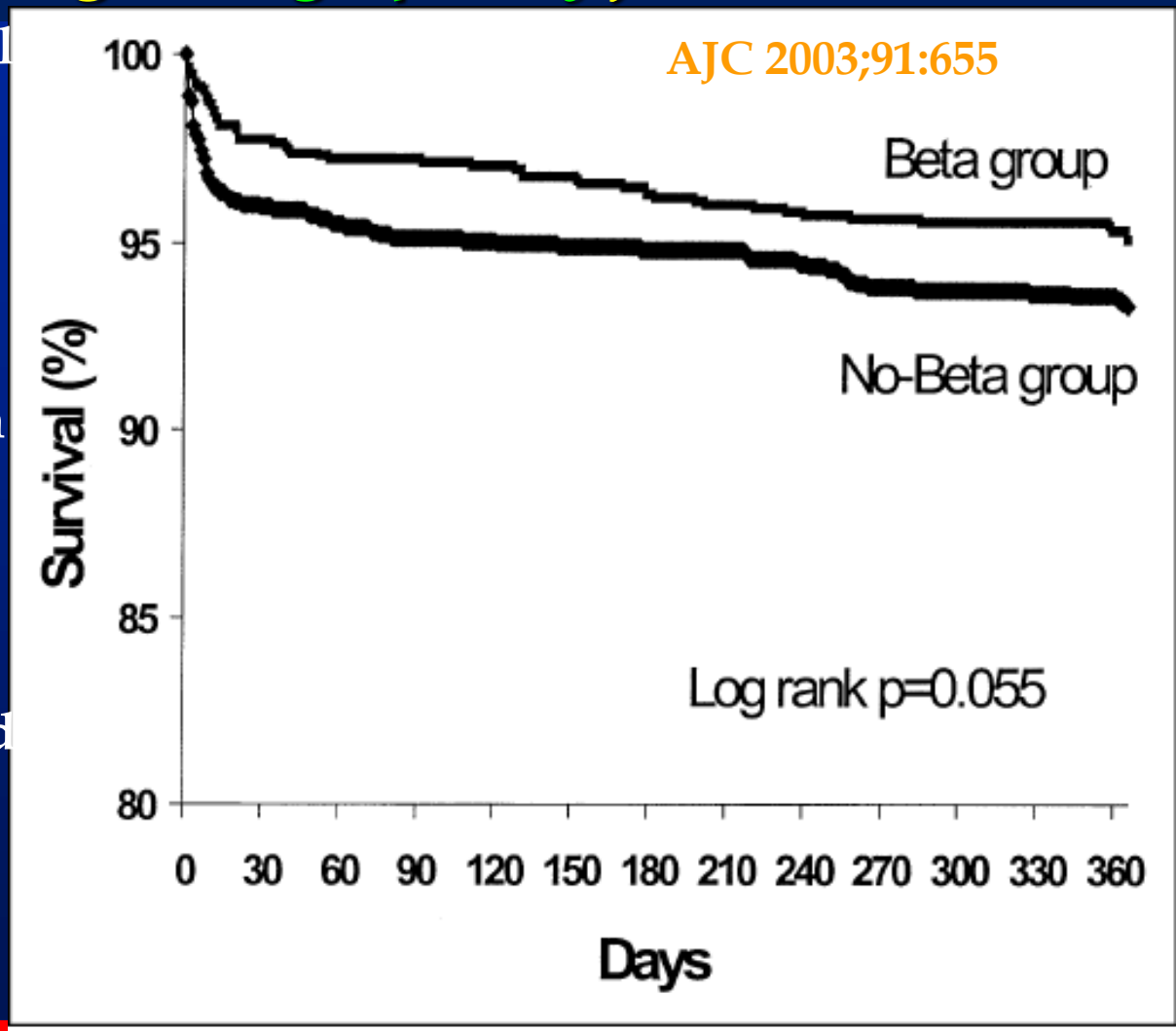
Antiarrhythmic Experience After Cardiac Arrest



Hallstrom AP. Am J Cardiol. 1991;68:1025-1031.

pretreatment with β-blockers has an independent beneficial effect on short-term clinical outcomes in pts undergoing 1º angioplasty for acute MI

- β-group had less procedural **complications** (23% vs 34%, p<0.0001) &
- a lower incidence of **death** (1.8% vs 3.7%, p = 0.0035) &
- **MACE**(5.5% vs 7.8%, p = 0.027) during hospitalization
- At 1 year, **mortality** remained lower in pts (4.9% vs 6.7%, log-rank p = 0.055)
- After adjustment for baseline differences, pts had signif. lower **inhospital mortality** (odds ratio 0.41; p <0.0148) &
- Nonsignificantly lower 1-year mortality (odds ratio 0.72; p = 0.11)



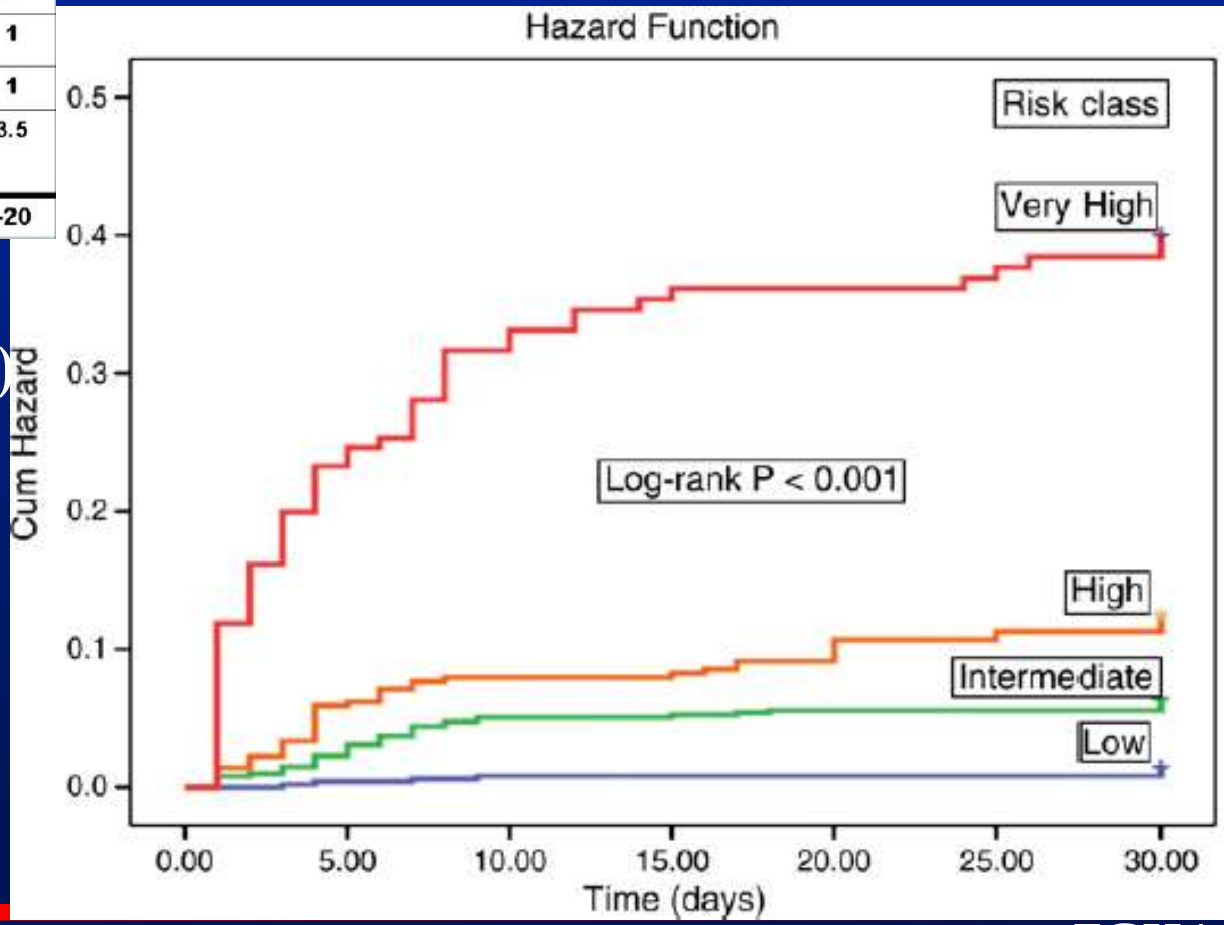
Survival curves in β and no- β patients

EGHA

Predicting 30-day MACE after primary PCI
The RISK-PCI score

A. Risk factor	Points	Risk factor	Points
Age >75 years	1	Creatinine Clearence * ≥ 90 ml/min 60-89 ml/min < 60 ml/min	0 1 2
Prior infarction	1.5		
Anterior infarction	1		
Complete AV block *	2	LV ejection fraction <40%	1.5
Acute BBB*	3.5	Referen. diameter ≤25 mm	1
Leukocyte * >12.0 $^{10\text{-}9/L}$	1	Pre-procedural TIMI flow 0	1
Glucose * ≥6.6 mmol/L	1	Post-procedural TIMI flow <3	3.5
at admission	*	TOTAL SCORE	0-20

- low (0–2.5 points),
- intermediate (3–4.5 points),
- high (5–6.5 points) &
- very high (≥7 points) risk classes



Mrdovic et al, Int J Cardiol (2011)

ASM

Achieving rapid reperfusion with primary PCI remains a challenge

- Time & speed to reperfusion time is a standard metric for performance in pts with STEMI
- This standard includes door to baloon time of ≤90 min
- There is continued need for quality improvement initiatives in AMI
- However, **primary PCI** is preferable for certain pts even if the "door-to-balloon" interval exceeds 90 min
- Such pts include among others (contraindication to fibrinolytic therapy/high risk of bleeding with fibrinolysis, incl. pts ≥75 years of age, HF, c. shock)
- and those with **electrical instability (SuVT/VF)**

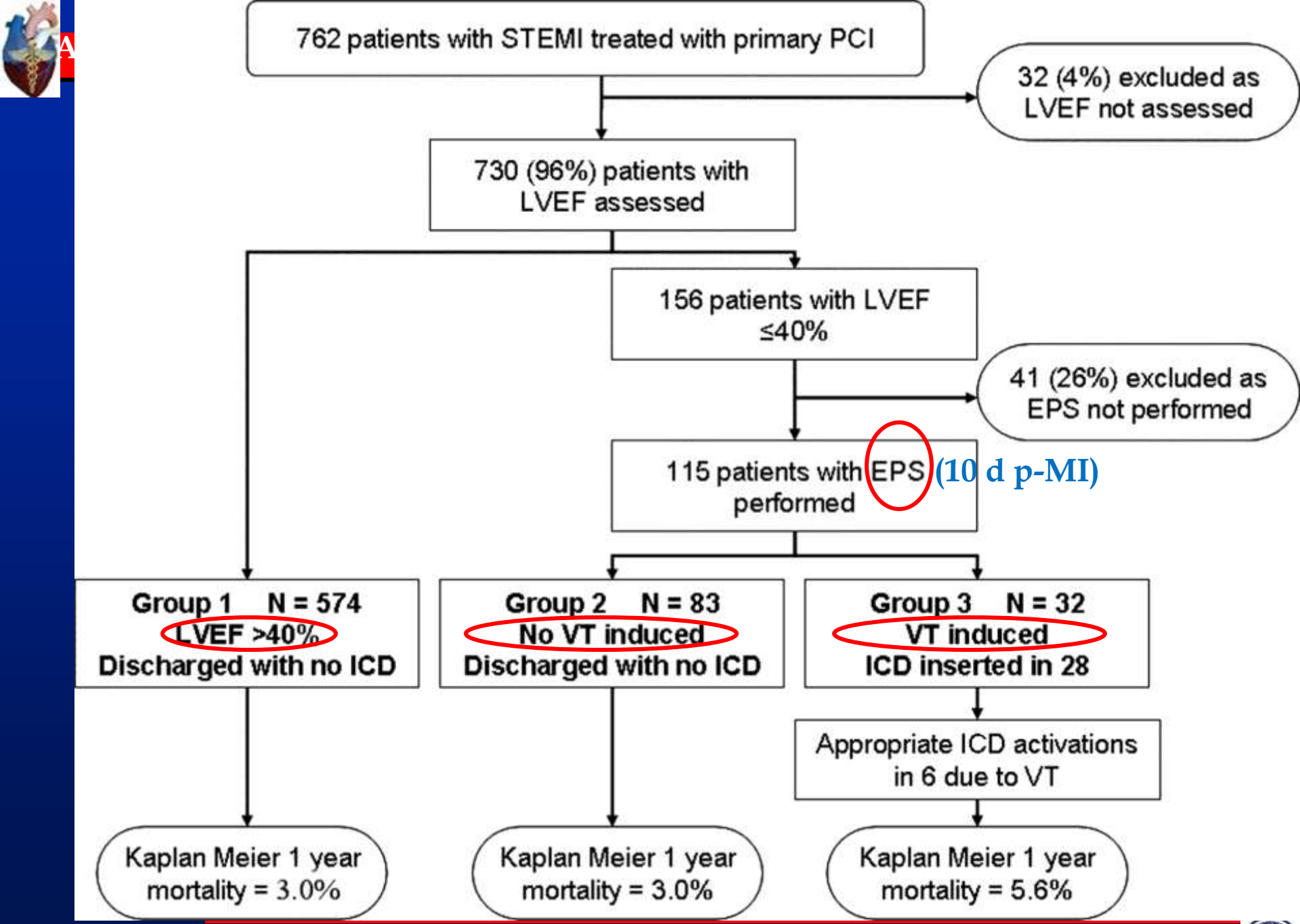
EGHA

Outcomes of Early Risk Stratification & Targeted ICD Implantation After STEMI Treated With Primary PCI (Zaman et al, Circ July 21, 2009)

Background

- **DINAMIT**: ICD use in 674 pts within 4-40 d after MI /optimal medical Rx / LVEF ≤35% /markers of autonomic dysfunction
- **Only 27%** of pts were treated with **PCI** (mean EF 28%)
- Although ↓LVEF and low HRV identify pts with ↑mortality risk, the trial did not identify any benefits from the use of ICD
- **IRIS**: 900 high-risk pts within 1 month of an MI c LVEF <40%
- **Primary PCI** was used in **72%** (mean EF 35%)
- Although the ICD group had a signif. ↓ in arrhythmic MR, this was offset by an ↑ in nonarrhythmic death, similar to DINAMIT
- **BEST-ICD**: PVS in pts at high risk of SCD within first month p-STEMI, randomizing 143 pts on optimal medical Rx to ICD
- Although a trend favored PVS-guided ICD therapy, no survival benefit was found in this trial / **PCI: 15-25%**/EF:31%

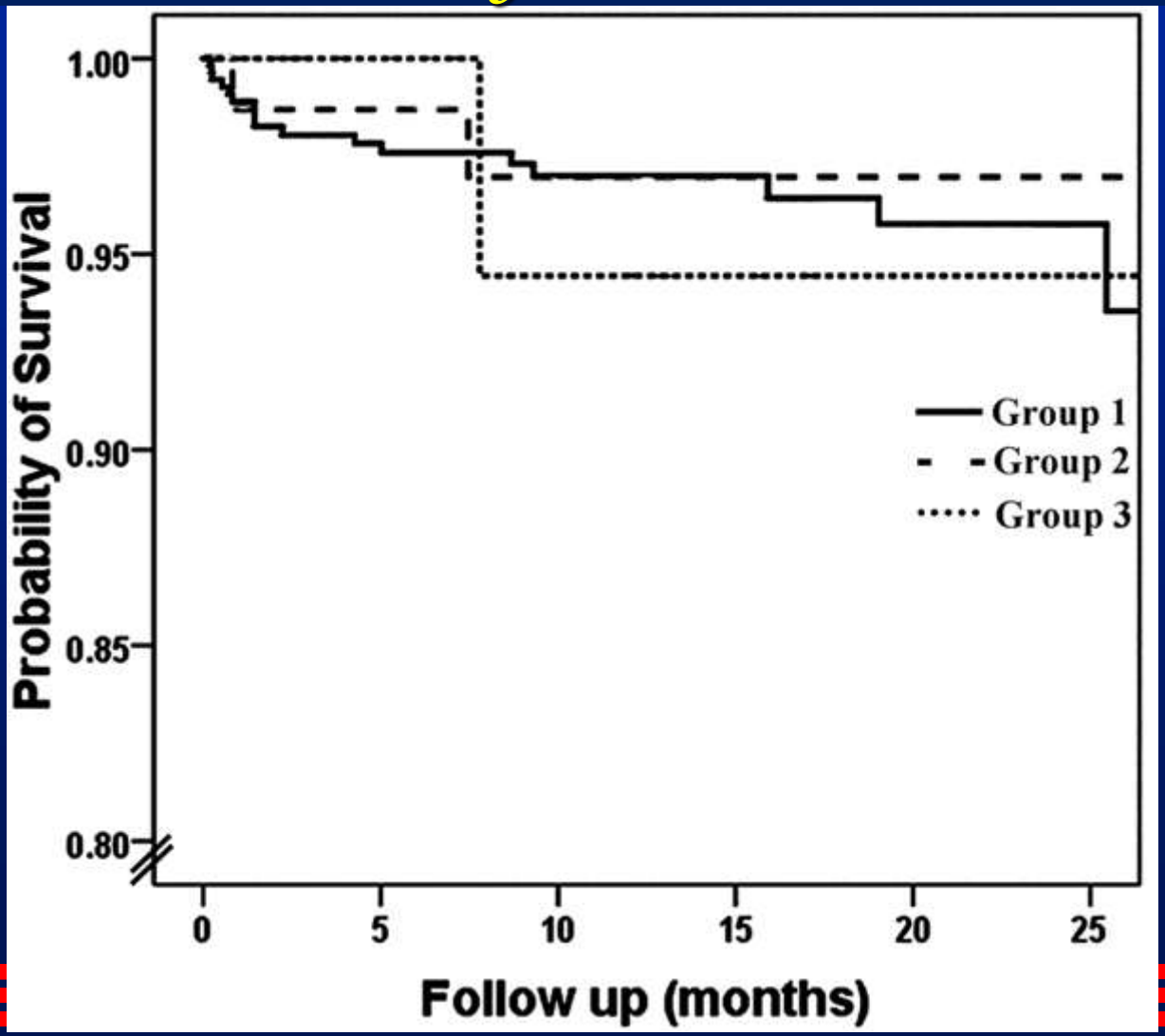
EGHA


762 patients with STEMI treated with primary PCI
32 (4%) excluded as LVEF not assessed
730 (96%) patients with LVEF assessed
156 patients with LVEF ≤40%
41 (26%) excluded as EPS not performed
115 patients with EPS performed
(10 d p-MI)
Group 1 N = 574
LVEF >40%
Discharged with no ICD
Group 2 N = 83
No VT induced
Discharged with no ICD
Group 3 N = 32
VT induced
ICD inserted in 28
Appropriate ICD activations in 6 due to VT
Kaplan Meier 1 year mortality = 3.0%
Kaplan Meier 1 year mortality = 3.0%
Kaplan Meier 1 year mortality = 5.6%

Outcomes of Early Risk Stratification and Targeted ICD Implantation After STEMI Treated With Primary PCI

	Group 1 (n=574)	Group 2 (n=83)	Group 3 (n=32)	*P*
Infarct-related artery, n (%)				<0.001
Left anterior descending	197 (34)	70 (84)	24 (75)	
Right coronary	271 (47)	5 (6)	4 (13)	
Circumflex	81 (14)	6 (7)	3 (9)	
Other	25 (4)	2 (2)	1 (3)	
STEMI therapy, n (%)				0.372
PTCA only	24 (4)	0	0	
PTCA and stent	519 (90)	79 (95)	30 (94)	
Medical management	26 (5)	2 (2)	1 (3)	
PTCA and CABG	5 (1)	0 (0)	1 (3)	
Symptom-to-reperfusion time, median (interquartile range), min	220 (168–330)	258 (185–329)	287 (195–380)	0.036
LVEF, mean±SD, %	54±8	32±6†	29±7†	0.032†
Median hospital stay (interquartile range), d	5 (4–7)	9 (7–13)	16 (10–23)	<0.001

Outcomes of Early Risk Stratification & Targeted ICD Implantation After STEMI Treated With Primary PCI



Circulation July 21, 2009

EGHA

Spontaneous ICD Activation in Group 3

Patient	LVEF, %	ICD Implantation to First Activation, mo	VT CL, ms
1	12	6	340
2	20	15	350
3	24	2	310
4	27	8	350
5	31	5	520
6	33	30	320
Mean±SD	25±8	11±10	365±78

Circulation July 21, 2009

Cause of Death by Group

Deaths	Group 1 (n=574), n	Group 2 (n=83), n	Group 3 (n=32), n
Total	17	2	1
Cardiac, arrhythmic	1	0	0
Cardiac, nonarrhythmic	8	2	1
Noncardiac	8	0	0

In contrast to prior studies in pts with recent MI, in which a minority of pts had PCI, this study had 95% of pts revascularized with 1º PCI

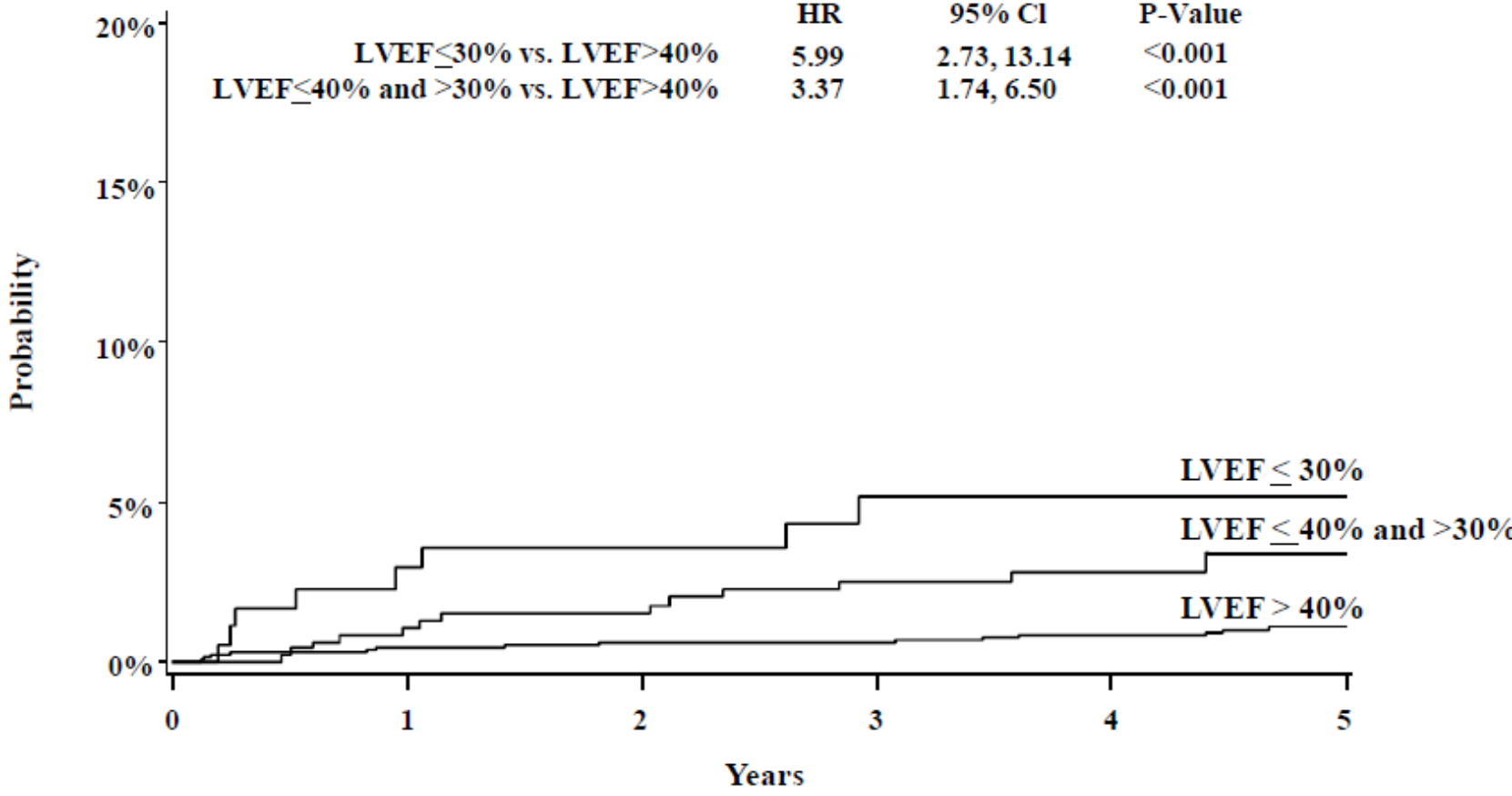
Conclusion

Use of LVEF assessment & EPS for risk stratification soon after primary PCI for MI, with ICD implantation limited to those with inducible VT, produces a uni-formly low mortality on FU, including those pts with low LVEF

5-year SCD in post-MI survivors with LVEF>40%, LVEF<40% & >30%, & LVEF<30%

4,122 pts with AMI: 77.8% had 1º PCI

HIJAMI II, Heart 2009, 95:216



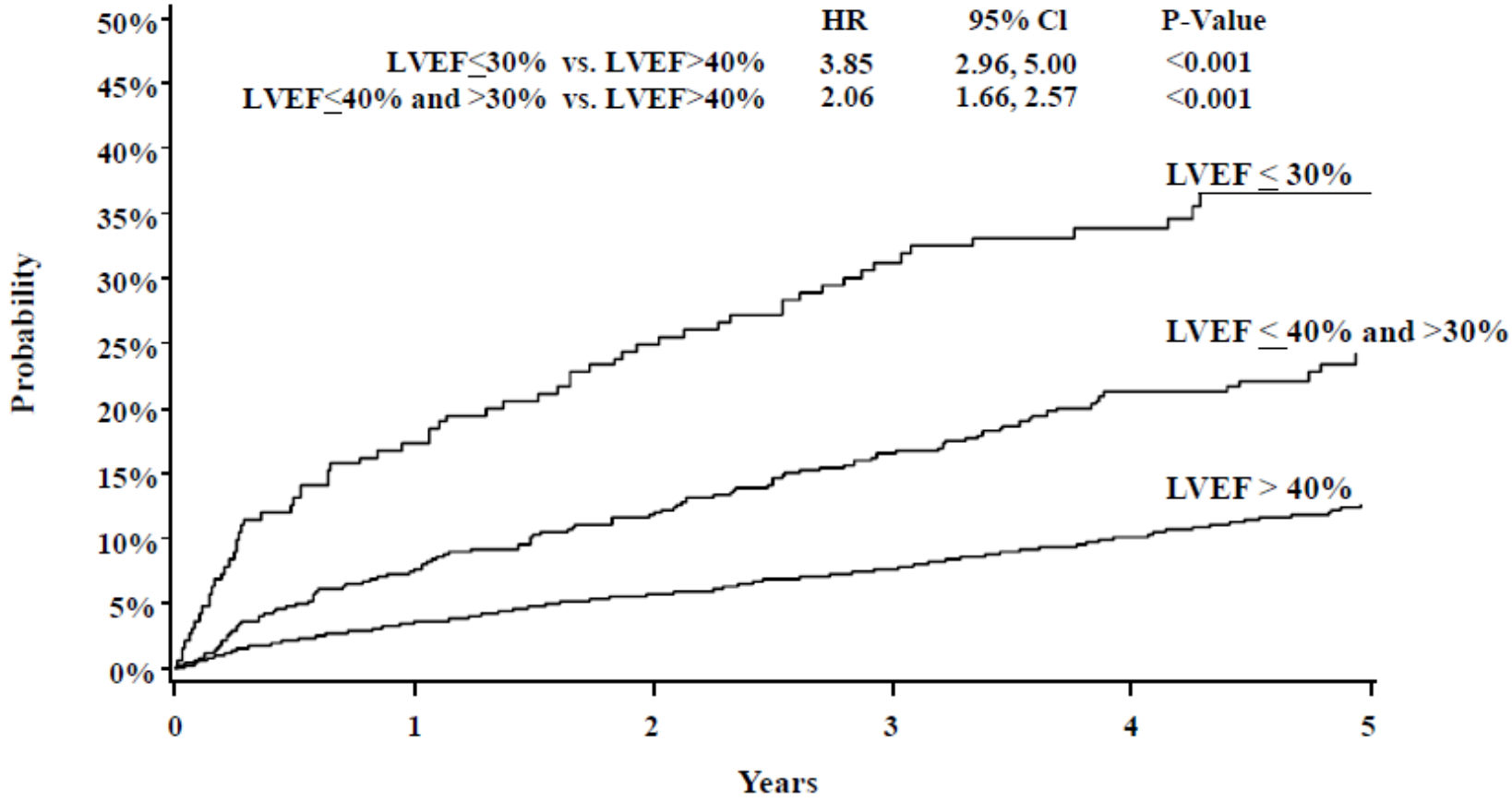
No. at risk

LVEF ≤ 30%	199	154	133	118	79	32
LVEF ≤ 40% and >30%	507	445	409	374	242	87
LVEF > 40%	3416	3136	3007	2814	1993	717

5-year mortality in post-MI survivors with LVEF>40%, LVEF<40% & >30%, & LVEF<30%

4,122 pts with AMI: 77.8% had 1º PCI

HIJAMI II, Heart 2009, 95:216



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LVEF ≤ 40% and >30%	507	445	409	374	242	87
LVEF > 40%	3416	3136	3007	2814	1993	717

SCD in the era of 1º PCI

- 4,122 pts (66±12 y) with AMI, 77.8% had PCI & 3.7% CABG
- 3 gps: EF>40% (n=3416), EF<40% & >30% (n=507) & EF<30% (n=199) / *17.1% had EF ≤40% & only 4.8% had EF ≤30%*
- At 4.1 y, SCD was 1.2% & mortality was 13.1%
- Pts with EF<30% & EF<40% and >30% were at ↑ risk for SCD (HR 5.99, P<0.001, HR 3.37, P<0.001, resp.), & mortality (HR 3.85, P<0.001, HR 1.66, P<0.001, resp.) c/w pts with LVEF>40%
- Kaplan-Meier estimates of SCD in pts with LVEF<30% were 2.9%, 5.1% and 5.1% at 1, 3 and 5 years, respectively
- Although LVEF is a predictor of ↑ risk for SCD,
- there is a low incidence of SCD in p-MI survivors in the 1º PCI era
- Use of the ICD makes only a minor contribution to decreasing the overall mortality in MI survivors with low LVEF

HIJAMI II, Heart 2009, 95:216

SCD in the era of 1ο PCI

- Σε άλλη μελέτη 1ο PCI (Zwolle MI Study) (AJC 2007;100:793)
- ΚΕ ≤30% παρατηρήθηκε σε ποσοστό 13.4% μεταξύ 2544 ασθενών με STEMI που υποβλήθηκαν σε 1ο PCI
- Επήλθαν μόνον 8 αιφνίδιοι θάνατοι (ποσοστό 2.3%) τον πρώτο χρόνο μεταξύ 342 ασθενών που είχαν ΚΕ≤30%.
- Σε άλλη ιαπωνική μελέτη (Circ J 2005;69:19) παρατηρήθηκαν μόνον 2 SCD σε 37 μήνες μεταξύ 99 ασθενών με ΕΜ & ΚΕ≤30% που είχαν υποβληθεί κατά κύριο λόγο (77%) σε 1ο PCI (10% είχαν υποβληθεί σε "bypass")
- Τα αποτελέσματα αυτά δίνουν έμφαση στη σημασία που έχει η βέλτιστη επαναγγείωση στη μείωση του αιφνιδίου θανάτου

ASM

SCD in the era of 1ο PCI

- 1ο PCI στο οξύ ΕΜ παίζει κεντρικό ρόλο στη βέλτιστη αντιμετώπιση του ΕΜ, ↓ το μέγεθος του ΕΜ και ελαχιστοποιώντας τη μυοκαρδιακή βλάβη, διατηρώντας τη λειτουργία της ΑΚ και ↓ τη νοσηρότητα & θνητότητα του ΕΜ
- Ωστόσο, η ↓ του SCD μετά την επιτυχή 1ο PCI είναι πολυπαραγοντιακής αιτιολογίας
- Κατ'αρχήν ↓ η πιθανότητα αναδιαμόρφωσης και επομένως η δημιουργία αρρυθμιολογικού υποστρώματος
- Η πρώϊμη επαναγγείωση βελτιώνει τη λειτουργία της ΑΚ & ↓ το μέγεθος του ΕΜ όψιμα μετά το οξύ ΕΜ, & αυτή η βελτίωση συνοδεύεται απο καλυτερη επιβίωση και άρα ↓ του SCD
- Τέλος, η επαναγγείωση βελτιώνει τη στεφανιαία κυκλοφορία και ↓ τα ισχαιμικά επεισόδια, επομένως ↓ την πιθανότητα πυροδότησης αρρυθμικών επεισοδίων και ενεργοποίησης των νευρο-ορμονικών συστημάτων

EGHA

Χαμηλή η Επίπτωση ΑΚΘ στην Εποχή της 1ο PCI

- ↓ των αρρυθμικών θανάτων σε χαμηλά ΚΕ μετά την 1ο PCI , σημαίνει επίσης πως η πλειονότητα των θανάτων σε αυτές τις ομάδες είναι μη-αρρυθμικής αιτιολογίας και επομένως και η προστασία απο τον ICD αμφίβολη
- Η διαστρωμάτωση του κινδύνου και σε αυτές τις περιπτώσεις παραμένει προβληματική με χρήση μόνου του χαμηλού ΚΕ
- Ακόμη και η μελέτη MADIT II έδειξε πως το κύριο όφελος απο τον ICD παρατηρήθηκε μετά τους πρώτους 6 μήνες απο το ΕΜ
- Εντός των πρώτων 6 μηνών μετά το ΕΜ παρατηρείται σημαντική βελτίωση στη λειτουργία της ΑΚ και ↓ του μεγέθους του ΕΜ μετά την επαναγγείωση
- Σε αυτές τις περιπτώσεις φαίνεται πως είναι πιο συνετό να επανεκτιμηθεί το ΚΕ μετά τους 6 μήνες απο το ΕΜ και την επαναγγείωση και τότε να ληφθούν οι αποφάσεις για την ανάγκη εμφύτευσης του ICD

EGHA

Χαμηλή η Επίπτωση ΑΚΘ στην Εποχή της 1ο PCI

- Προς το παρόν οι οδηγίες θέτουν σαν όριο τις πρώτες 40 ημ μετά το ΕΜ, σαν κατάλληλο χρόνο για τη διαστρωμάτωση του κινδύνου για πιθανή εμφύτευση του ICD
- καθ'όσον η μελέτη DINAMIT έδειξε πως ο ICD δεν οφελεί και μάλλον οδηγεί σε ↑ της συνολικής θνητότητας τις πρώτες 4-6 εβδομάδες μετά το ΕΜ
- Παρόμοια μάλιστα αποτελέσματα είχε και η μελέτη IRIS
- Ωστόσο, και στις δύο αυτές μελέτες δεν μελετήθηκε η επίδραση της 1ο PCI στο οξύ ΕΜ
- Παρ'όλο που το χαμηλό ΚΕ φαίνεται να προοιωνίζεται ↑ διαχρονικό κίνδυνο, η επίπτωση του SCD στην εποχή της 1ο PCI είναι σημαντικά ↓ και ο ρόλος του ICD αποδυναμωμένος
- **Targeted ICD implantation after STEMI treated with 1ο PCI / Early ICD implantation limited to pts with inducible VT**

(Zaman et al, Circ July 21, 2009)

Thank you
for your attention

Ευχαριστώ για την προσοχή σας