# VT/VF During Primary PCI

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A variety of arrhythmias and conduction disturbances may occur; as sign of reperfusion, as complication of the intervention or as complication of acute MI in patients undergoing primary PCI

Serious ventricular arrhythmias have been reported up to occur in 5% of the patients undergoing PCI, and in 30% of the patients undergoing primary PCI

Gorenek J Electrocardiol 2006

## Sustained VT and VF, Risk Factors and Predictors

### Role of contrast agents

The risk of ventricular arrhythmias from intracoronary dye is greater with the injection of ionic (high osmolar) contrast agents into the right coronary artery, particularly in the setting of prolonged injection or a damped pressure tracing

VF may occur if dye is allowed to remain static in the coronary tree

Gorenek et al, Acute Cardiac Care, 2007

**Independent Predictors of Sustained Ventricular Arrhythmias**

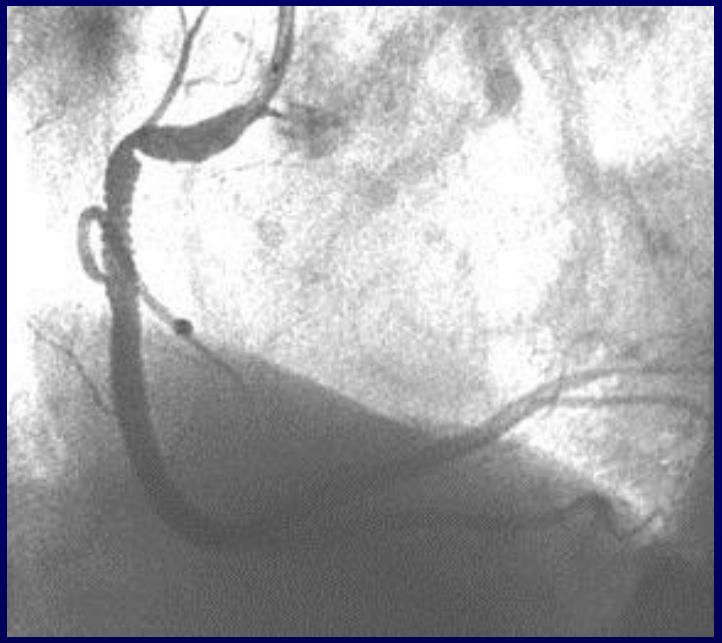
| Predictor Variable | OR | p-Value | 95% CI |
|---|---|---|---|
| Use of low-osmolar ionic agents vs | | | |
| Nonionic agents | 2.6 | 0.02 | 1.1–5.9 |
| High-osmolar ionic agents | 5.1 | 0.01 | 1.5–17.9 |
| History of ventricular arrhythmias | 7.8 | <0.001 | 3.9–15.8 |
| Angiography within 24 hr of AMI | 3.5 | 0.001 | 1.6–7.6 |

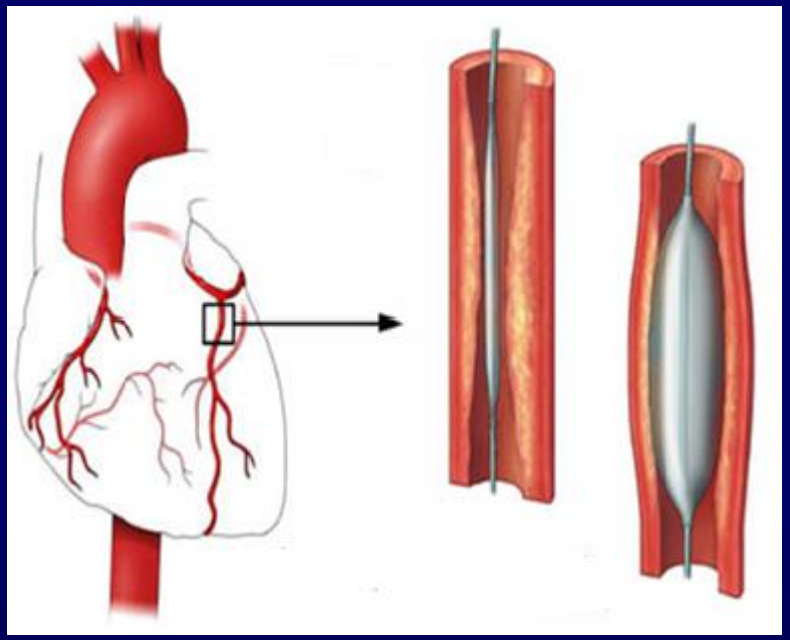
CI = confidence interval.

Nonionic agents in diagnostic coronary angiography may be associated with an increased risk of sustained ventricular arrhythmias

Nonionic contrast agents should be prefered during acute MI, especially in high risk patients to decrease the risk of serious ventricular arrhythmias

Hajj-Ali et al, Am J Cardiol, 2001 (TCT abstracts)





VF may occur with guide catheter wedging or prolonged balloon inflations

Gorenek et al, Acute Cardiac Care, 2007

# Presence of Heart Failure

**TABLE 4** Outcomes of Percutaneous Intervention by Killip Class

| | Class I (n = 2,305) | Class II (n = 302) | Class III (n = 47) | p Value |
|---|---|---|---|---|
| PCI attempted (%) | 89 | 88 | 82 | NS |
| Success (%)* | 97 | 95 | 96 | NS |
| TIMI 3 flow (%) | 93 | 90 | 94 | NS |
| Final stenosis (%) | 15 ± 17 | 18 ± 20 | 15 ± 20 | NS |
| No. of stents† | 1.4 ± 0.7 | 1.6 ± 0.8 | 1.4 ± 0.7 | NS |
| Peak CK | 2,012 ± 1,975 | 2,579 ± 2,719 | 2,913 ± 2,634 | 0.0001 |
| IABP (%)‡ | 3 | 13 | 36 | 0.001 |
| Renal failure§ (%) | 1 | 2 | 33 | <0.001 |
| Arrhythmia‖ (%) | 6 | 13 | 13 | 0.001 |
| Major bleed¶ (%) | 8 | 12 | 24 | 0.001 |
| Length of stay (d) | 6.2 ± 5.3 | 8.2 ± 78.0 | 10.8 ± 11.5 | 0.0001 |
| In-hospital (%) | | | | |
| Stroke | 0.6 | 0.8 | 2 | NS |
| Reinfarction | 1 | 4 | 5 | 0.001 |
| CABG | 4 | 6 | 6 | NS |
| Death (%) | | | | |
| In-hospital | 2.4 | 7.0 | 19.2 | 0.001 |
| 6 mo | 4.0 | 10 | 28 | 0.001 |

*Success defined as <50% residual stenosis and more than or equal to TIMI 2 flow.
†A total of 680 patients received stents.
‡Does not include PAMI 2 patients randomized to prophylactic IABP insertion.
§Requiring transient or permanent dialysis.
‖Brady- or tachycardia requiring pharmacologic therapy or temporary/permanent pacemaker insertion.
¶Requiring blood transfusion.
CK = creatinine kinase; IABP = intra-aortic balloon pulsation; other abbreviations as in Table 1.

Killip classification predicts the incidence of arrhythmias in patients undergoing PCI for acute MI

De Geare et al ,Am J Cardiol, 2001

# Importance of Vessel Diameter

Baseline characteristics and electrophysiological data of study patients

| | Gr I (Vf)-RCA | Gr II (RCA) | *P* value |
|---|---|---|---|
| Number | 16 | 51 | |
| Sex (M/F) | 15/1 | 48/3 | |
| Age (years) | 71±8 | 70±9 | 0.38 |
| MI | 5/16 (31..2%) | 15/51 (29.4%) | 0.26 |
| CAD | 1.8±0.7 | 1.9±0.8 | 0.5 |
| RCA total occlusion | 5/16 | 14/51 | 0.14 |
| Coronary risk factors | | | |
| Smoking | 11/16 (68.7%) | 29/51 (56.8%) | 0.51 |
| Hypertension | 9/16 (56.2%) | 31/51 (60.7%) | 0.42 |
| DM | 8/16 (50.0%) | 20/51 (39.2%) | 0.09 |
| Hyperlipidemia | 6/16 (37.5%) | 14/51 (27.4%) | 0.06 |
| LVEF (%) | 40.5±5.9 | 41.2±7.4 | 0.09 |
| RCA-0 (mm) | 2.7±0.8 | 4.1±1.2 | <0.001 |
| LCA-0 (mm) | 5.2±1.2 | 5.4±1.6 | 0.18 |
| QT dispersion (ms) | 66.3±20.5 | 69.3±17.5 | 0.24 |
| ST change | 11/16 (68.7%) | 5/51 (9.8%) | 0.01 |
| BUN (mg/dl) | 19.8±9.1 | 22.4±14.9 | 0.26 |
| Cr (mg/dl) | 1.1±0.4 | 1.3±0.7 | 0.3 |
| Na (mmol/l) | 140.4±2.9 | 140.1±2.2 | 0.6 |
| K (mmol/l) | 4.2±0.6 | 4.3±0.3 | 0.7 |
| ASA | 16/16 (100%) | 50/51 (98%) | 0.6 |
| Nitrate | 16/16 (100%) | 48/51 (94.1%) | 0.5 |
| Ca-antagonist | 6/16 (37.5%) | 15/51 (29.4%) | 0.11 |
| ACEI | 11/16 (68.7%) | 27/51 (52.3%) | 0.24 |

In patients with small caliber of RCA associated ST segment changes, the risk of VF was higher during PCI

Huang et al, Int J Cardiol, 2002

# QT Dispersion

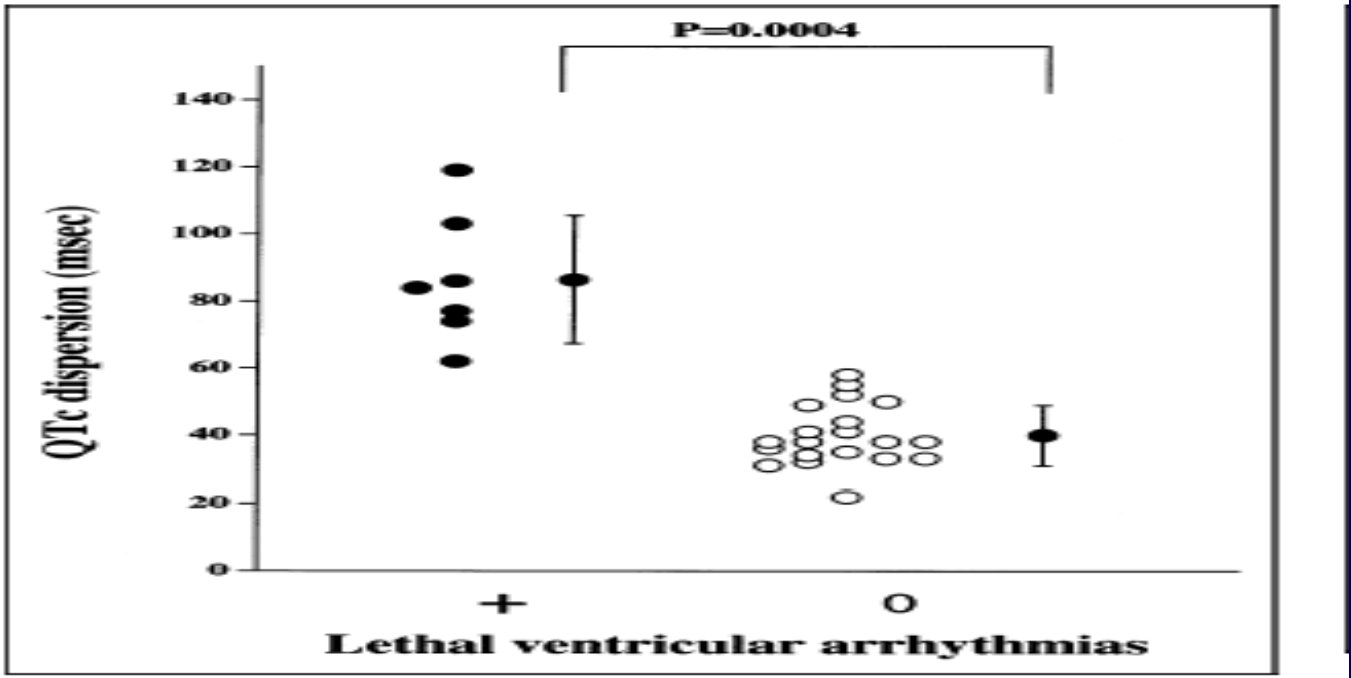


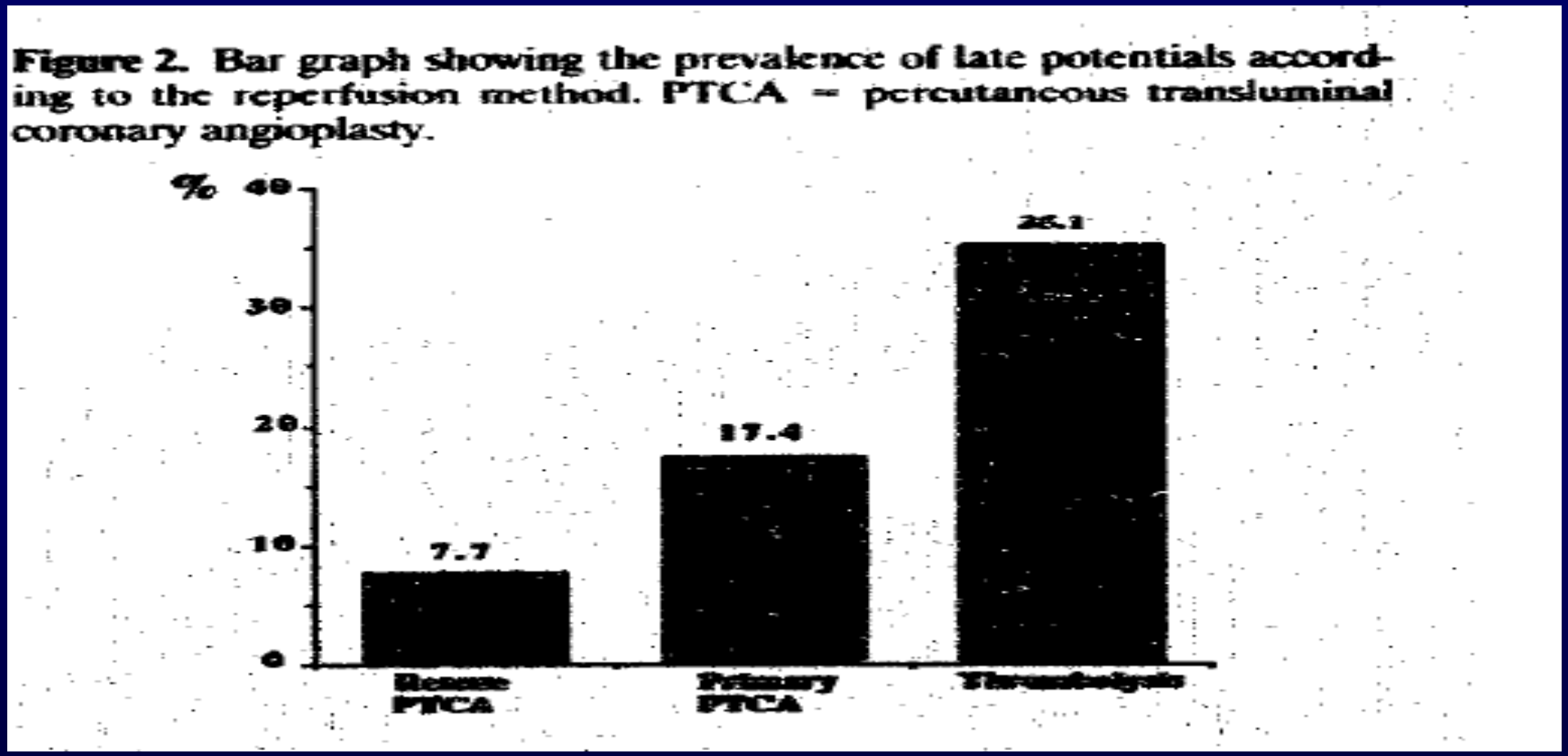

FIGURE 1. $QT_c$ dispersion in patients with *(closed circle)* and without *(open circle)* lethal ventricular arrhythmias complicating angioplasty before angioplasty.

Increased $QT_C$ dispersion may predict the risk for lethal ventricular arrhythmias during PCI

*The fact that successful angioplasty decreased $QT_C$ dispersion indicates that a part of increased $QT_C$ dispersion is related to myocardial ischemia in patients with coronary artery disease*

Ashikaga et al, J Am Coll Cardiol,1998

# Late Potantials in SAECG & PCI




Primary PCI reduces the prevelance of LP more than thorombolytic agents do.The reduction is more prounced in rescue PCI

Karam C et al, J Am Coll Cardiol, 1996

# Infarct Location

| | Ventricular fibrillation | | *p*-Value |
|---|---|---|---|
| | Before PCI | During PCI | |
| | (*n*=145) (5%) | (*n*=74) (3%) | |
| Male (%) | 120 (83) | 52 (70) | 0.03 |
| Age >60 years | 65 (45) | 44 (59) | 0.04 |
| Anterior infarction (%) | 96 (66) | 29 (39) | <0.001 |
| Previous coronary event (%) | 19 (13) | 13 (18) | 0.38 |
| Family history (%) | 57 (39) | 25 (34) | 0.42 |
| Hypertension (%) | 29 (20) | 18 (24) | 0.46 |
| Diabetes (%) | 10 (7) | 9 (12) | 0.19 |
| Hypercholesterolaemia (%) | 25 (17) | 10 (13) | 0.48 |
| Smoking (%) | 71 (49) | 37 (50) | 0.88 |
| Killip >1(%) | 35 (24) | 9 (12) | 0.04 |
| Preinfarction angina (%)[a] | 32 (27) | 28 (47) | 0.009 |

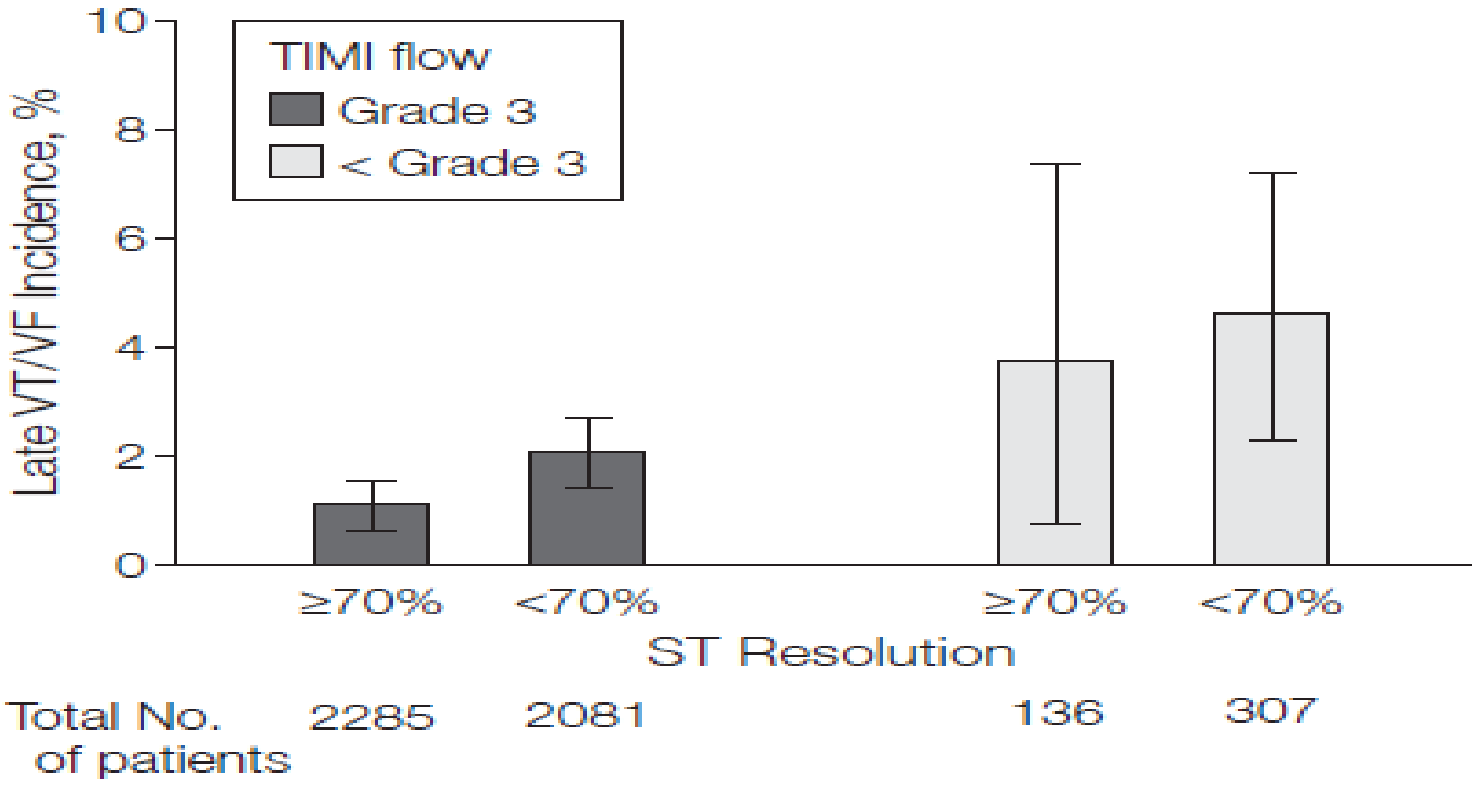
Characteristics of the patients who had VF before PCI and during PCI

Infarct location was a major determinant of timing of VF, anterior infarction had greater risk for VF before PCI

Henriques et al, Int J Cardiol, 2005

# TIMI Flow and ST Resolution

**Figure 1.** Postprocedural TIMI Flow and ST Resolution and Incidence of Late VT/VF




TIMI indicates thrombolysis in myocardial infarction; VT/VF, ventricular tachycardia or fibrillation. Error bars indicate 95% CIs.

Mehta RH et al, JAMA, 2009

# Infarct Size

European Heart Journal (2009) **30**, 757–764
doi:10.1093/eurheartj/ehp005

**CLINICAL RESEARCH**
*Coronary heart disease*

## Reperfusion ventricular arrhythmia 'bursts' predict larger infarct size despite TIMI 3 flow restoration with primary angioplasty for anterior ST-elevation myocardial infarction

**Mohamed Majidi[1,2], Andrzej S. Kosinski[1,3], Sana M. Al-Khatib[1,4], Miguel E. Lemmert[2], Lilian Smolders[2], Anton van Weert[5], Johan H.C. Reiber[5,6], Dan Tzivoni[7], Frits W.H.M. Bär[2], Hein J.J. Wellens[8], Anton P.M. Gorgels[2,8], and Mitchell W. Krucoff[1,4]***

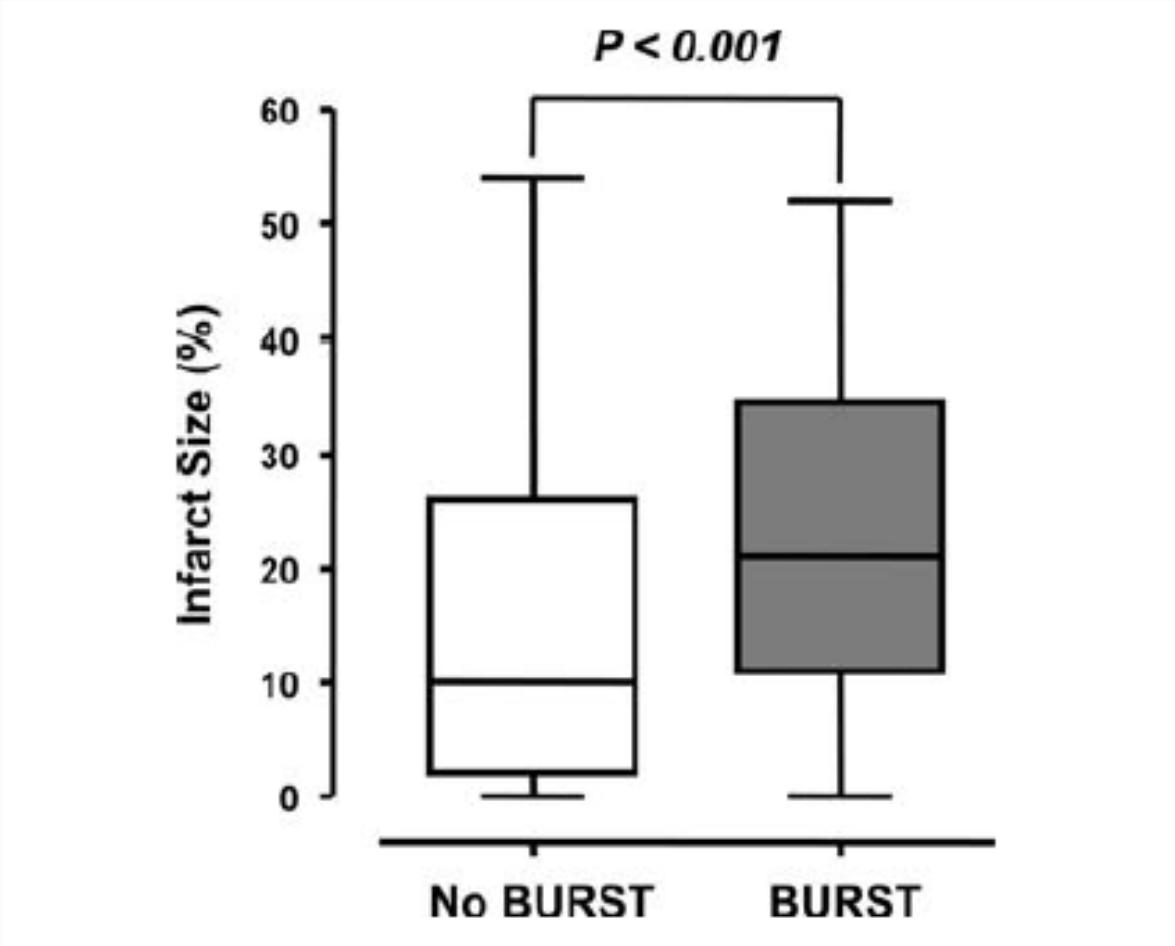



**Figure 3** Box plot presenting the correlation of presence or absence of reperfusion ventricular arrhythmia bursts ('BURST' vs. 'no BURST') with Day 7/discharge myocardial infarct size as measured by single-photon emission computed tomography.

# Hypertension&Diabetes Mellitus

| Variable | VF | | p Value |
|---|---|---|---|
| | No (n = 19,333) | Yes (n = 164) | |
| Men | 13,110 (68%) | 101 (62%) | 0.08 |
| Age (yrs) | | | |
| <65 | 9,326 (48%) | 66 (40%) | 0.11 |
| 65–75 | 6,395 (33%) | 61 (37%) | |
| >75 | 3,562 (19%) | 37 (23%) | |
| Creatinine >1.5 mg/dl | 1477 (8%) | 3 (2%) | 0.002 |
| Previous myocardial infarct | 6,979 (36%) | 55 (34%) | 0.50 |
| Previous coronary bypass | 4,294 (22%) | 20 (12%) | 0.002 |
| Diabetes mellitus | 5,362 (28%) | 24 (15%) | <0.001 |
| Ejection fraction <40% | 2,127 (15%) | 19 (12%) | 0.18 |
| Hypertension | 8,277 (43%) | 124 (76%) | <0.001 |
| Ionic contrast | 11,555 (60%) | 109 (66%) | 0.08 |

Patients developing VF during PCI were more likely to have a history of hypertension and DM

Addala et al, Am J Cardiol, 2005

# Independent Risk Predictors

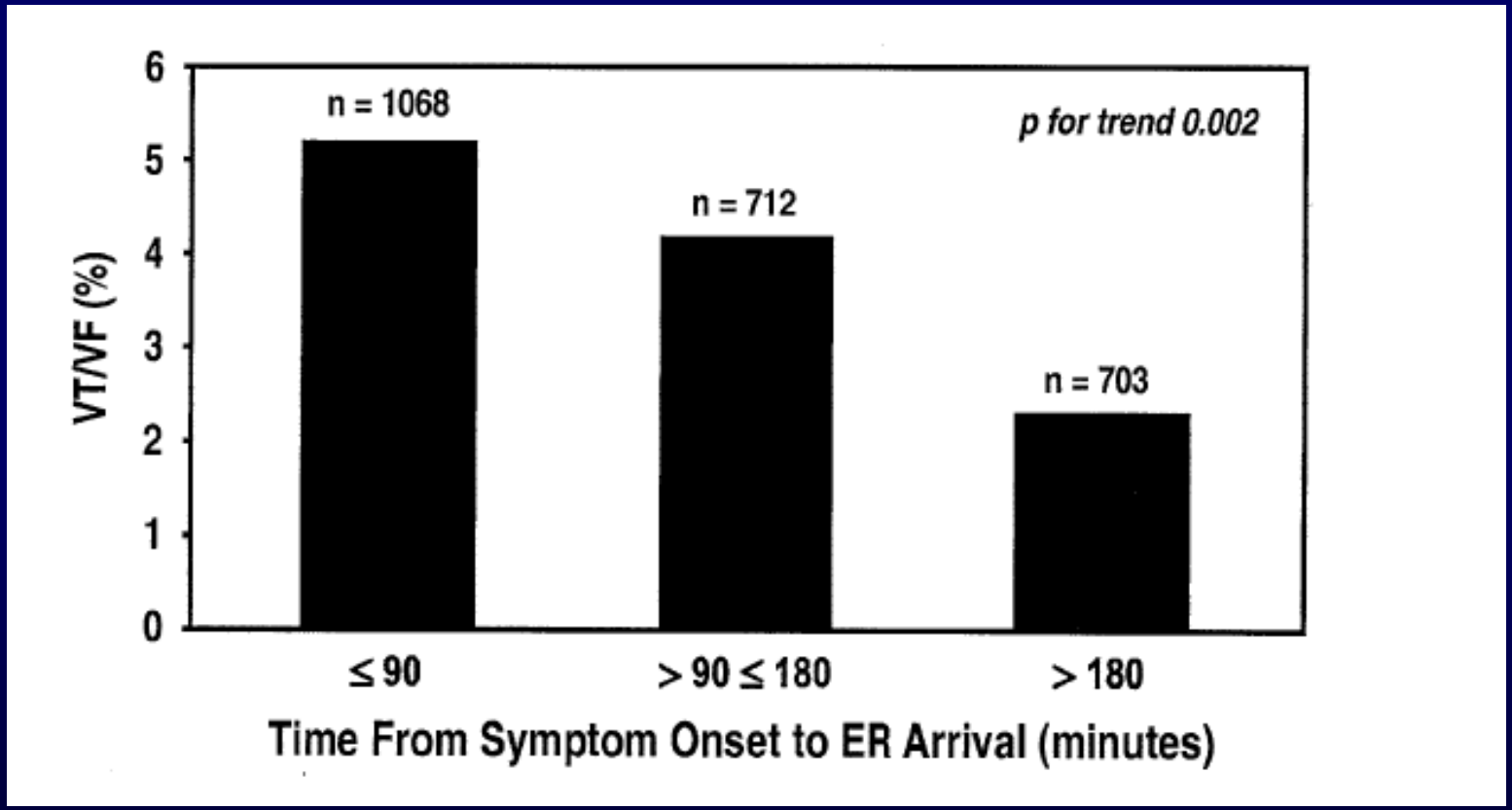
**Table 4.** Adjusted Odds Ratios of Clinical Variables Associated With the Risk of Ventricular Tachycardia or Fibrillation During Primary Percutaneous Coronary Intervention

| 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 |

Smoking, lock of beta blocker administration in ER, RCA as IRA, presence of initial TIMI grade O flow and timing of PCI were the independent risks for VT/VF during PCI

Mehta et al, Am Coll Cardiol, 2004

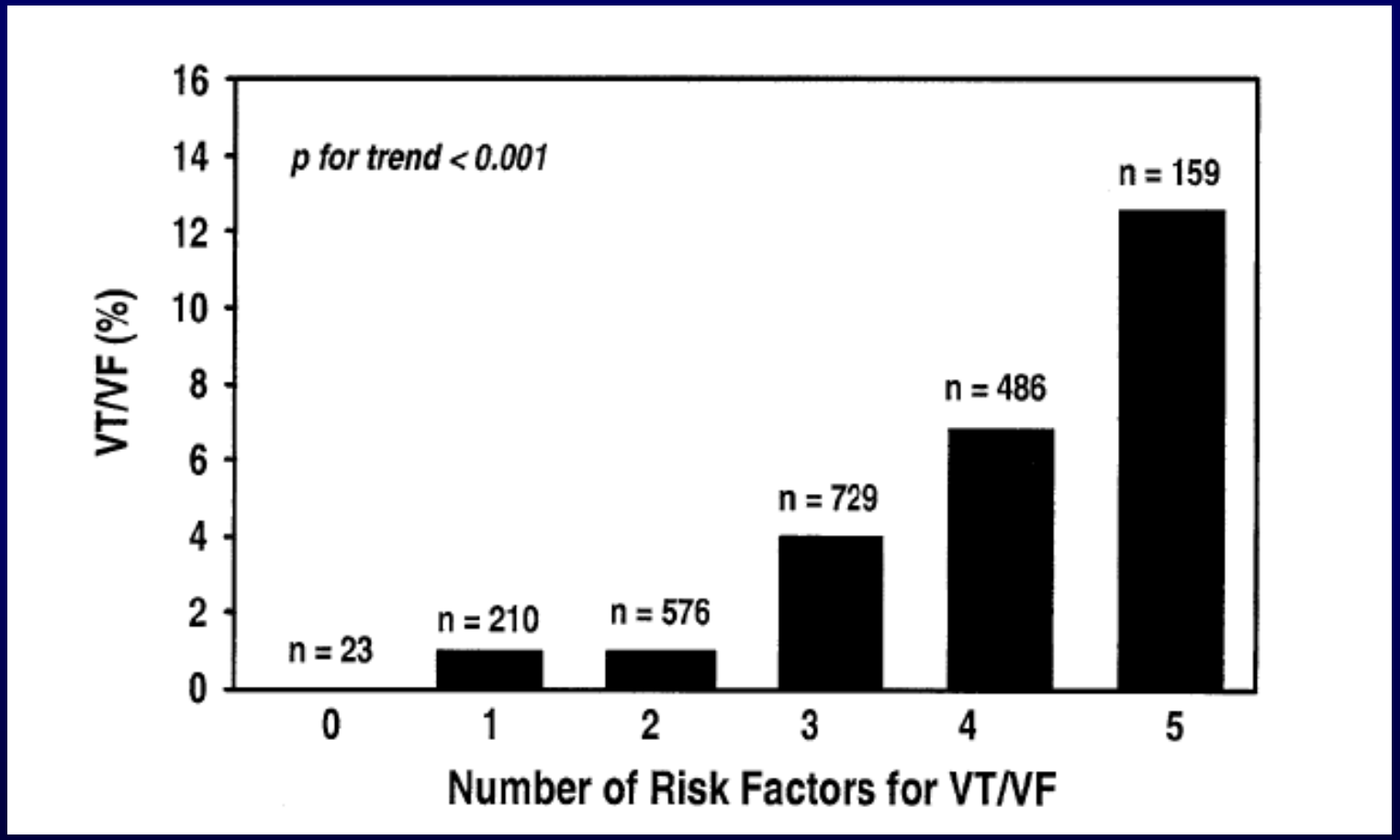
# Time from symptom onset to ER arrival and frequency of VT/VF




The frequency of VT/VF increases as the time from symptom onset to ER arrival decreases

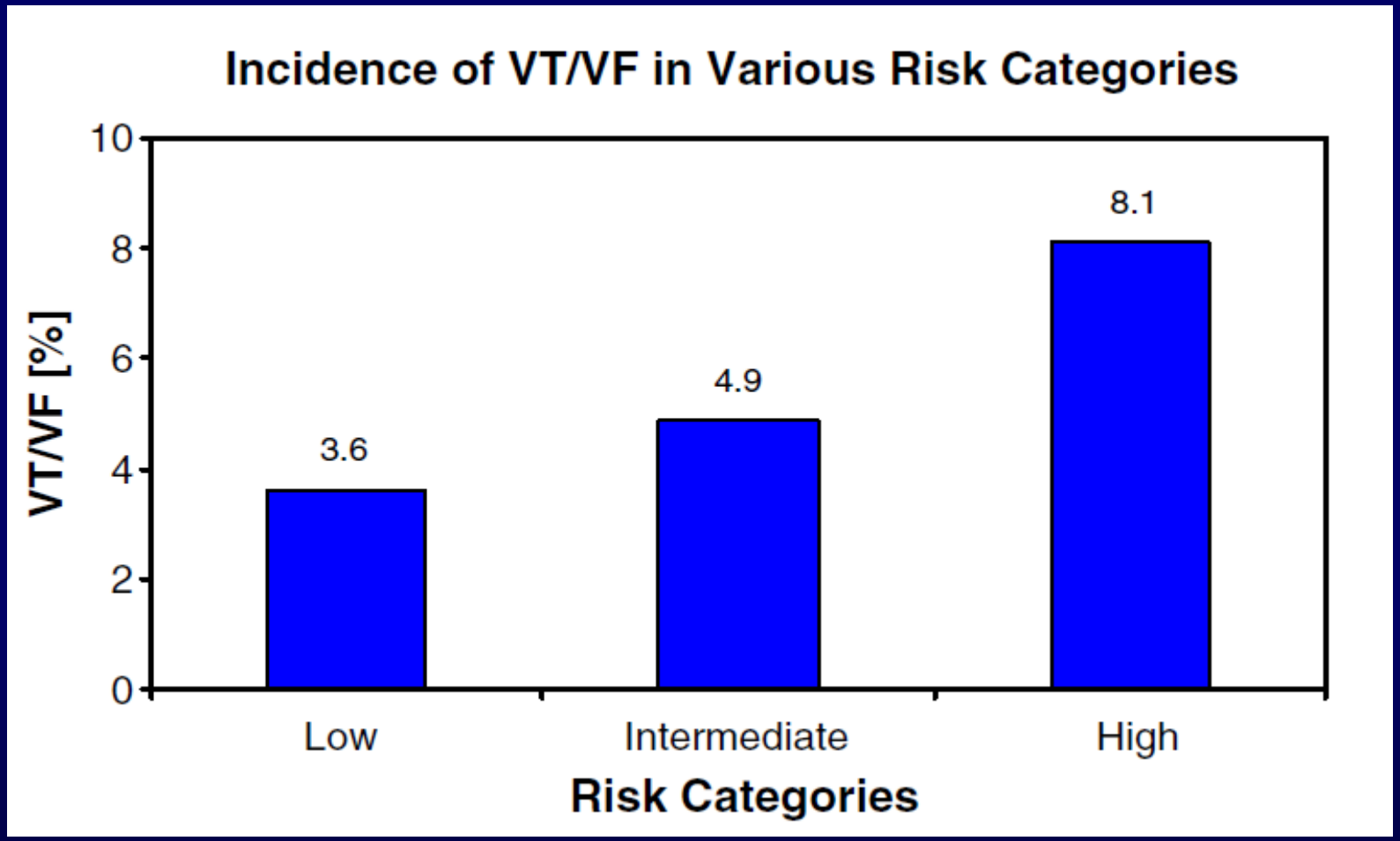
Mehta et al, Am Coll Cardiol, 2004

# Increasing number of risk factors and the incidence of VT/VF




The frequency of VT/VF increases as the number of risk predictors increases

Mehta et al, Am Coll Cardiol, 2004




The incidence of VT/VF and mortality increased as patients' baseline risk increased

Am Heart J 2011;161:782-9

# Prophylactic Strategies

Adenosine has been shown to suppress reperfusion injury and to terminate VT caused by intracellular calcium overload

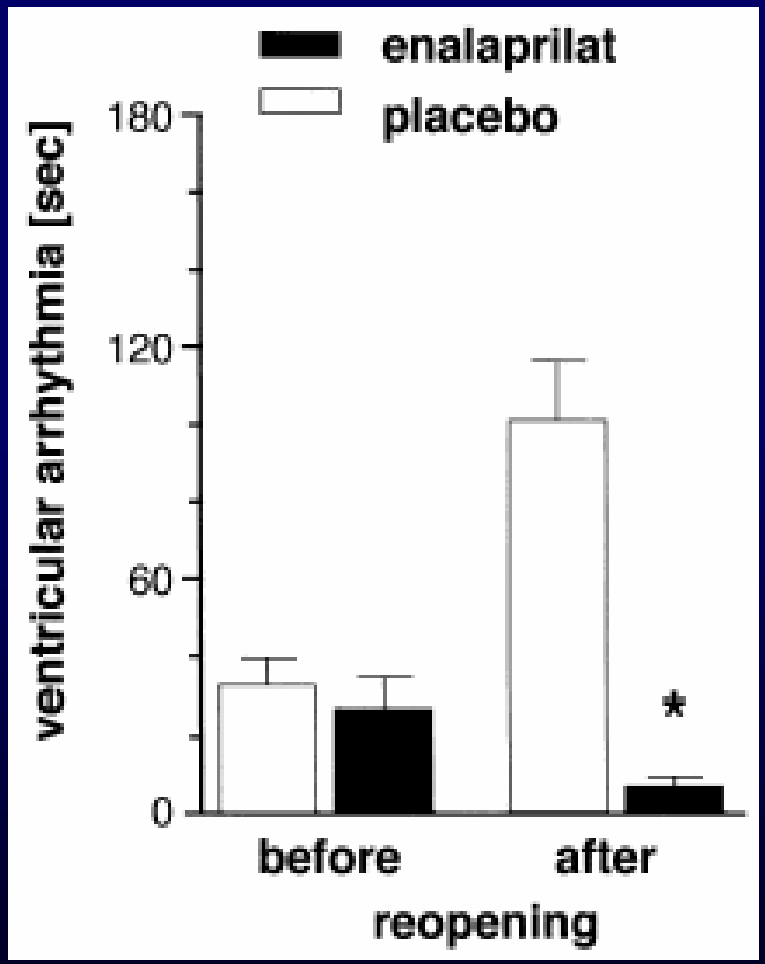
**Lerman BB,et al. Circulation ,1993**

| Arrhythmia Type | DP(n=23) | Non-DP(n=38) | p |
|---|---|---|---|
| PVC≥1 bpm | 9(39.1%) | 14(36.8%) | 0.86 |
| AIVR/VT | 0 | 7/3(26.3%) | <0.01 |
| VF | 0 | 2(5.3%) | 0.52 |

Administration of dipyridamole, increasing interstitial myocardial concentration of adenosine, can prevent and terminate reperfusion arrhythmias such as AIVR and VT in patients undergoing primary PCI

Yoshida et al, Circulation, 2000

# RAS inhibition may decrease reperfusion arrhythmias




Intra-coronary enalaprilat infusion in the infarct related artery is feasible in the setting of primary angioplasty which is safe and well tolerated

*Effective cardiac ACE inhibition can be achieved by low-dose intracoronary enalaprilat, which primarily causes a potentiation of bradykinin*

Kurz et al, Am J Cardiol, 2001

TABLE 3. EFFECTS OF PRETREATMENT WITH LOSARTAN ON THE NUMBER OF VENTRICULAR PREMATURE CONTRACTIONS (VPC) AND VENTRICULAR TACHYCARDIA (VT) AND THE TOTAL DURATION OF VENTRICULAR FIBRILLATION (VF) WHICH OCCURRED DURING 45 MIN LEFT CORONARY ARTERY OCCLUSION PERIOD IN ANAESTHETIZED SHR

| Group | N | VPC (no.) | VT (no.) | VF (sec) |
|---|---|---|---|---|
| Control | 10 | 104.3 ± 27.0 | 7.7 ± 3.4 | 165.0 ± 27.5 |
| Losartan, 2 mg/kg | 8 | 105.8 ± 37.4 | 4.0 ± 2.0 | 18.0 ± 12.0* |
| Losartan, 5 mg/kg | 8 | 46.5 ± 10.2* | 7.0 ± 5.0 | 55.0 ± 15.0* |
| Losartan, 10 mg/kg | 10 | 73.8 ± 12.0 | 2.5 ± 1.0 | 107.8 ± 71.0 |

*N represents the number of rats. Values are expressed as means ± SEM.*

**P < .05 v control value.*

Losartan attenuates myocardial ischemia-induced ventricular arrhythmias and reperfusion injury in hypertensive rats

Lee et al, Am J Hypertens, 1997

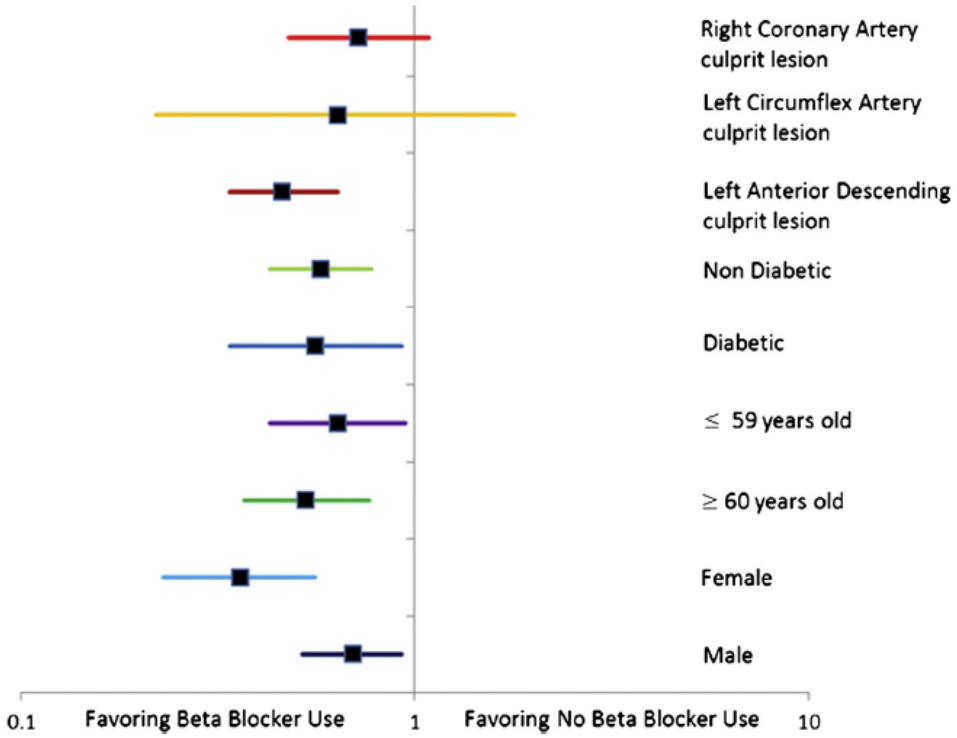
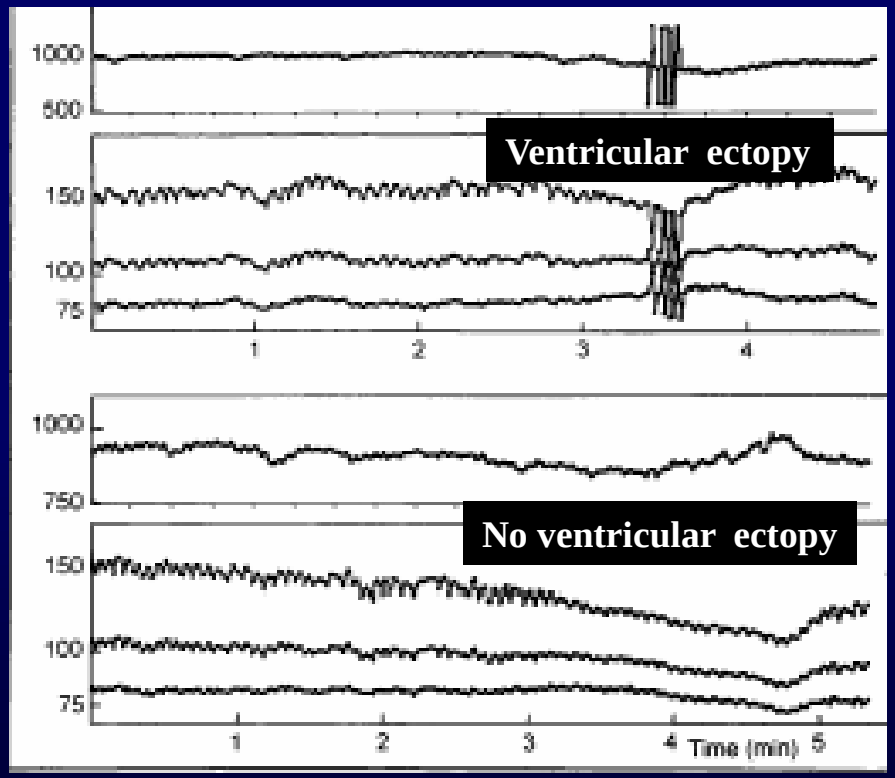



Figure 2. Adjusted ORs for intraprocedural VT or VF requiring cardioversion in patients receiving preprocedural BBs versus none in acute myocardial infarction, by subgroup.

Pre-PCI beta blocker use was associated with decreased arrhythmia and mortality, without increasing rates of cardiogenic shock and heart failure

Am J Cardiol 2013;111:1714e1720

# Antiarrhythmic Effect of Repeated Coronary Occlusion During Balloon Angioplasty




A preceding, short vessel occlusion-reperfusion cycle seems to increase the electrical stability of ischemic myocardium

Airaksinen et al, J Am Coll Cardiol, 1997

| | IABC<br>Pre intervention | No IABC or<br>IABC<br>Post intervention | All Patients | p |
|---|---|---|---|---|
| **Cardiogenic shock**<br>**(n=119)** | **12.9%** | **29.8%** | **21.0%** | **0.02** |
| **CHF or low EF(≤30%)**<br>**(n=119)** | **0%** | **5.8%** | **5. 0%** | **0.32** |
| **All high risk patient**<br>**(n=238)** | **10.3%** | **14.4%** | **13. 0%** | **0.38** |

In high risk patients prophylactic use of IABC may decrease the incidence of VF, especially in patients with cardiogenic shock

Brodie et al, Am J Cardiol, 1999

## Management

Ventricular arrhythmias usually terminate without any intervention

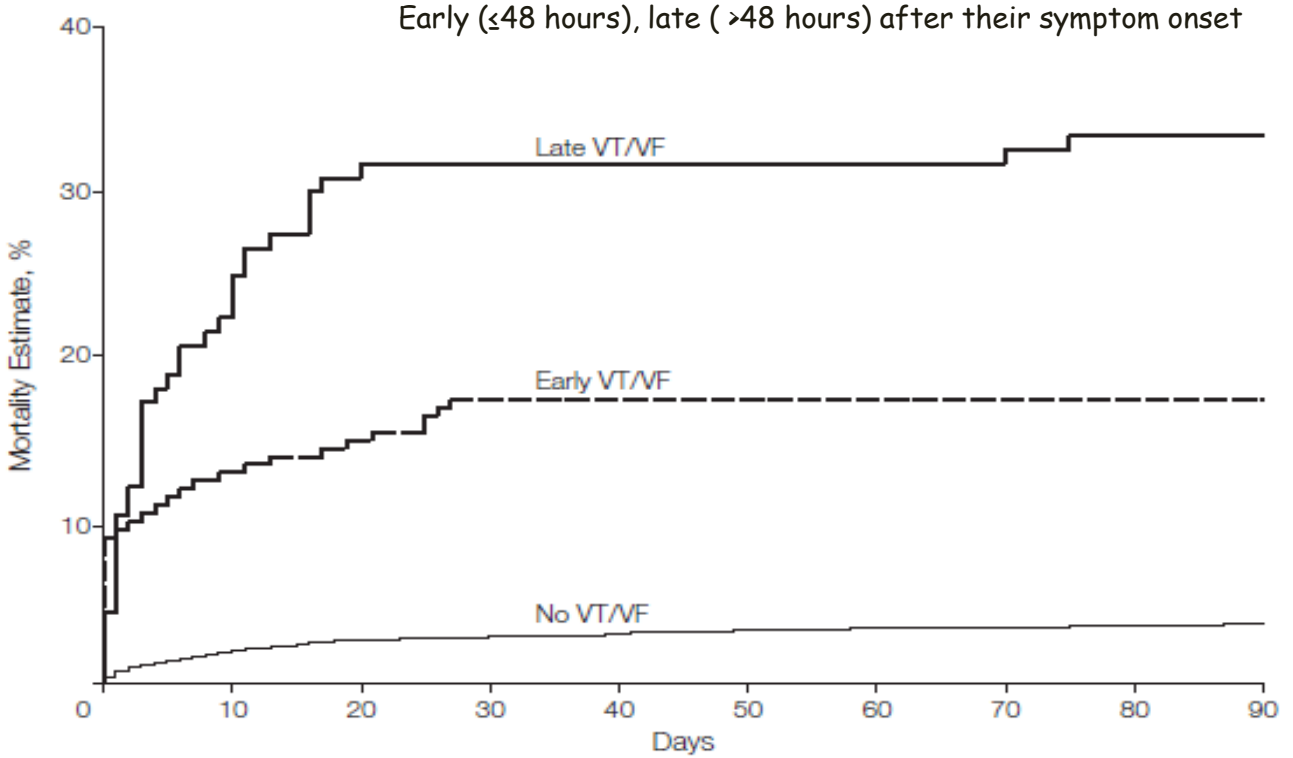
Sustained VT associated with hemodynamic compromise, or VF should be treated with synchronized electrical cardioversion/defibrillation

No drug therapy is recommended, unless arrhythmias remain after PCI

Gorenek et al, J Electrocardiol, 2006

# Outcomes of VT/VF

**Figure 2.** Ninety-Day Mortality




| 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 |

During the 90-day period, the total numbers of deaths were 39 for the late VT/VF category, 35 for early VT/VF, and 195 for no VT/VF. Log-rank $P < .001$ for comparisons between no VT/VF and early VT/VF, no VT/VF and late VT/VF, and early VT/VF and late VT/VF. VT/VF indicates ventricular tachycardia or fibrillation.

Mehta RH et al, JAMA, 2009

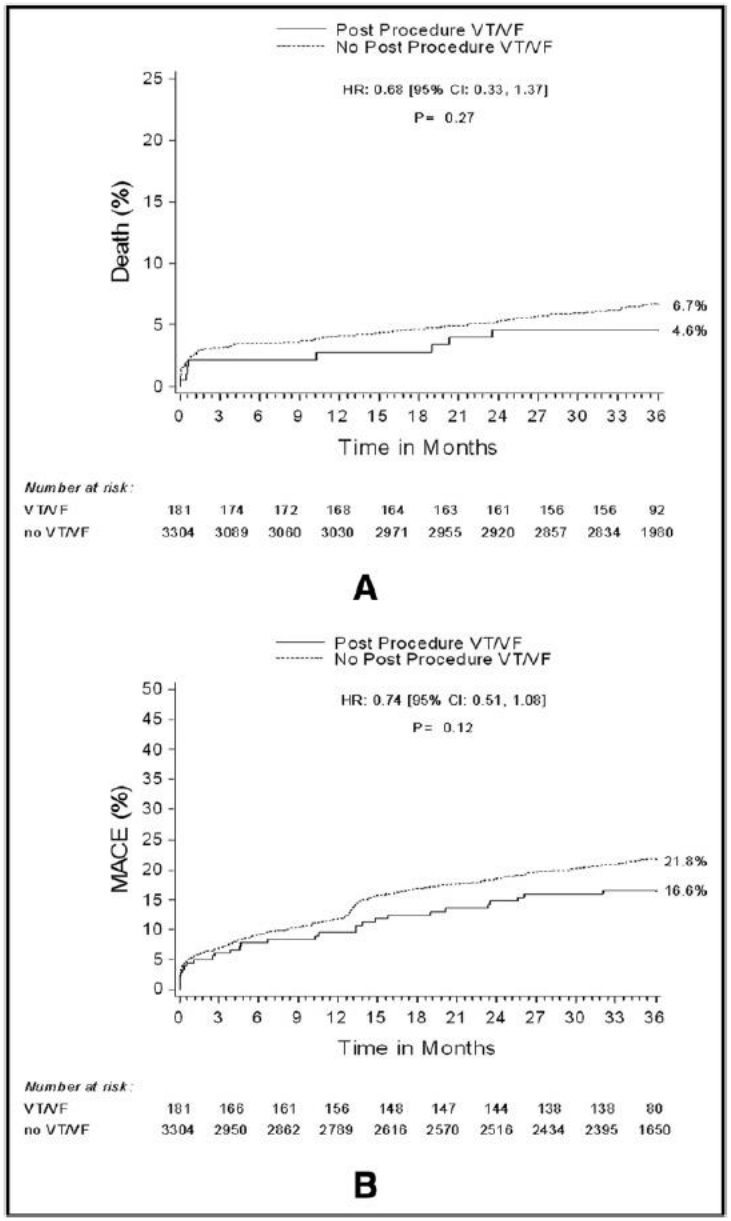



Figure 2. Time-to-event curves for 3-year mortality *(A)* and major adverse clinical events *(B)* in patients with versus without post procedural ventricular tachycardia or ventricular fibrillation.

Sustained VT/VF after PCI in the HORIZONS-AMI trial was not significantly associated with 3-year mortality or major adverse clinical events

Am J Cardiol 2012;109:805-812

# Conclusions

Arrhythmias may occur either as complication of intervention or as complication of acute MI in patients undergoing primary PCI

However, in many cases VT/VF are the predictors of successful reperfusion

Generally, they tend to revert spontaneously, but when necessary, electrical cardioversion/defibrillation should be applied promptly

VT/VF during primary PCI do not influence PCI success. The extremely short time to defibrillation and easy access to other emergency equipment likely explain this

Long term outcomes are not affected by these arrhythmias

Maiden Tower, Istanbul-TURKEY