ECG: The Overview

- ECG is the most common diagnostic test in cardiovascular work up of a patient
- ECG is the only practical and objective way to detect myocardial ischemia
- Detection of ischemia requires simultaneous ECG acquisition, thus frequent or continuous monitoring results in the best sensitivity
- Detection of ischemic changes identifies a high risk patient.

ST segment monitoring in patients with ACS

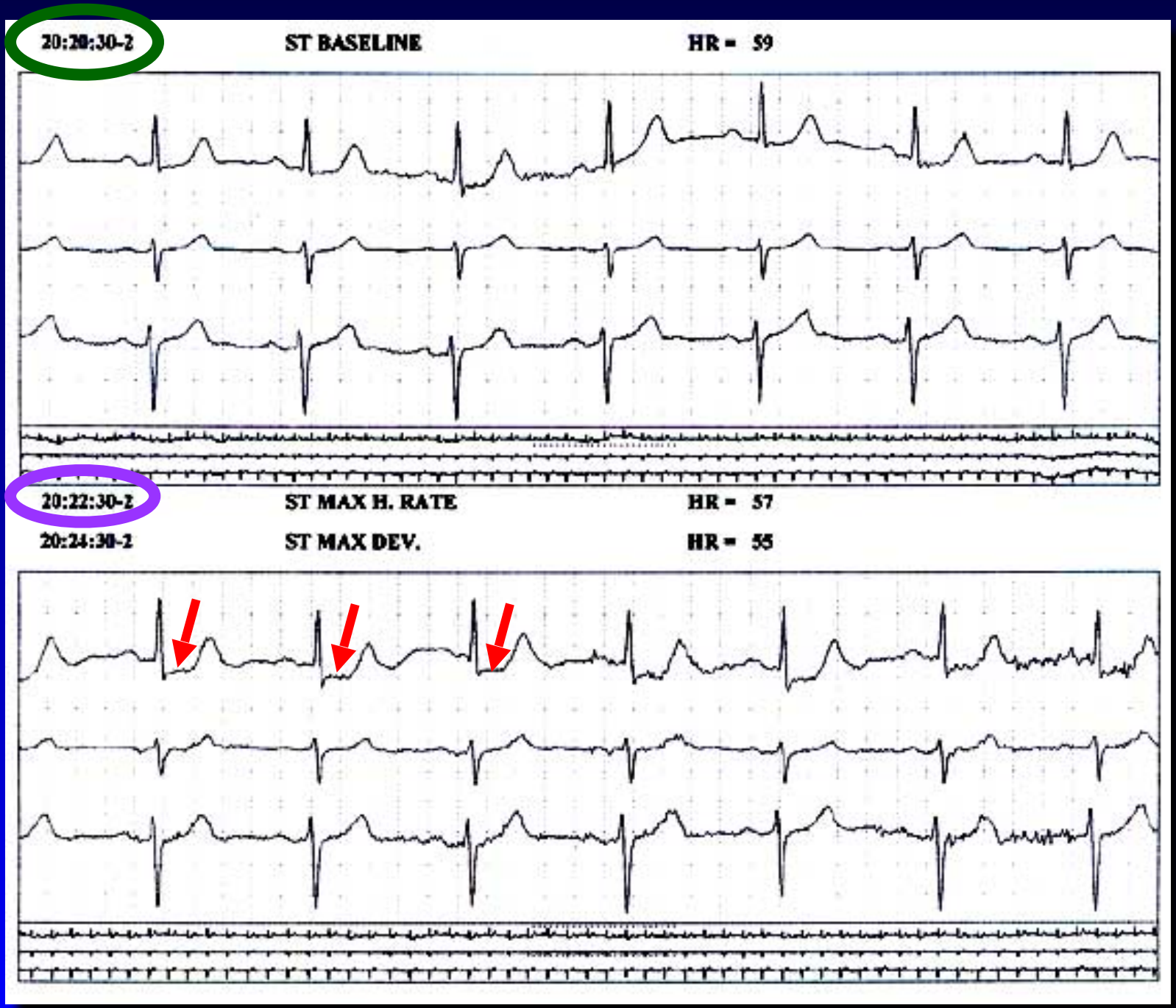
- Continuous ST segment monitoring is simple, non-invasive, and universally available tool for assessment of ongoing or recurrent myocardial ischemia
- 17-66% of patients with unstable CAD have transient episodes of ST segment changes
- Detection of ST segment shift is of prognostic value in addition to other important variables (e.g., LV function, angiographic extent of CAD)
- Up to 94% of all ischemic episodes are silent

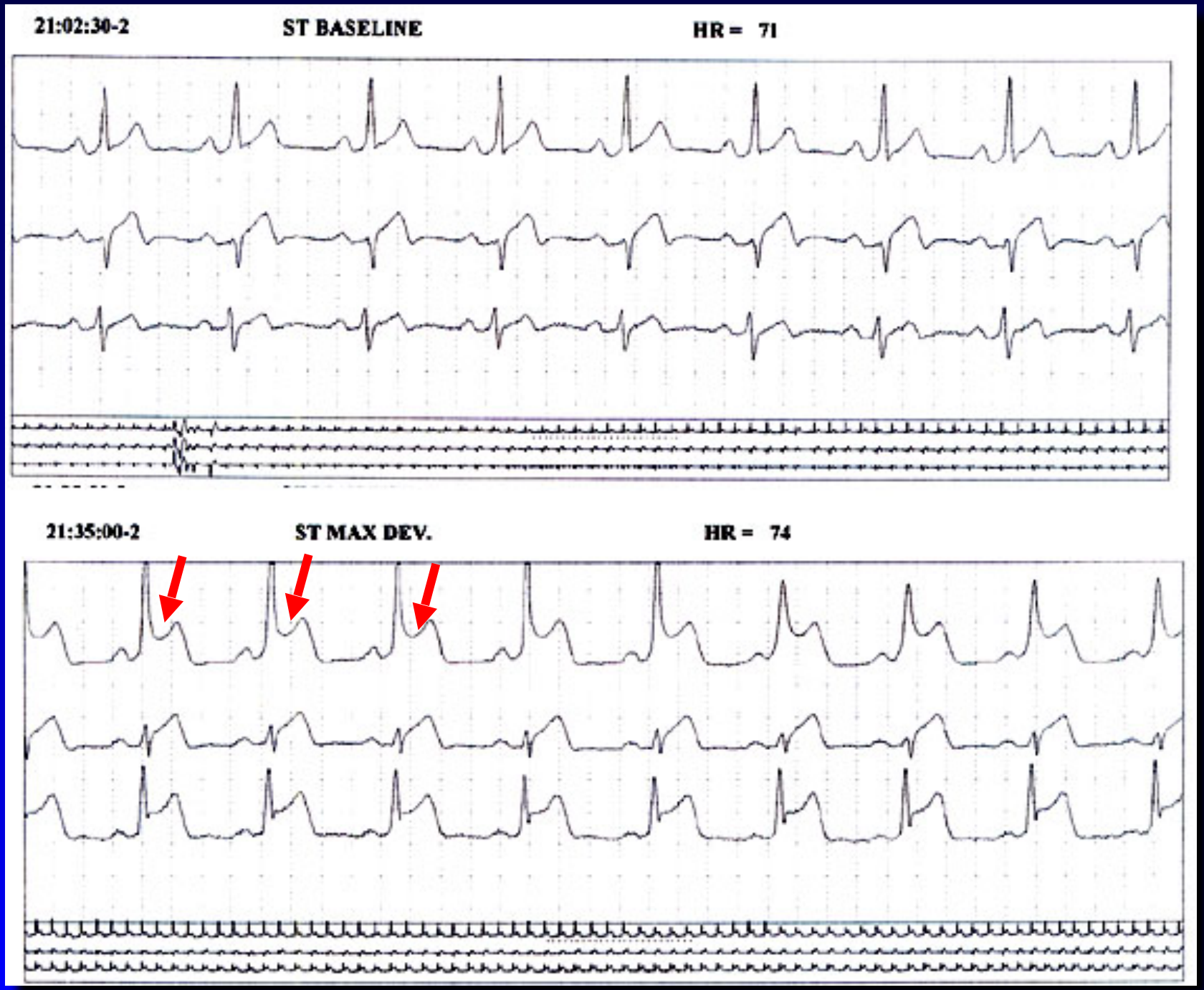
3 lead

Monitoring

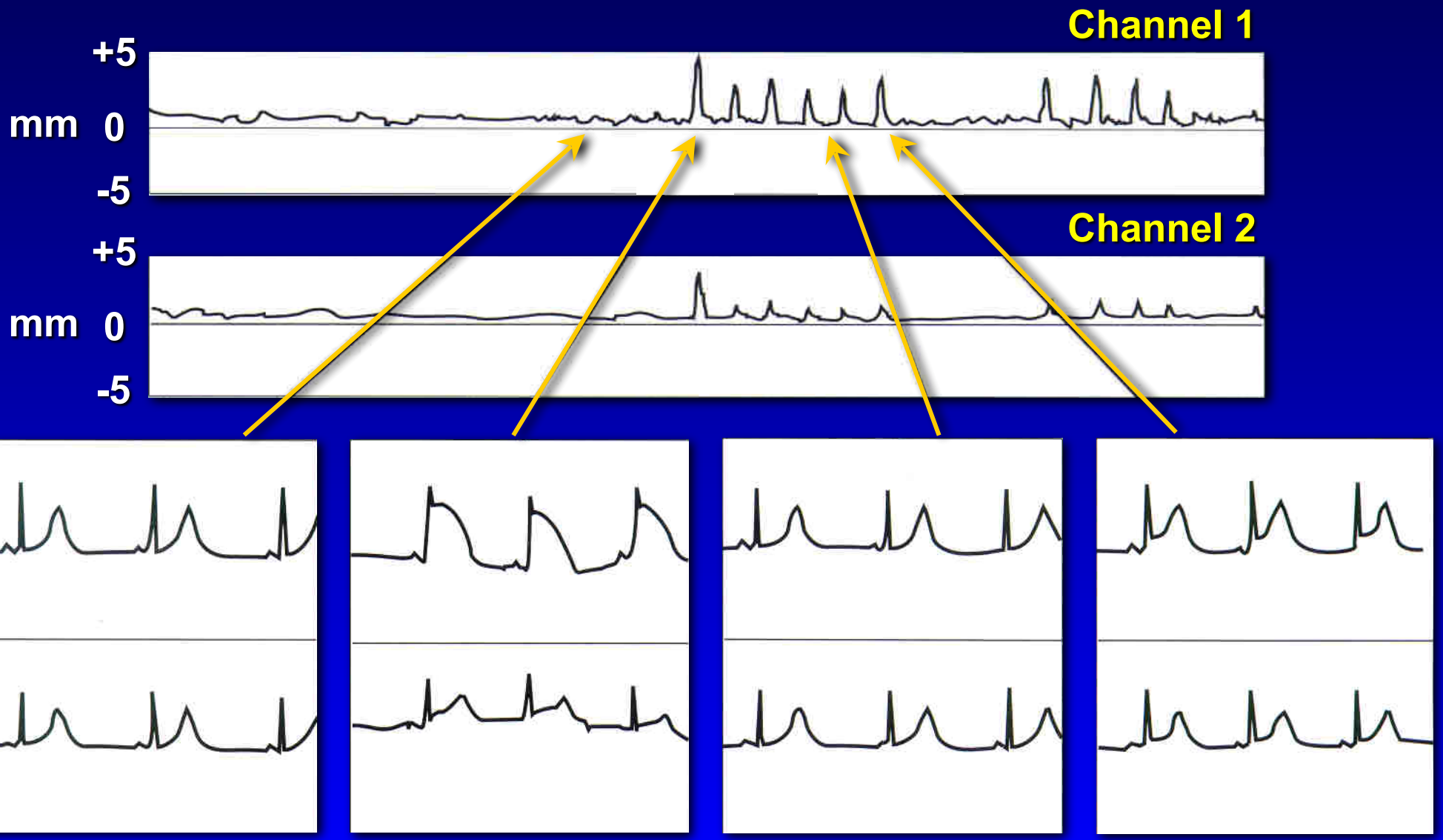
No ST changes

Ischemic ST ↓



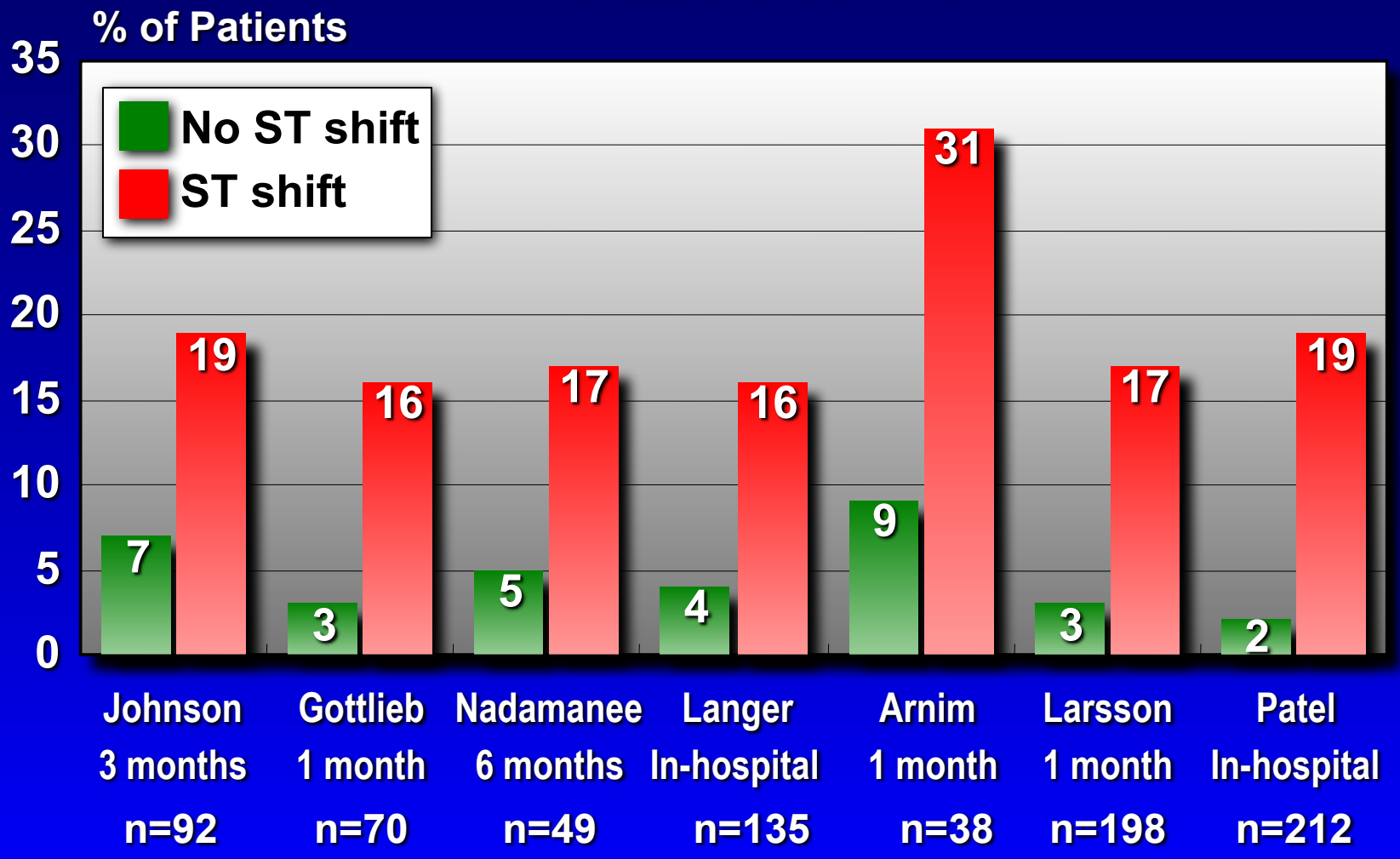

21:02:30-2
ST BASELINE
HR = 71
21:35:00-2
ST MAX DEV.
HR = 74

ST Segment Shift in Unstable Angina

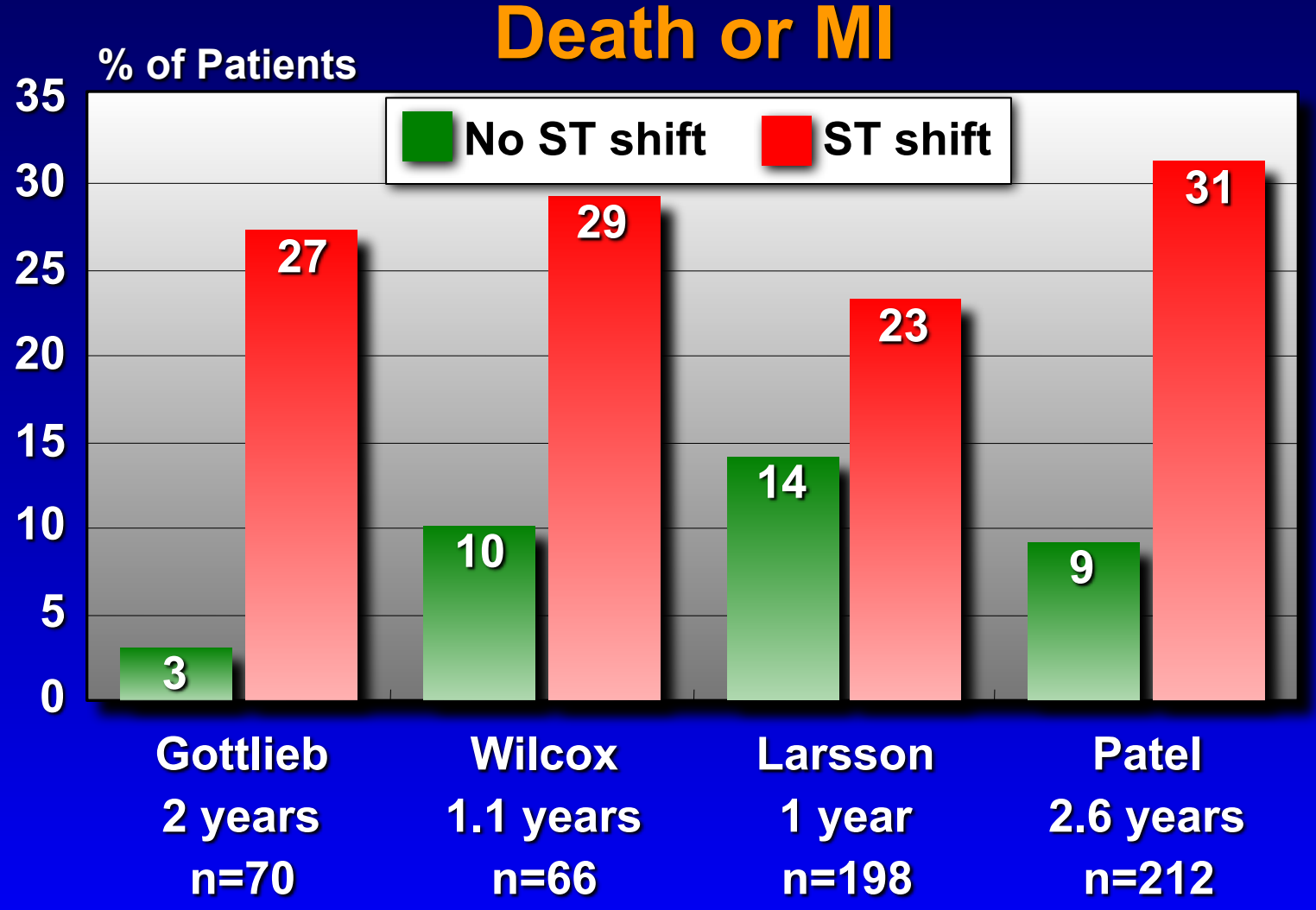


Detection of ST Shift Identifies ACS Patients with Higher Risk

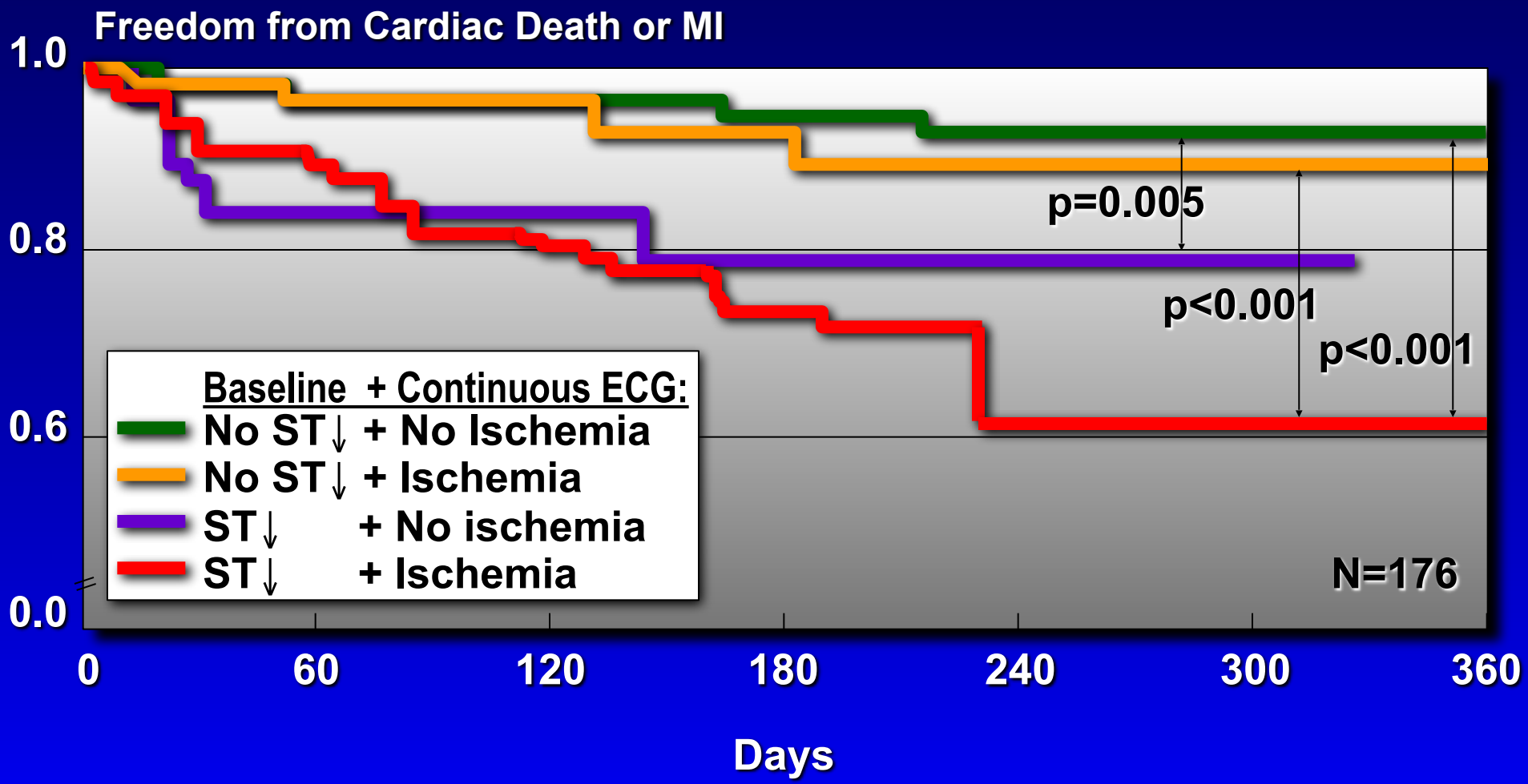
Death or MI



Prognostic Value of ST Shift Detection Long Term

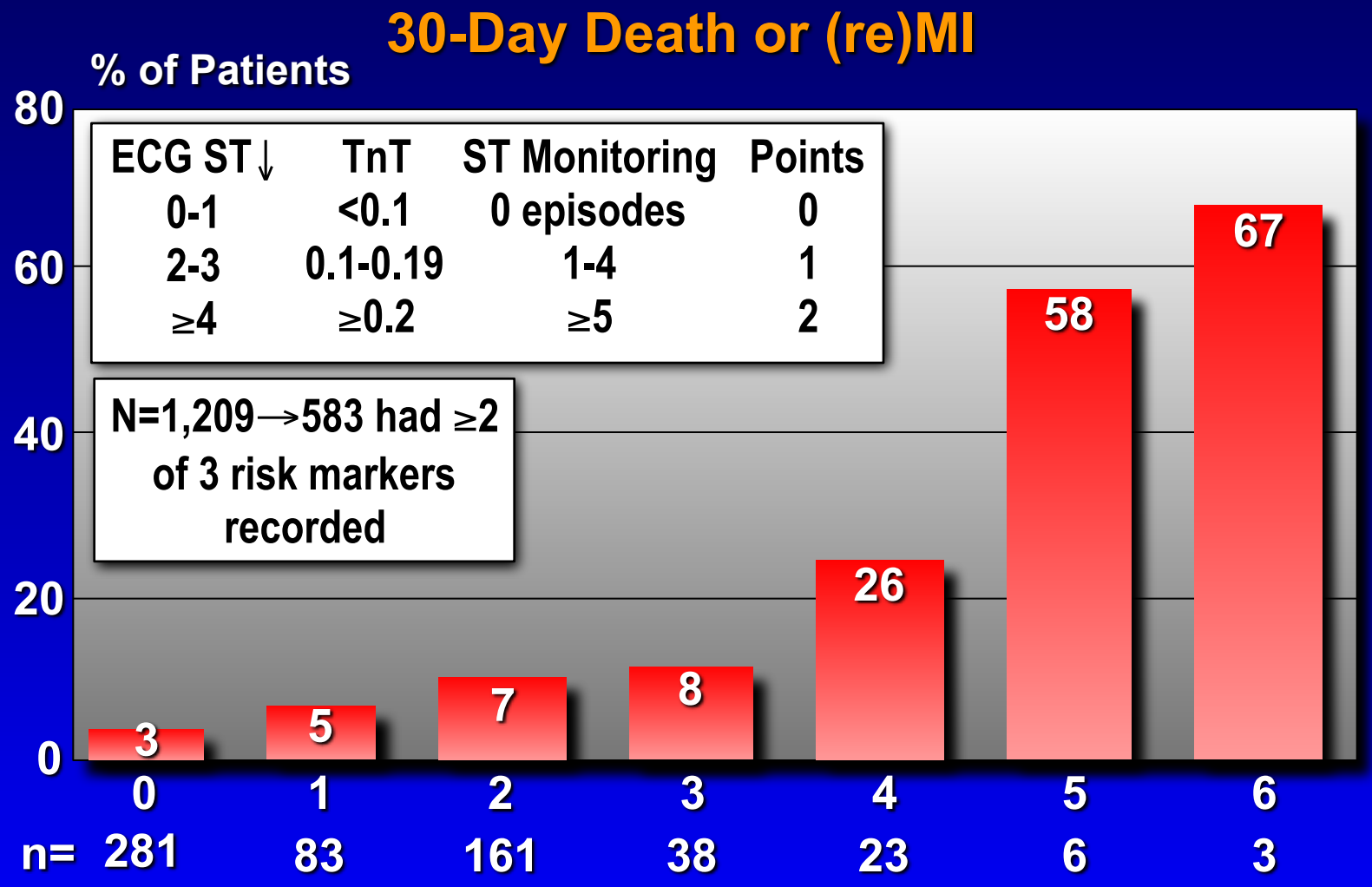


Baseline ECG and Continuous 12-lead ECG Monitoring in Non-ST↑ ACS



Jernberg et al *J Am Coll Cardiol* 1999;34:1413-19

Early Risk Stratification Based on Admission ECG, Troponin, and Continuous ST-segment Monitoring



Anderson et al for the TRIM Study Investigators *Eur Heart J* 1999;20(suppl):280

Complementary Long-term Prognostic Information from Global Risk Scoring (GRACE) and Continuous ST-segment Monitoring in ACS

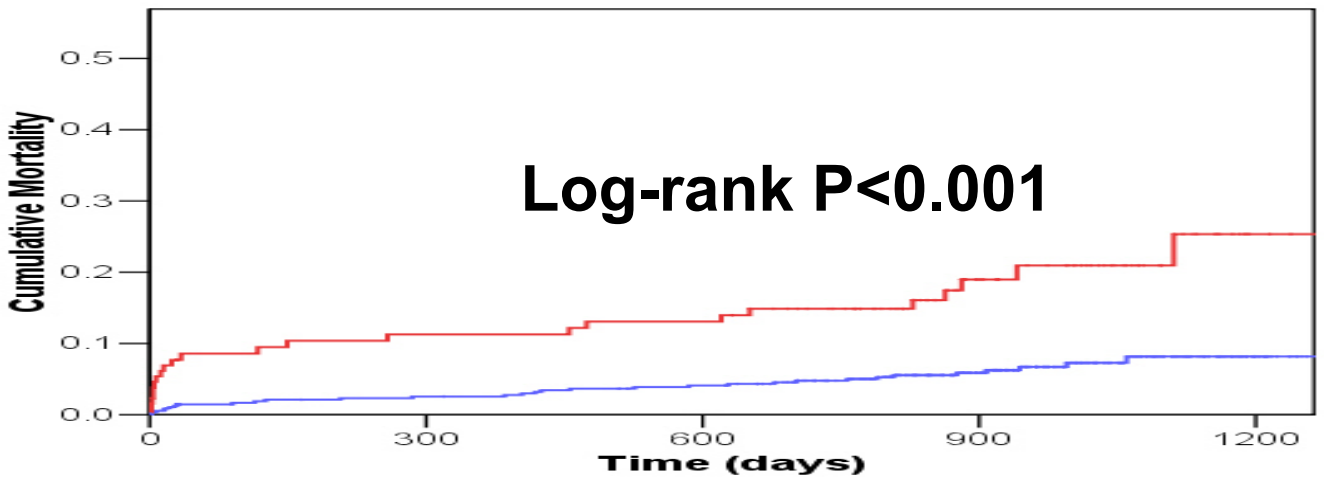
- 746 ACS patients (Rest angina ≥ 10 min within 24h + ST deviation or elevated cardiac biomarker)
- All received IIb/IIIa (Integrilin) and randomized to enoxaparin vs unfractionated heparin Goodman et al. *J Am Coll Cardiol* 2000;36:1507-13

- 38 of 50 sites participated in long-term (> 1 year) follow-up (n=571) Fitchett et al. *Am Heart J* 2006;151:373-9

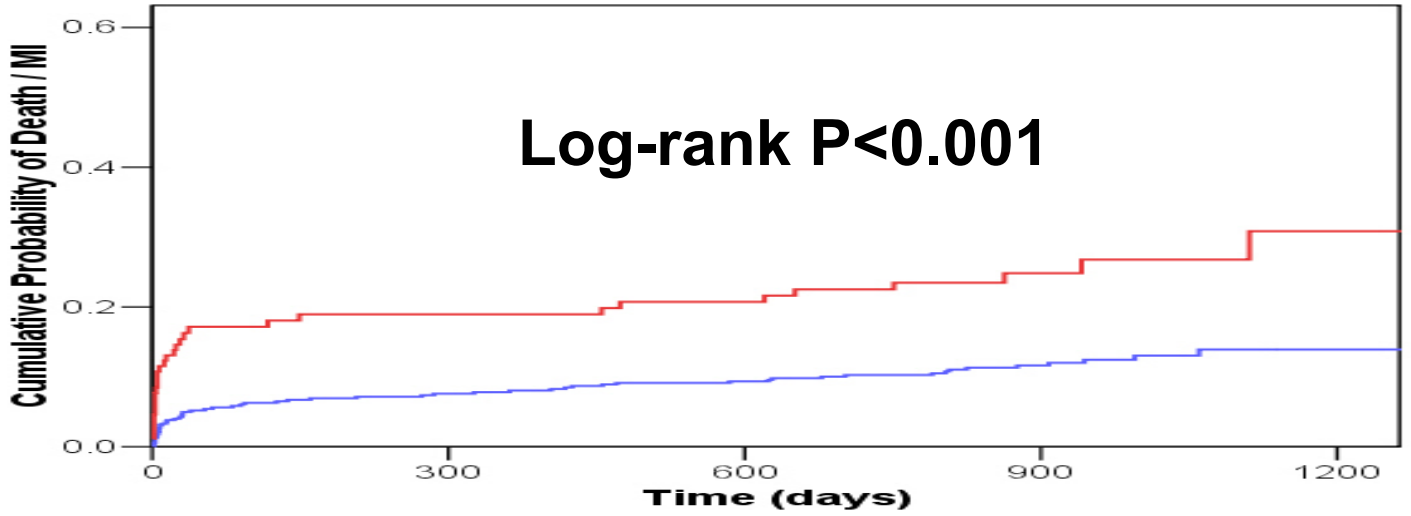
- Patients without long-term follow-up data (n=110) were censored at 30 days
- Multivariable Cox regression to evaluate the independent prognostic value of ST-segment shift, after adjusting for GRACE risk score (analyzed as a continuous variable)

Yan et al, Am Heart J 2007;153:500-6.

Death



Death/ non-fatal MI



GRACE Risk Score

- Age
- Heart Rate
- Systolic BP
- Killip class
- Cardiac arrest
- ST-segment deviation
- Creatinine
- Elevated biomarker

1. Find Points for Each Predictive Factor:

Killip Class	Points	SBP, mm Hg	Points	Heart Rate, Beats/min	Points	Age, y	Points	Creatinine Level, mg/dL	Points
I	0	≤80	58	≤50	0	≤30	0	0-0.39	1
II	20	80-99	53	50-69	3	30-39	8	0.40-0.79	4
III	39	100-119	43	70-89	9	40-49	25	0.80-1.19	7
IV	59	120-139	34	90-109	15	50-59	41	1.20-1.59	10
		140-159	24	110-149	24	60-69	58	1.60-1.99	13
		160-199	10	150-199	38	70-79	75	2.00-3.99	21
		≥200	0	≥200	46	80-89	91	>4.0	28
						≥90	100		

Other Risk Factors	Points
Cardiac Arrest at Admission	39
ST-Segment Deviation	28
Elevated Cardiac Enzyme Levels	14

2. Sum Points for All Predictive Factors:

Killip Class + SBP + Heart Rate + Age + Creatinine Level + Cardiac Arrest at Admission + ST-Segment Deviation + Elevated Cardiac Enzyme Levels = Total Points

3. Look Up Risk Corresponding to Total Points:

Total Points	≤60	70	80	90	100	110	120	130	140	150	160	170	180	190	200	210	220	230	240	≥250
Probability of In-Hospital Death, %	≤0.2	0.3	0.4	0.6	0.8	1.1	1.6	2.1	2.9	3.9	5.4	7.3	9.8	13	18	23	29	36	44	≥52

For example, a patient has Killip class II, SBP of 100 mm Hg, heart rate of 100 beats/min, is 65 years of age, has serum creatinine level of 1 mg/dL, did not have a cardiac arrest at admission but did have ST-segment deviation and elevated enzyme levels.

His score would be: 20 + 53 + 15 + 58 + 7 + 0 + 28 + 14 = 196

This person would have about a 16% risk of having an in-hospital death.

Similarly, a patient with Killip class I, SBP of 80 mm Hg, heart rate of 60 beats/min, is 55 years of age, has serum creatinine level of 0.4, and no risk factors would have the following score:

0 + 58 + 3 + 41 + 1 = 103, which gives approximately a 0.9% risk of having an in-hospital death.

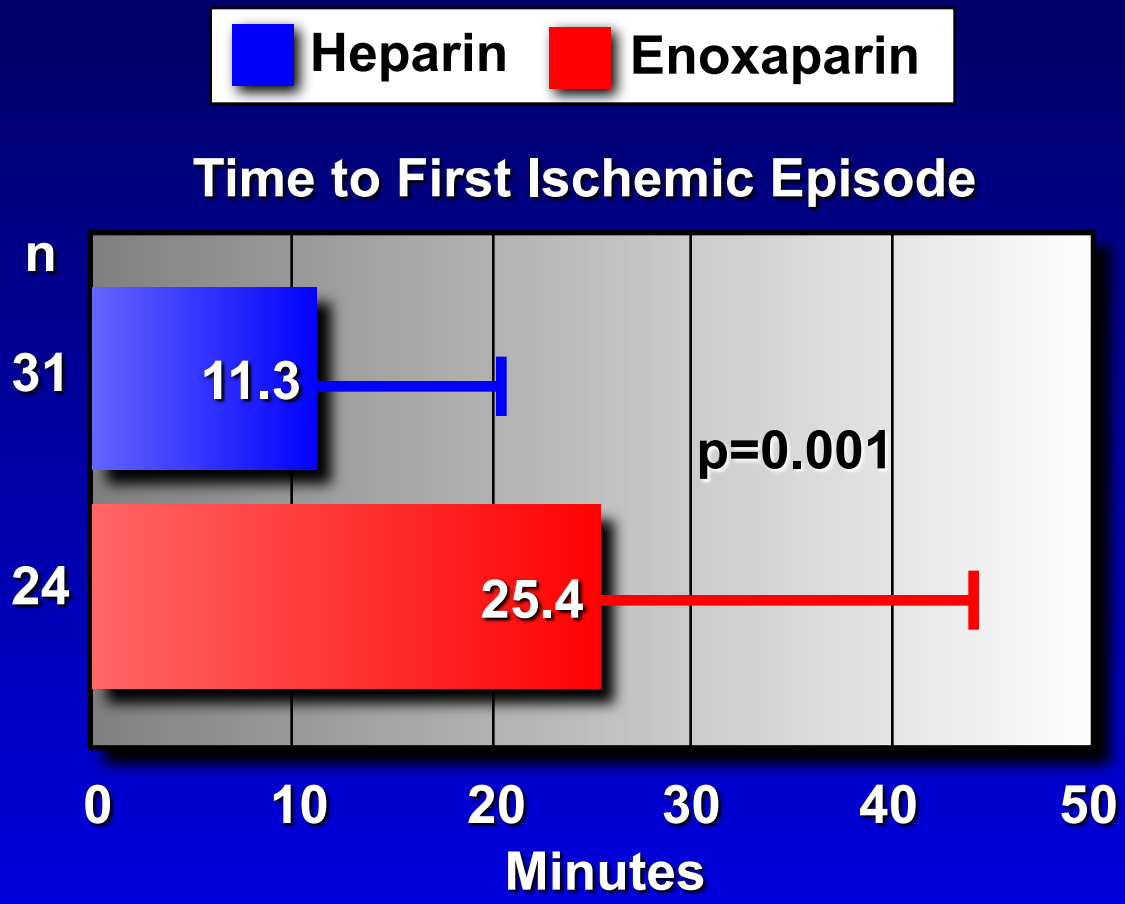
Granger et al. *Arch Intern Med* 2003;163:2345-53

Multivariable Analysis

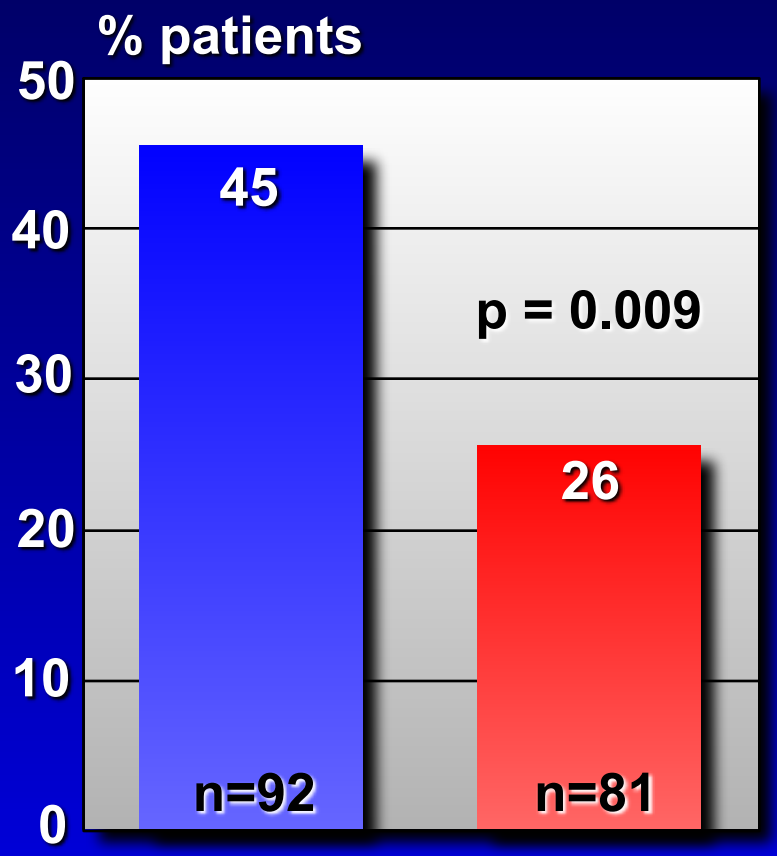
Outcomes	Predictors	Adj. HR (95% CI)	P value
Death	GRACE risk score*	1.26 (1.18-1.34)	<0.001
	ST shift	2.37 (1.38-4.09)	0.002
Death/ MI	GRACE risk score*	1.17 (1.10-1.23)	<0.001
	ST shift	1.93 (1.25-3.00)	0.003

* Per 10-point increase
HR= hazard ratio; MI= myocardial infarction

Patients with ST Shift



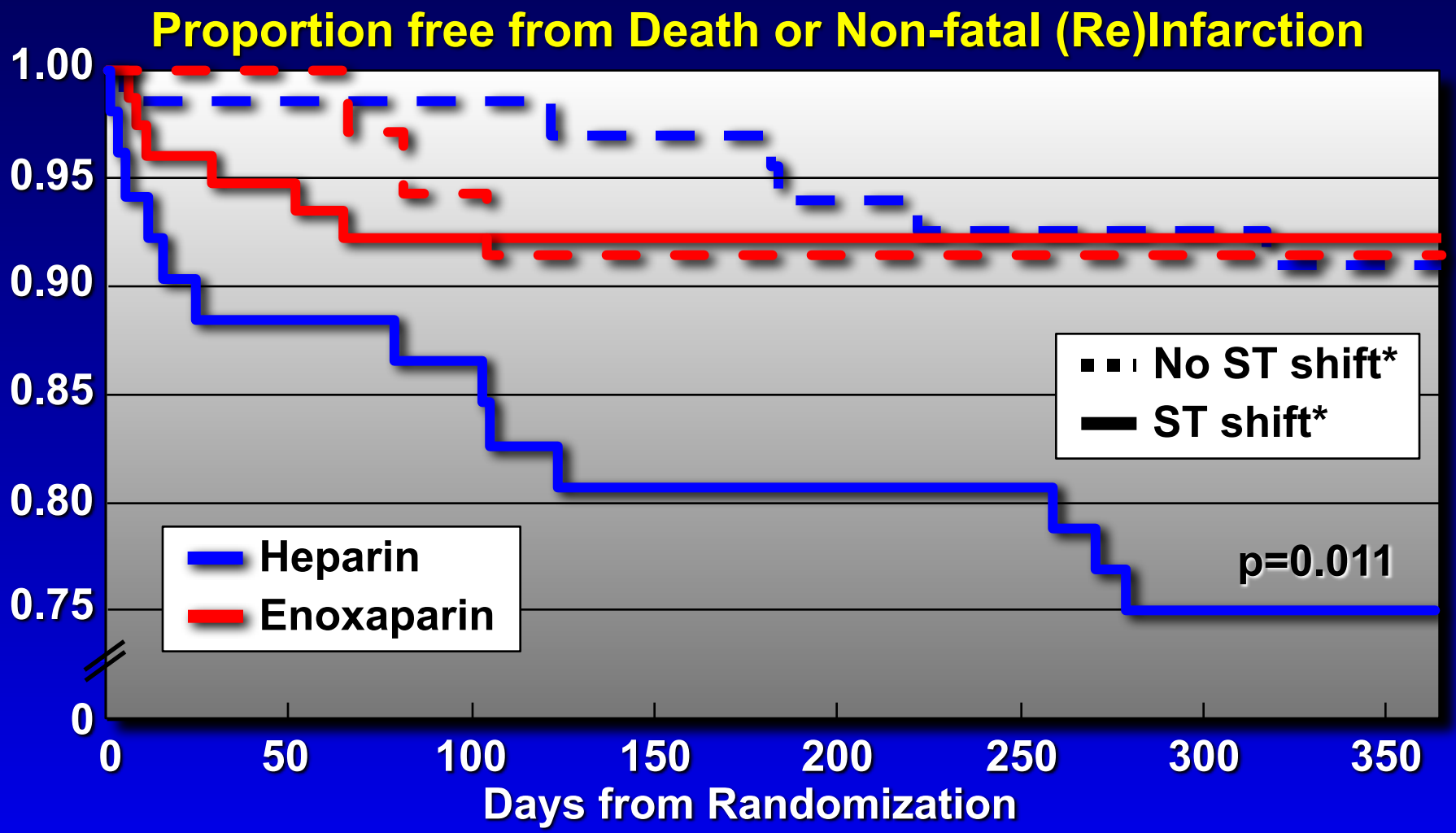
After study drug initiation
Holter # 1



48 hrs after study drug stopped
Holter # 2

Goodman et al *J Am Coll Cardiol* 2000;36:1507-13

Canadian ST Segment Monitoring Substudy

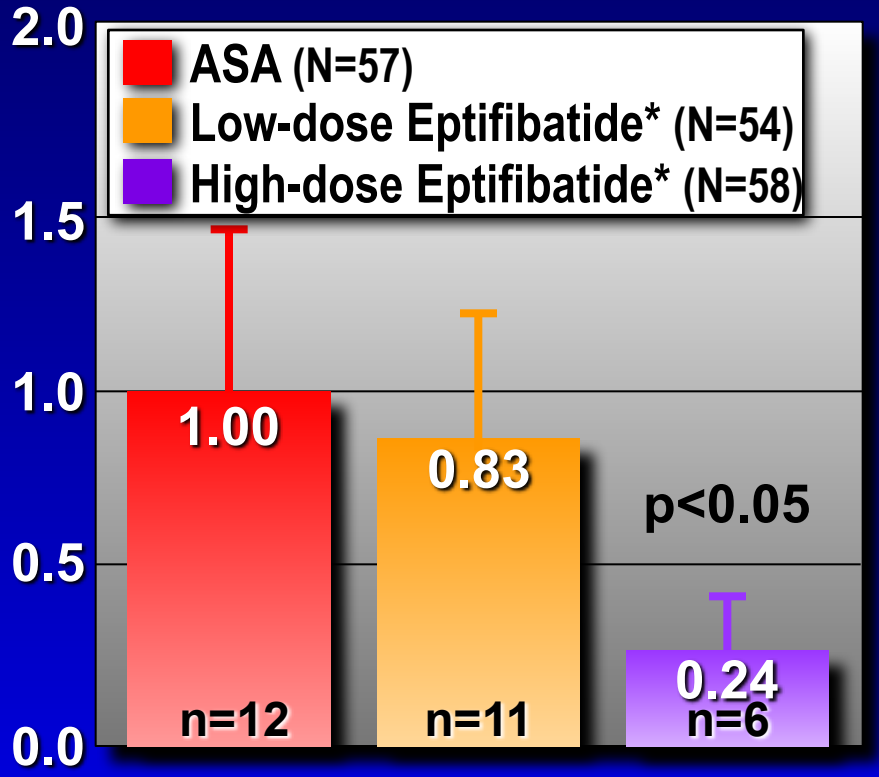


*during either 48 hr period of continuous ECG monitoring

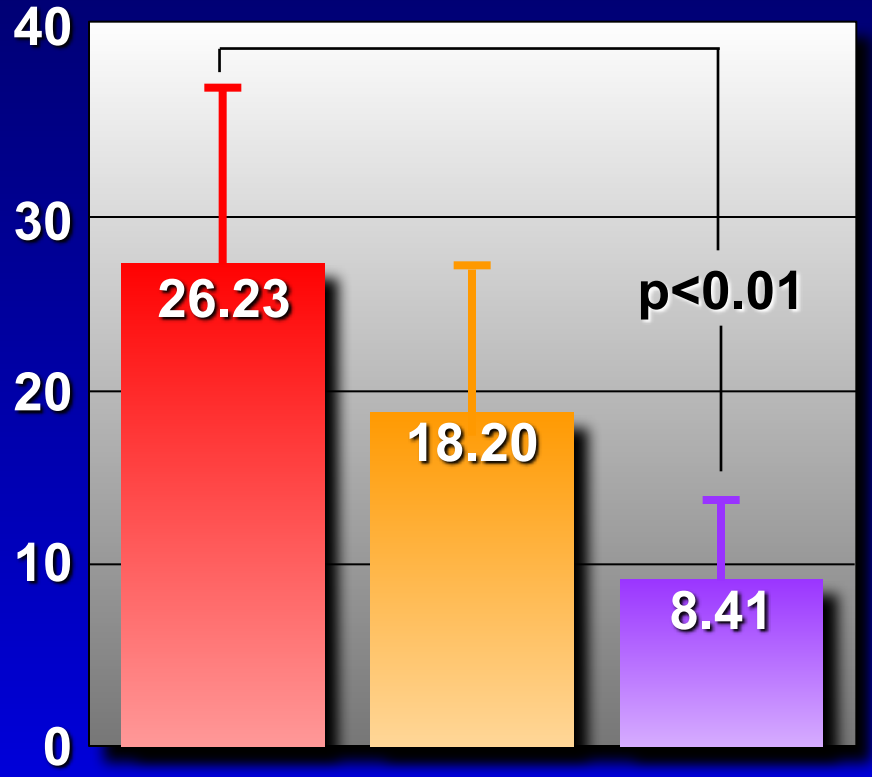
Goodman et al *J Am Coll Cardiol* 2000;36:1507-13

GP IIb/IIIa Inhibition in Unstable Angina

Number of Ischemic Events per 24 hours



Duration of Ischemia per 24 hours



No change in mean number/duration of ischemic episodes post-drug withdrawal (n=110; 20.7 hrs)

* Low = 45 μg/kg bolus → 0.5 μg/kg infusion
High = 90 μg/kg bolus → 1.0 μg/kg infusion

Schulman et al *Circulation* 1996;94:2083-89

Summary

- Detection of Ischemia on ECG is feasible, including on the continuous basis, and is associated with worse prognosis in patients with ACS, independent of all other variables such as troponin, baseline ECG, or chest pain.
- Continuous ST segment monitoring can be used for risk stratification to identify those patients most in need of intervention.
- Continuous ST segment monitoring can be used for assessment of a success of a therapeutic intervention.

Conclusion

- The use of ECG, including ambulatory monitoring, is recommended in all patients at risk for myocardial ischemia.
- Detection of ST segment shift can be achieved in-hospital or at home utilizing 3 or 12-lead Holter or event monitoring devices with ST segment capability devices. To improve sensitivity of ischemia detection, 12-lead and continuous monitoring is recommended.
- Monitoring and transmission of ECG signal can now be performed reliably over the telephone or internet (www.cardiocomm.com)
- Given the inexpensive and non-invasive nature of ST segment monitoring, this diagnostic modality is underutilized in patients at risk.