AMI DIAGNOSIS AND REPERFUSION THERAPY

A CASE-BASED MANUAL

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LIPPINCOTT WILLIAMS & WILKINS

To Nan, Josh and Weth
No man could have asked for more

CONTENTS

PREFACE

The expertise of vitreoretinal surgeon is often needed in the management and treatment of the severly injured eye. THe pathophysiology of closed-globe and open-globed injuries results in vitreoretinal pathology that often necessitates surgical management. Since 1973, when Robert Machemer introduced pars plana vitrectomy, there has been a burgeoning of technological and scientific information on the surgical approach to the injured eye Virgil Alfaro and Peter Liggett's textbook, Vitreoretinal Surgery of the Injured Eye, provides a comprehensive and systematic presentation of this information.

Vitreoretinal Surgery of the Injured Eye is written by vitreoretinal specialists with the vast experience in ocular trauma. Alfaro and Liggett have organized an internal team to contribute to the textbook.

The Texbook is organized systematically and includes two chapters on subjects that are often overlooked in similar texts: a historical perspective and counseling of the injrued patient. The other 27 chapters provide in-depth and comprehensive treaties on the management of ocular trauma, with notable contributions by Klaus Heimann, Eugene de Juan, and D. Jackson Coleman. It is beautifully illustrated by Timothy Hengst, providing detail of surgical techniques in the management of the severely injured eye.

Vitroretinal Surgery of the Injured Eye represents a scholarly work dedicated to the understanding and treatment of a clinically important problem. I commend the editors and the contributors of this textbook for their outstanding work.

ACKNOWLEDGMENTS

I would like to thank my colleagues and collaborators Fred Coe, Murray Favus, Nancy Krieger, Riccardo Levi-Setti, Jan Chabala, Kevin Frick, Mac Grynpas, John Featherstone, and George Schwartz for years of intellectual collaboration and exploration; I continue to be amazed that I am paid to have fun. I would also like to thank the many dedicated investigators who set the stage for our current work in bone and stone and my chiefs, prsent and past, who have allowed me tht freedom to follow my dream. Thanks to Danette Knopp, Juleann Dob, Ellen DiFrancesco, and Kathey Alexander at Lippincot Williams and Wilkins for their good humored persistence. Mostly, I would like to thank my family, to whom this volume is dedicated, for their understnading and patience with their ften-times working husband and father in his struggle for balance.

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PART

I

ECG MORHPOLOGIES AND DIAGNOSIS OF AMI: GENERAL ISSUES

6

AMI AND ST SEGMENT ELEVATION

KEY POINTS

- ST elevation is measured relative to the PR segment
- ST elevation >/= 1mm in 2 consecutive leads is the "criterion" for thrombolysis in AMI
- Height and extent of ST elevation correlates with prognosis and benefit of thrombolysis.

GENERAL BACKGROUND

Measuring ST segment elevation and depression (Figs. 6-1a and 6-1b)

The best and easiest method is to **measure the ST segment relative to the PR segment.** Atrial repolarization occurs in the opposite direction from the P-wave, lasts until 40–80 ms after the end of the QRS, and frequently depresses the PR segment at baseline. If the PR segment is depressed, the normal condition of the ST segment at the J-point (junction of the QRS and ST segments) is also depression. Thus, relative to the TP segment:

- The PR segment may be depressed as a normal condition, and, if it is so depressed, the ST segment should be equally depressed.

Because atrial repolarization lasts a maximum of 80 ms, **an alternative method** is to **measure the ST segment relative to the TP segment at 60 ms (417) or 80 ms (162) after the J-point.**

An **inverted P-wave** results when retrograde depolarization of the atrium causes a positive atrial repolarization wave and resultant ST elevation.

Evolution of an ST Elevation AMI (STE-AMI)

A non-reperfused complete coronary occlusion, without good collateral circulation, may demonstrate the following sequence of events *(see Fig. 6-2)*. **This evolution may be altered by reperfusion therapy.**

- Increased amplitude of R-waves and T-waves
- Enlargement of the T-wave, in both width and height
- ST elevation, with instability (204)
- Q-wave or loss of R-wave amplitude. A Q-wave may start to form in < 1 hour, is reversible for up to 6 hours (171, 144), and complete by 12 hours.
- T-wave inversion before normalization of the ST segment (this contrasts with ST segment normalization before T-wave inversion in pericarditis)

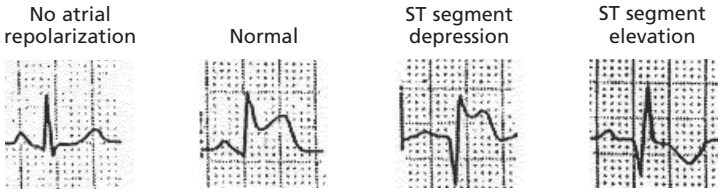


FIGURE 6-1A. ST elevation and depression with no atrial repolarization wave

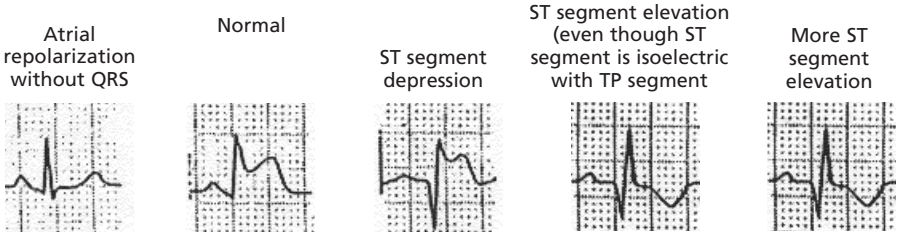


FIGURE 6-1B. ST elevation and depression with a (negative) atrial repolarization wave

CASE 6-1

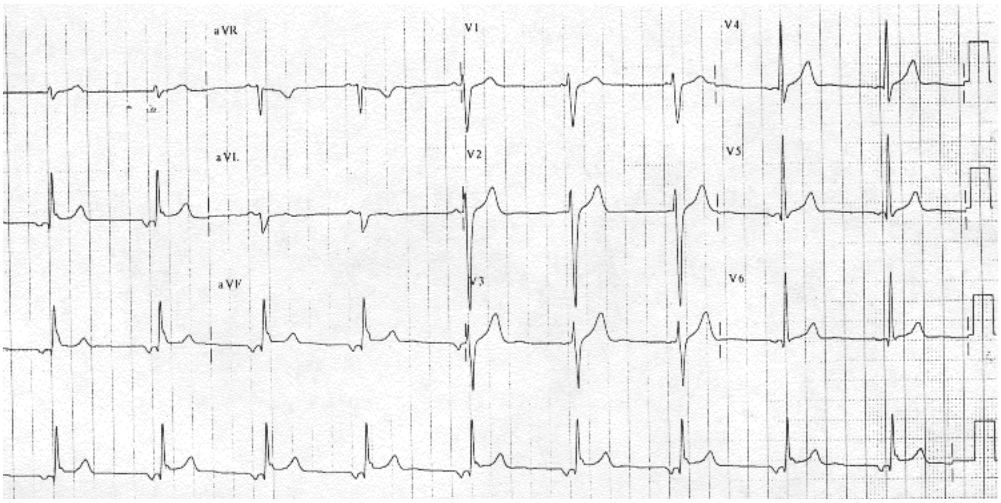
Inferior ST Elevation Due to an Upright Atrial Repolarization Wave

History
This 24 year-old man presented with chest pain.

ECG 6-1 (Type 3)
- Inverted P-wave: II, with a short PR interval. There is a pacemaker high in the AV node or low in the atrium.
- ST elevation: V2-V6, due to benign early repolarization (normal variant).
- ST elevation: II, III, aVF, maximal in II, but without reciprocal ST depression in aVL
- In the context of an inverted P-wave, ST elevation may be due to upright atrial repolarization wave. The P-wave persists well beyond the end of the QRS due to the very short PR interval.

Clinical Course
There was no AMI; no reperfusion therapy was administered.

Conclusion
This is not true ST segment elevation.



- ST segment normalization, usually within the first 12 hours
- **Re-elevation of the ST** segment may occur due to infarct extension, reocclusion in a partially reperfused AMI.
- Established Q-waves may disappear in days/weeks/months in 15-30% (274, p131)
- T-waves may normalize over days, weeks, or months (274).
- Established Q-waves may disappear in days/weeks/months in 15-30% (274, p131)
- T-waves may normalize over days, weeks, or months (274).

Early repolarization (benign normal variant)

Some non-pathologic ST segment elevation is seen in up to 90% of normal subjects (#274). This is considered **normal variant** and is typically:

- Highest in V2 and V3, up to 3mm
- ST segments are upwardly concave, not convex (*Figs. 6-3a-c*).
- Rarely more than 1mm in lateral precordial leads
- More pronounced in younger individuals

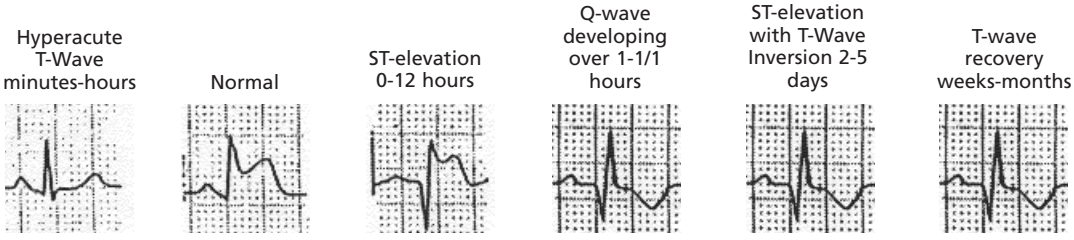


FIGURE 6-2. Progression of a non-reperfused Q-wave ("transmural") AMI

TABLE 6-1. PATHOLOGIC CAUSES OF ST SEGMENT ELEVATION

AMI
Left Ventricular Hypertrophy (LVH)
Ventricular "Aneurysm"
Pericarditis
Left Bundle Branch Block (LBBB)
Hyperkalemia
Critical illness, including neurologic conditions such as subarachnoid hemorrhage, may result in ST elevation and T-wave inversion, with ultrasonographic wall motion abnormalities mimicking AMI (328).

- Seldom higher than 2mm in individuals of age > 40
- T-waves tall but not wide like hyperacute T-waves
- Much less common in individuals of age > 55

Anterior AMI can mimic early repolarization

Small degrees of ST segment elevation, even less than 1mm, may represent AMI

- Look for hyperacute T-waves
- **Consult a previous ECG.**
- Rule out other pathologic causes of ST elevation *(see Table 6-1)*

ST SEGMENT ELEVATION AND REPERFUSION THERAPY

Criteria for thrombolytic therapy

All studies use 1 mm elevation in 2 or more limb leads as criteria for thrombolytic therapy. In the precordial leads, most studies use 2 mm elevation in 2 or more leads as their criteria. The ACC and the TIMI and TAMI Study Groups, however, use 1 mm of elevation in precordial leads. ST segment criteria are relatively crude instruments for the identification of AMI, as ST segment elevation on a single ECG is only 45% sensitive for all enzyme-diagnosed AMI (360, 52). Thus, many AMI's are not eligible for thrombolysis using these criteria; sensitivity is especially poor for CFA occlusions with resultant lateral and/or posterior AMI (358). Thus, many AMI's are not eligible for thrombolysis using these criteria; sensitivity is especially poor for CFA occlusions with resultant lateral and/or posterior AMI (358). Thus, many AMI's are not eligible for thrombolysis using these criteria; sensitivity is especially poor for CFA occlusions.

Misdiagnosis from use of ST segment "criteria" alone

Misdiagnosis may result from **inter- and intra-observer variation** in interpretation of ST elevation, which is responsible for 14% misdiagnosis (619). ST segment elevation should be assessed **in relation to QRS voltage**, because, in AMI, the ST segment may be only minimally elevated in a lead with low QRS voltage *(see Fig. 6-20, below)*. **Underdiagnosis** may occur because:

- Early subtle AMI may have **< 1 mm ST elevation**
- 2 mm precordial criteria is insensitive for **many early anterior AMI's**
- Posterior AMI, for which thrombolysis is indicated (317, 96), may have **ST depression only**

Overdiagnosis may occur due to ST elevation caused by a normal variant or by non-AMI pathologic conditions, as listed in *Table 6-1***.**

ST segment morphology

A **straight ST segment** is the most common finding in AMI, with **upward concavity** (fig. 3a-3c) the next most common (464); these are also the most common findings in the non-pathologic state. **Upward *convexity*** is *unlikely to be normal* and, although often present in AMI, it is still less common than upward concavity or straight morphologies (464). Upward convexity is also associated with larger infarct and lower ejection fraction at discharge. Examples of ST segment deviation are shown in *Figures 6-4 to 6-22*.

Predictors of poor outcome

ST segment findings should be taken into account when determining the benefit/risk ratio in administering reperfusion therapy. ST segment findings that correlate with poor outcome and large benefit to reperfusion therapy include:

- **Anterior location** (432, 433, 359, 168)
- **Greater number** of leads with ST elevation
- **Greater height** of ST segments
- **Greater number** of leads with ST depression. Mortality increases by 35% for each 0.5mV (5mm) of summed ST depression (167)
- **Total sum** of absolute ST segment deviation, whether positive or negative
- **Terminal QRS distortion** by the ST segment (see Figures 15 and 16):
  - **J-point** at height >/= 50% of R-wave height OR
  - **Disappearance of S-wave** in leads with RS configuration

Benefit of thrombolysis

In small inferior AMI with ST elevation in only 2 or 3 leads, no reciprocal changes, and no RV AMI, GISSI-1 data showed **no benefit of thrombolysis** (359,168). The Fibrinolytic Therapy Trialists Collaborative Group (FTT) data (229) showed demonstrated statistically significant **benefit of thrombolysis for lateral AMI's,** despite being frequently cited as similarly small**.** Certain exceptions exist for individual types of AMI's. ST segment findings that correlate with poor outcome and large benefit to reperfusion therapy include:These can be found in corresponding AMI sections.

Clinical predictors of poor outcome

The following findings correlate with worse prognosis and, therefore, greater benefit from reperfusion therapy (156):
Systolic Blood Pressure < 90
Pulse > 100 beats per minute
Presence of rales on physical exam
Older age

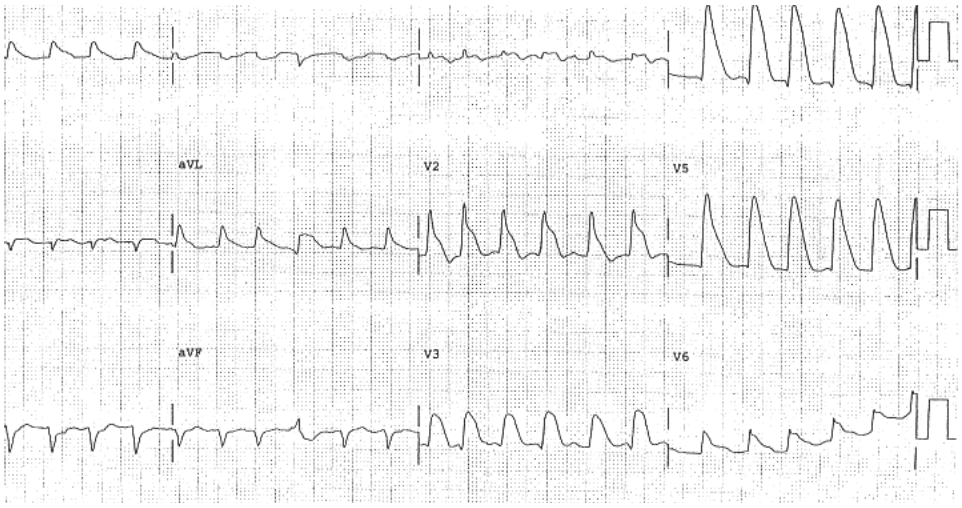
CASE 6-2

Extensive Acute Anterolateral AMI

History
This 24 year-old man presented with chest pain.

ECG 6-1 (Type 3)
- **ST elevation:** V1-V6, I, II, aVL, maximal V4 (20 mm); **ST depression:** III; **ST score:** approximately 60
- **Distorted terminal QRS:** V1-V6, I, aVL
- **Minimal Q-waves:** V2-V5
- **"Giant R-waves:"** V3-V5, in which the ST segment is as high as the R-wave (467)

Conclusion
An ECG with a high ST score has high mortality and great benefit from reperfusion therapy. This may be mistaken for ventricular tachycardia on a single lead monitor.



ANNOTATED BIBLIOGRAPHY

Measurement of the ST segment

GISSI (Gruppo Italiano Per Lo Studio Della Sopravivenza Nell'Infarto Miocardio). Effectiveness of intravenous thrombolytic treatment in acute myocardial infarction, 1986; GISSI-2 (Gruppo Italiano Per Lo Studio Della Sopravivenza Nell'Infarto Miocardio). GISSI-2: A factorial randomised trial of alteplase versus streptokinase and heparin versus no heparin among 12,490 patients with acute myocardial infarction. 1990; GUSTO Investigators. An international randomized trial comparing four thrombolytic strategies for acute myocardial infarction, 1993; Ryan TJ, et al., 1999. Update: ACC/AHA guidelines for the management of patients with acute myocardial infarction. A report of the American College of Cardiology/American Heart Association Task Force on Practice Guidelines (Committee on Management of Acute Myocardial Infarction.

Methods: As criteria for ST segment elevation, Gruppo Italiano Per Lo Studio Della Sopravivenza Nell'Infarto Miocardio-1 (**GISSI**-1) (#271) (pain duration up to 12 hours), **GISSI–2** (#251) (up to 6 hours), and **GUSTO** (#252) (up to 6 hours) used 1mm in the limb leads and 2mm in the precordial leads. **ISIS 1-4** used "suspected MI" with or without ECG changes. **TIMI** and **TAMI** study groups used 1 mm of ST elevation in any 2 consecutive leads.

Rude RE, et al. Electrocardiographic and clinical criteria for recognition of acute myocardial infarction based on analysis of 3,697 patients, 1983.

Methods: Rude et al. (360) studied ECG's of over 3000 patients with chest pain > 30 minutes.

Findings: **1mm ST elevation in any 2 consecutive leads** (*not 2mm*), or **ST depression**, **new Q waves**, or **new LBBB** was **81% sensitive for AMI** and **69% specific.** Prevalence of AMI was 49% in this entire group and the PPV was 72% for any one of the criteria above. The sensitivity of ST elevation alone for AMI was only 46% but specificity was 91%. The sensitivity of ST elevation *or* depression was 75% and specificity was 77%.

Tandberg D, et al. Observer variation in measured ST-segment elevation, 1999.

Methods: Tandberg et al. (#619) analyzed ECG interpretations by physicians, residents, and medical students who read identical pairs of ECG complexes.

Findings: There was **significant inter- and intra-observer variation** in measurement of ST elevation < / > 2 mm; 14% of ECG's were inconsistently classified.

Q waves, R waves, and QRS distortion

Raitt MH, et al. Appearance of abnormal Q waves early in the course of acute myocardial infarction: implications for efficacy of thrombolytic therapy, 1995.

Methods: Raitt et al. (171) studied ECG's of 695 patients with no previous history of MI whose admission ECG allowed prediction of infarct size based on myocardium at risk.

Findings: Of patients whose ECG was recorded within 1 hour of symptom onset, **53% already had abnormal Q-waves** on the initial ECG. As much myocardium was saved by thrombolysis in these patients as in patients without such Q-waves. Vermeer et al. (363) support these findings.

CASE 6-3

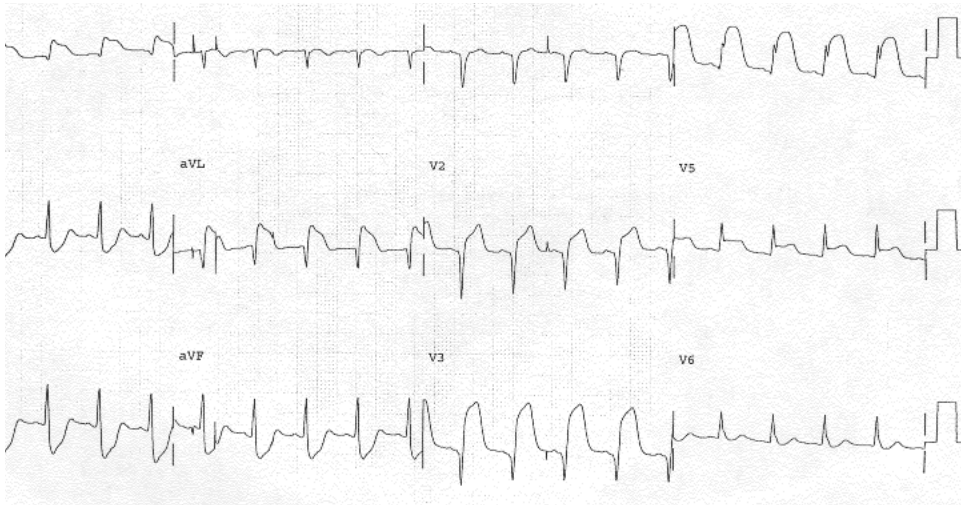
Left Main Coronary Occlusion

History
This 42 year-old man experienced onset of chest pain at 07:00, followed by syncope. Vital signs were BP=100/60, P=100, and O_2 Saturation=89% on room air.

ECG 6-3 (Type 1a)
- **Profound ST abnormalities:** 9 leads; **ST elevation:** V1-V5, I, aVL, maximal V3-V4 (approximately 10 mm); **moderately large ST score**; **ST depression:** deep, II, III, aVF. This is a common finding in patients with left main coronary occlusion who survive to the hospital
- **Q-waves:** V1-V4, I, aVL (this is common in early anterior AMI); **distorted terminal QRS:** V2-V5, I, aVL

Clinical Course
The patient's BP dropped to 69/43 mm Hg. A chest film indicated no pulmonary edema. Fluids were opened and his BP increased to 102/64 mm Hg. Thrombolytics, aspirin and hirudin were administered and the patient was taken to the Cath Lab. An 80% left main coronary occlusion was located, with TIMI grade 2 flow. The patient's BP began to drop and an intra-aortic balloon pump was placed. He was taken for emergency CABG and survived, but he suffered CHF.

Conclusion
This ECG is indicative of **high acuity, a very large amount of myocardium at risk, high mortality, and great benefit from reperfusion therapy.**



Bar FW, et al. Development of ST-segment elevation and Q- and R-wave changes in acute myocardial infarction and the influence of thrombolytic therapy, 1996.

Methods: Bar et al. (144) analyzed serial ECG's of 358 patients with reperfused and non-reperfused AMI.

Findings: Mean magnitude of fully developed Q-waves or loss of R-wave did not change after 9 hours in non-reperfused cases. **ST elevation was stabilized by 5 hours and slowly normalized over days.**

Birnbaum Y, et al. Prognostic significance of the admission electrocardiogram in acute myocardial infarction, 1996. ***Methods:*** Birnbaum et al. (146) analyzed 2603 thrombolysed patients with ST elevation and positive T-waves in at least 2 adjacent leads.

Findings: **Hospital mortality** for 1371 patients **with and** 1232 patients **without QRS distortion** (as defined above) was **6.8% and 3.8%** respectively. This was an independent predictor of mortality but the authors did not investigate whether it is independent of ST segment height. A very small study by Hasdai et al. (152), supported by data from Garcia-Rubira et al.

Madias JE. The "giant R waves" ECG pattern of hyperacute phase of myocardial infarction, 1993.

Findings: Madias (467) describes **"giant R-waves"** identical to those in Case 6-2. Madias suggests that these "giant" R-waves may represent abnormal propagation of ventricular activation, and that they are a marker of the hyperacute phase, at which time thrombolysis is most beneficial. They may simply represent a huge amount of ST elevation, causing distortion of the QRS such that the end is not definable.

ST score, infarct size, and outcomes; relation to benefit from reperfusion

Gwechenberger M, et al. Prediction of early complications in patients with acute myocardial infarction by calculation of the ST score, 1997.

Methods: Gwechenberger et al. (151) analyzed data from 243 patients. ST score was calculated by adding heights of the ST segments; ST depression was not included.

Findings: **ST score predicted complications in patients who were thrombolyzed**; a cutoff of **9mm for inferior AMI.**

Christian TF, et al. Estimates of myocardium at risk and collateral flow in acute myocardial infarction using electrocardiographic indexes with comparison to radionuclide and angiographic measures, 1995.

Methods: Christian et al. (149) utilized radionuclide and angiographic studies of 67 AMI patients to develop ECG correlates of **myocardium at risk, collateral flow, and time to reperfusion** and evaluate them as **predictors of final infarct size.**

Findings: Anterior infarct location correlated most strongly with large amount of myocardium at risk, and ST score correlated inversely with collateral flow. These 2 variables, as well as time from onset of chest pain to ECG evidence of reperfusion, correlated independently with infarct size, but the confidence intervals were wide. This suggests that **ST score is a weaker predictor of myocardium at risk than is anterior infarct location.**

Vermeer F, et al. Which patients benefit most from early thrombolytic therapy with intracoronary streptokinase? 1999; Bar FW, et al. Value of admission electrocardiogram in predicting outcome of thrombolytic therapy in acute myocardial infarction, 1987.

Methods: These two studies (363 and 285) analyzed data from 488 patients randomized to streptokinase or control.

Findings: **Infarct size limitation** by thrombolysis was greatest in patients with **electrocardiographically larger AMI's** (large new Q-waves, high ST elevation, reciprocal depression, and anterior AMI) or in those **admitted within 2 hours of symptom onset**. Patients with an **ST score < 1.2 mV who received thrombolytics did no better** than those who did not receive them**.**

Hands ME, Lloyd BL, Robinson JS, et al. Prognostic significance of electrocardiographic site of infarction after correction for enzymatic size of infarction. *Circulation* 1986;73:885-891 and Stone PH, Raabe DS, Jaffe AS, et al. Prognostic significance of location and type of MI: Independent adverse outcome associated anterior location *Journal of the American College of Cardiology* 1988;11:453-463.

Methods: These two studies (432/433) compared elevation of CK enzyme in patients with anterior vs. inferior AMI.

Findings: For any given infarct size, **anterior AMI resulted in lower ejection fraction (EF), more congestive heart failure (CHF), and greater short and long term mortality than inferior AMI.**

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