

Prognostic Value of the Admission Electrocardiogram in Acute Coronary Syndromes

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THE ELECTROCARDIOGRAM (ECG) is the most accessible and widely used diagnostic tool for patients arriving at an emergency department with symptoms suggestive of acute myocardial ischemia. Although the presence of acute ischemic changes on the admission ECG has been associated with a higher risk of cardiac events,¹ the prognostic implications of the different ECG presentations of acute myocardial ischemia remain ill-defined. Investigations of the relationship between the findings on the presenting ECG and outcome have reflected the traditional separation of acute myocardial ischemia into its different nosologic entities of Q-wave myocardial infarction (MI),²

See also pp 714 and 753.

Context The presence of ischemic changes on electrocardiogram (ECG) correlates with poorer outcomes in patients with acute chest pain.

Objective To determine the prognostic value of various ECG presentations of acute myocardial ischemia.

Design Retrospective analysis of the presenting ECGs of patients enrolled in Global Use of Strategies To Open Occluded Arteries in Acute Coronary Syndromes (GUSTO-IIb).

Setting Three hundred seventy-three hospitals in 13 countries in North America, Europe, Australia, and New Zealand.

Patients A total of 12 142 patients who reported symptoms of cardiac ischemia at rest within 12 hours of admission and had signs of myocardial ischemia confirmed by ECG. On presenting ECG, 22% of patients had T-wave inversion, 28% had ST-segment elevation, 35% had ST-segment depression, and 15% had a combination of ST-segment elevation and depression.

Main Outcome Measure Ability of presenting ECG to predict death or myocardial reinfarction during the first 30 days of follow-up.

Results The 30-day incidence of death or myocardial reinfarction was 5.5% in patients with T-wave inversion, 9.4% in those with ST-segment elevation, 10.5% in those with ST-segment depression, and 12.4% in those with ST-segment elevation and depression ($P < .001$). After adjusting for factors associated with an increased risk of 30-day death or reinfarction, compared with those who had T-wave inversion only, the odds of 30-day death or reinfarction were 1.68 (95% confidence interval [CI], 1.36-2.08) in those with ST-segment elevation, 1.62 (95% CI, 1.32-1.98) for those with ST-segment depression, and 2.27 (95% CI, 1.80-2.86) for those with combined elevation and depression. An elevated creatine kinase level at admission correlated with a higher risk of death (odds ratio [OR], 2.36; 95% CI, 1.92-2.91) and death or reinfarction (OR, 1.56; 95% CI, 1.32-1.85). The ECG category and creatine kinase level at admission remained highly predictive of death and myocardial infarction after multivariate adjustment for the significant baseline predictors of events.

Conclusions The ECG at presentation allows immediate risk stratification across the spectrum of acute coronary syndromes. An elevated creatine kinase level at admission is associated with worse outcomes.

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non-Q-wave MI,³ and unstable angina.⁴⁻⁷ However, this approach precludes a comprehensive evaluation of the prognostic value of the presenting ECG.

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The Global Use of Strategies To Open Occluded Arteries in Acute Coronary Syndromes (GUSTO-IIb) trial included 12 142 patients who presented with ischemic pain within the previous 12 hours and ECG signs of acute myocardial ischemia.⁸ Thus, we had a unique opportunity to investigate the presenting clinical characteristics and outcomes of a large population of patients with acute coronary syndromes.

METHODS

Patient Population

The GUSTO-IIb trial enrolled 12 142 patients with acute coronary syndromes in 13 countries in North America, Europe, Australia, and New Zealand. All patients had to have reported symptoms of cardiac ischemia at rest within 12 hours of their admission, and they had to have had accompanying ECG signs of acute myocardial ischemia. The primary aim of the study was to compare the effects of heparin sodium and the direct thrombin inhibitor desirudin (REVASC, Ciba-Geigy, Summit, NJ), on the composite end point of death and myocardial reinfarction in the first 30 days of follow-up.⁸ We excluded patients with active bleeding, prior stroke, a contraindication to heparin, a serum creatinine level greater than 176.8 $\mu\text{mol/L}$ (2.0 mg/dL), systolic blood pressure of more than 200 mm Hg or diastolic blood pressure of more than 110 mm Hg, and those receiving warfarin sodium at enrollment, or of childbearing potential.

ECG Classification

To be enrolled in the GUSTO-IIb trial, the patients were required to demonstrate ECG signs of myocardial ischemia consisting of either transient or persistent ST-segment elevation or depression of more than 0.05 mV, or persistent and definite T-wave inversion of more than 0.1 mV (including the normalization of a previously negative T-wave). Of the 12 142 randomized patients, 12 124 had their ECG changes categorized by the attending physician at hospital admission, and these patients form the population described in the present report; the remaining 18 had

missing data. By checking the appropriate box on the study case report form, each investigator provided the qualitative categories of the ECG criteria for each patient that form the basis for these analyses. This classification was used to evaluate a simple and practical approach toward clinical categorization of general ECG abnormalities.

The patients were divided into 4 groups on the basis of the ECG findings at presentation: (1) isolated T-wave inversions of more than 0.1 mV (including the normalization of a known negative T-wave); (2) ST-segment elevation of at least 0.05 mV in at least 2 contiguous leads; (3) ST-segment depression of greater than 0.05 mV (alone or with concomitant T-wave inversion); and (4) the combination of ST-segment elevation and depression. The 145 patients with new or previously unknown left bundle branch block were included in the group with ST-segment elevation. Of the randomized patients, 2723 (22%) had T-wave inversion alone, 3369 (28%) had ST-segment elevation, 4263 (35%) had ST-segment depression, and 1769 (15%) had a combination of ST-segment elevation and depression.

Creatine Kinase and Creatine Kinase-MB Measurements

Creatine kinase (CK) and, if available, CK-MB levels were determined at admission, at 8 and 16 hours afterward, and with any suspected reinfarction. At admission, 95.9% of the patients had a CK level measured, while CK-MB values were available for only 56.0%. Therefore, only CK values were used in this analysis, with the patients being classified as having a normal or elevated (more than twice the upper limit of the normal range for the local laboratory) serum CK level at admission. The episode leading to hospital admission was classified as an acute MI on the basis of the CK levels measured within 16 hours of symptom onset. The MI was considered to have occurred at admission if the CK level was elevated at the baseline or 8-hour sampling. If no symptoms had occurred between the admission and 16-hour samples, but the level of CK was simi-

larly high, this was also considered to indicate MI at admission. If ischemic symptoms had occurred between admission and an elevated CK level at 16 hours only, the Clinical Events Committee classified the event after reviewing all of the clinical information.

Treatment Protocol and Follow-up

Standard medical care included a daily dose of 80 to 325 mg of aspirin; anti-ischemic therapy with β -blockers, nitrates, or calcium channel blockers; and intravenous thrombolysis with either accelerated alteplase or streptokinase when indicated. In addition, the patients were randomized to receive antithrombotic treatment with either intravenous heparin or desirudin for 3 to 5 days at the discretion of the attending physician, with dose adjustments to maintain the activated partial thromboplastin time between 60 and 85 seconds.⁸ The patients were followed up according to the practices of routine care, and all information concerning them was recorded in the GUSTO-IIb case record forms until death or hospital discharge occurred, or for 30 days, whichever occurred first. For the patients discharged before the 30th day, the 30-day and 6-month follow-up consisted of a medical examination, a self-administered questionnaire, or a telephone interview.

End Points

The primary end point of GUSTO-IIb was the composite of death and myocardial reinfarction during the first 30 days of follow-up. Prospectively identified secondary end points considered for this analysis were the incidences at 30 days and 6 months of death, myocardial reinfarction, and coronary artery bypass surgery or angioplasty, and the composite of death or MI at 6 months. Myocardial (re)infarction was defined based on either cardiac enzyme or ECG evidence. Enzyme evidence of reinfarction was defined as a re-elevation of CK-MB to higher than the upper limit of normal if prior CK-MB was in the normal range, or 50% above the prior level if the prior level was above normal range. If CK-MB was not available, then total CK must have been greater than 2 times above the upper limit of normal

and increased by at least 25% or 200 U/mL more than the previous value. Electrocardiogram evidence of recurrent MI was defined as new, significant Q waves in at least 2 leads and discrete from the enrollment MI. Although the end points were originally classified by the investigators at each participating center, all were later adjudicated by the Clinical Events Committee at the GUSTO-IIb coordinating center. The committee made its determinations after review of all source documents relating to in-hospital death and myocardial reinfarction.

Statistical Analysis

Continuous variables are presented as medians and 25th and 75th percentiles, and discrete variables as frequencies and percentages. The probabilities of the 30-day and 6-month clinical outcomes are also expressed as 95% confidence intervals (CIs). Only descriptive statistics are presented for the comparison of the baseline characteristics of the 4 ECG groups.

Multivariate logistic regression techniques were used to develop a 30-day death model, and a 30-day death or reinfarction model, using the baseline characteristics as candidate predictors. A backward-elimination method was used to determine the significant predictors in each model (elimination criterion, $P > .05$). Logistic models were created to determine the effect of the ECG category and elevated CK on admission on 30-day death and 30-day death or reinfarction, after adjusting for the baseline predictors. The interaction between the ECG category and an elevated CK level was tested to determine whether the effect of the latter was similar across categories. Statistical testing for all models was performed using the Wald χ^2 test. Results are also presented as odds ratios (ORs) and 95% CIs. A $P < .05$ was considered statistically significant.

RESULTS

Baseline Characteristics

The baseline characteristics of the patients, divided on the basis of the features of their presenting ECG, are shown in TABLE 1. Patients presenting with ST-

segment elevation or ST-segment elevation and depression were more likely to be men and current smokers. Those with T-wave inversion or ST-segment depression had a higher prevalence of hypercholesterolemia and hypertension, and a longer history of coronary disease, as is shown by a higher prevalence of previous angina, MI, angioplasty, or bypass surgery. Coronary angiography, which was performed in 6957 patients (57%) during hospitalization, showed that the highest incidence of normal coronary arteries or insignificant coronary disease was in the group with T-wave inversion (19%), and the highest incidence of 3-vessel disease occurred in the group

with ST-segment depression (36%). Patients with ST-segment elevation or ST-segment elevation and depression were more likely to have single-vessel disease. The patients with ST-segment depression had the worst overall risk profile; they were older and had a worse Killip class, and more of them had diabetes, prior bypass surgery, a history of heart failure, or 3-vessel disease. The medications and procedures used in the trial are summarized in TABLE 2.

Clinical Outcomes According to the Presenting ECG

The incidence of the primary end point of death and reinfarction, and of its com-

Table 1. Baseline Characteristics of the Patients, According to the Prevailing Changes in T-Wave and ST-Segment on the Admission Electrocardiogram*

| Characteristic | Isolated T-Wave Inversion (n = 2723) | ST-Segment | | |
|-------------------------------------|--------------------------------------|----------------------|-----------------------|-------------------------------------|
| | | Elevation (n = 3369) | Depression (n = 4263) | Elevation and Depression (n = 1769) |
| Men | 68 | 76 | 64 | 75 |
| Age, y† | 63 (54-71) | 63 (53-72) | 67 (59-75) | 64 (55-71) |
| Weight, kg† | 77 (68-88) | 77 (68-87) | 75 (66-85) | 77 (69-86) |
| Systolic blood pressure, mm Hg† | 136 (120-150) | 130 (118-149) | 140 (122-155) | 130 (114-149) |
| Diastolic blood pressure, mm Hg† | 80 (70-90) | 80 (70-90) | 80 (70-90) | 80 (70-90) |
| Heart rate, beats/min† | 70 (62-80) | 74 (64-85) | 76 (66-89) | 74 (63-85) |
| Killip class | | | | |
| I | 91 | 89 | 85 | 86 |
| II | 8 | 10 | 13 | 12 |
| III | <1 | 1 | 2 | 1 |
| IV | <1 | <1 | <1 | <1 |
| Prior myocardial infarction | 32 | 20 | 32 | 20 |
| Prior bypass surgery | 11 | 6 | 13 | 6 |
| Prior angioplasty | 11 | 7 | 10 | 6 |
| Prior angina | 77 | 52 | 78 | 52 |
| Hypertension | 45 | 41 | 51 | 42 |
| Diabetes | 16 | 17 | 20 | 17 |
| Hypercholesterolemia | 41 | 36 | 42 | 36 |
| Prior congestive heart failure | 5 | 4 | 8 | 4 |
| Prior cerebrovascular disease | 3 | 2 | 4 | 2 |
| Former smoker | 35 | 29 | 37 | 30 |
| Current smoker | 29 | 40 | 23 | 39 |
| Myocardial infarction at enrollment | 32 | 81 | 48 | 89 |
| No. diseased vessels | (n = 1466) | (n = 1864) | (n = 2170) | (n = 899) |
| 0 | 19 | 10 | 11 | 5 |
| 1 | 35 | 45 | 26 | 42 |
| 2 | 25 | 27 | 28 | 28 |
| 3 | 21 | 18 | 36 | 25 |
| Time to treatment h† | 6 (4-10) | 4 (3-7) | 6 (4-9) | 4 (3-6) |

*Values are percentages unless otherwise indicated. Percentages may not total 100 due to rounding.

†Values are presented as median (25th-75th percentile).

ponents, is shown in TABLE 3. At 30 days, the patients presenting with T-wave inversion had the lowest incidence of death or reinfarction ($P < .001$ vs each of the other groups), followed, in order, by the ST-segment elevation, the ST-segment depression, and the ST-segment elevation plus depression groups. The difference between the ST-segment depression and the ST-segment elevation groups was not statistically significant, whereas the group with ST-segment elevation and depression had a significantly higher incidence of events in comparison with both

the ST elevation ($P = .001$) and the ST depression groups ($P = .03$). At 6 months, the group with T-wave inversion still had a much lower incidence of events ($P < .001$ vs each of the other groups). The group with ST-segment elevation had an intermediate incidence, and the 2 groups with ST-segment depression (alone or with ST-segment elevation) had the highest incidence of events (both $P < .001$ vs ST-segment elevation).

The largest difference in mortality was observed between the group with T-wave inversion and the other groups. The probability of death was highest during

the first few days in the 2 groups with ST-segment elevation, but then tended to plateau in the group with ST-segment elevation alone (FIGURE, upper panel). On the other hand, the probability of early death was lower in the group presenting with ST-segment depression, but tended to increase over time and the mortality rate in this group at 6 months was not different from that of the group with ST-segment elevation plus depression (Figure, lower panel).

Prognostic Importance of Elevated CK Levels at Admission

On admission, an elevated level of CK was found in 10.9% of the patients with T-wave inversion, 15.7% of those with ST-segment elevation, 10.9% of those with ST-segment depression, and 11.5% of those with ST-segment elevation and depression. The 30-day incidences of death and death or reinfarction were greater when the CK level on admission was elevated (TABLE 4), with an OR of 2.36 (95% CI, 1.92-2.91) for 30-day death and 1.56 (95% CI, 1.32-1.85) for 30-day death or reinfarction.

Within 16 hours of admission, 32% of the patients with T-wave inversion, 81% of those with ST-segment elevation, 48% of those with ST-segment depression, and 89% of those with ST-segment elevation and depression had developed an acute MI. The median peak levels of CK were 124 U/L (25th and 75th percentile, 68 and 327 U/L) in patients with isolated T-wave inversion, 923 U/L (286 and 2190 U/L) in those with ST-segment elevation, 206 U/L (84 and 622 U/L) in those with ST-segment depression, and 1172 U/L (480 and 2355 U/L) in those with ST-segment elevation and depression.

Multivariate Modeling

Increased age, a higher Killip class, smoking, a previous MI, peripheral vascular disease, and hypertension were associated with increased 30-day death. Increased age, a higher Killip class, increased heart rate, diabetes, peripheral vascular disease, previous angina, and hypertension were associated with increased 30-day death or reinfarction. Af-

Table 2. Medications Given and Procedures Performed During Hospitalization in Patients With Acute Coronary Syndromes, by Electrocardiogram Category*

| Medication† or Procedure | Isolated T-Wave Inversion (n = 2723) | ST-Segment | | |
|------------------------------------------|--------------------------------------|----------------------|-----------------------|-------------------------------------|
| | | Elevation (n = 3369) | Depression (n = 4263) | Elevation and Depression (n = 1769) |
| Angiotensin-converting enzyme inhibitors | 22 | 37 | 30 | 34 |
| β-Blockers | | | | |
| Intravenous | 6 | 16 | 9 | 19 |
| Oral | 70 | 69 | 69 | 73 |
| Any | 70 | 70 | 70 | 75 |
| Calcium channel blockers | 51 | 31 | 55 | 29 |
| Thrombolytics | 3 | 60 | 4 | 67 |
| Aspirin | 94 | 94 | 94 | 94 |
| Coronary angiography | 59 | 60 | 56 | 54 |
| Bypass surgery | 12 | 8 | 15 | 10 |
| Angioplasty | 21 | 31 | 19 | 28 |

*Values are expressed as percentages.

†All patients were also randomized to receive intravenous heparin or desirudin.

Table 3. Major Clinical Outcomes During the 30-Day and 6-Month Follow-up by Electrocardiographic Category*

| Outcome | Isolated T-Wave Inversion (n = 2723) | ST-Segment | | |
|-----------------------|--------------------------------------|----------------------|-----------------------|-------------------------------------|
| | | Elevation (n = 3369) | Depression (n = 4263) | Elevation and Depression (n = 1769) |
| 30 Days | | | | |
| Death | 1.7 (1.3-2.3) | 5.1 (4.4-6.0) | 5.1 (4.5-5.9) | 6.6 (5.5-7.9) |
| Reinfarction | 4.2 (3.4-5.0) | 5.0 (4.3-5.8) | 7.0 (6.3-7.8) | 7.1 (5.9-8.4) |
| Death or reinfarction | 5.5 (4.7-6.4) | 9.4 (8.4-10.4) | 10.5 (9.6-11.5) | 12.4 (10.9-14.0) |
| Angioplasty | 22.3 (20.8-24.0) | 31.7 (30.1-33.3) | 19.7 (18.5-20.9) | 28.9 (26.8-31.1) |
| Bypass surgery | 14.2 (13.0-15.6) | 8.9 (7.9-9.9) | 18.0 (16.9-19.2) | 10.7 (9.4-12.3) |
| Any revascularization | 35.6 (33.8-37.4) | 39.3 (37.6-41.0) | 36.8 (35.4-38.3) | 38.1 (35.9-40.5) |
| 6 Months | | | | |
| Death | 3.4 (2.8-4.2) | 6.8 (6.0-7.8) | 8.9 (8.1-9.8) | 9.1 (7.8-10.6) |
| Reinfarction | 5.4 (4.6-6.4) | 6.8 (6.0-7.7) | 9.2 (8.4-10.2) | 8.9 (7.6-10.4) |
| Death or reinfarction | 8.1 (7.1-9.3) | 12.3 (11.2-13.5) | 15.4 (14.3-16.5) | 15.7 (14.1-17.5) |

*All values are presented as percentage (95% confidence interval). The P value is $< .001$ for all outcomes except any revascularization, which is $< .02$. The P values are a test for differences across the 4 electrocardiographic categories and based on likelihood ratio χ^2 test.

ter adjusting for the significant baseline predictors and elevated CK on admission, the ECG category at presentation was highly significant in predicting both death or reinfarction (χ^2 , 48.53; $P < .001$) and death (χ^2 , 42.32; $P < .001$) at 30 days. In comparison with the group with T-wave inversion only, the ORs for death or reinfarction at 30 days were 1.68 (95% CI, 1.36-2.08) for the group with ST-segment elevation, 1.62 (95% CI, 1.32-1.98) for the group with ST-segment depression, and 2.27 (95% CI, 1.80-2.86) for the group with ST-segment elevation and depression. The respective ORs for 30-day death were 2.59 (95% CI, 1.47-2.92), 2.07 (95% CI, 1.82-3.69), and 3.29 (95% CI, 2.27-4.79).

After adjusting for the significant baseline predictors and ECG category, an elevated CK level at admission remained highly predictive of both outcomes (χ^2 , 44.72 for death and 21.18 for death or reinfarction; both $P < .001$). Although the interaction between the ECG category and an elevated CK level on admission was not significant for either outcome, the impact of elevated CK appeared to be limited to the groups with ST-segment deviation.

COMMENT

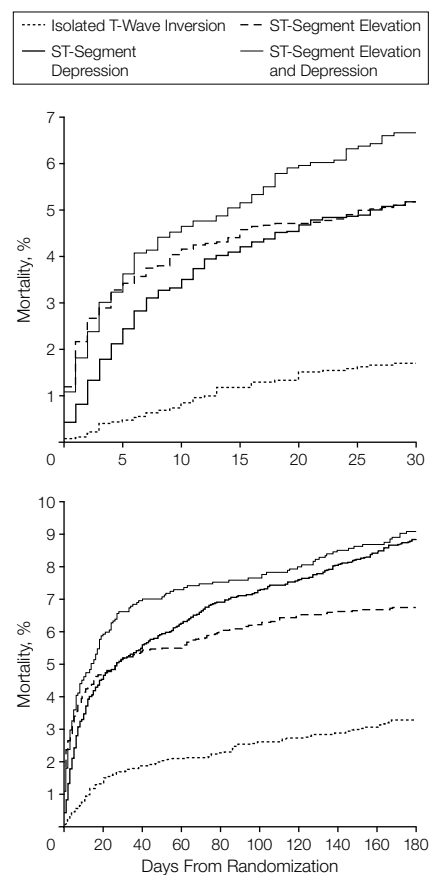
The GUSTO-III trial enrolled the whole spectrum of patients with acute coronary syndromes presenting with chest pain and ECG signs of myocardial ischemia.⁸ By excluding patients without ECG changes, who have been shown to be at

low short- and long-term risk,^{1,5,9-13} the trial selected a population at high risk for cardiac events. The present analysis shows that patients with these characteristics continue to manifest a high incidence of death and MI despite state-of-the-art therapy with aspirin, a thrombin inhibitor, thrombolysis, revascularization procedures, or all of these. Based on our results, the first 2 diagnostic tools available in the emergency department, the ECG and CK determinations, may allow bedside risk stratification and prediction of cardiac events.

The ECG was capable of discriminating the risk of developing cardiac events during short- and long-term follow-up. The higher rates of early events in the 2 groups with ST-segment elevation may well be explained by the higher incidence of MI (>80%), which carries an immediate risk of death due to fatal arrhythmias, left ventricular failure, and cardiac rupture. On the other hand, in the patients with ST-segment depression only, the incidence of early events was lower but continued to increase during follow-up, as has been reported in previous studies.^{3,5,14-16} Mortality during follow-up has been attributed to reinfarction and congestive heart failure, particularly in elderly patients, and may reflect the higher incidence of severe coronary disease and left ventricular dysfunction observed in these patients.^{3,14} In keeping with these considerations, the group with ST-segment elevation and depression should have the worst prognosis because, as

shown in the present study, it is at high risk of both early and later events. In comparison with patients with ST-segment elevation alone, patients with ST-segment

Figure. Kaplan-Meier Estimates of Probability of Death



Top, mortality rate up to 30 days. Bottom, mortality rate to 6 months.

Table 4. Incidence of Death and Death or Reinfarction at 30 Days and 6 Months According to the Electrocardiogram at Presentation and Creatine Kinase (CK) Level at Enrollment*

| Outcome | Isolated T-Wave Inversion | | ST-Segment | | | | | |
|-----------------------|---------------------------|-------------------------|--------------------------|-------------------------|--------------------------|-------------------------|--------------------------|-------------------------|
| | Elevated CK (n = 282) | Normal CK (n = 2295) | Elevation | | Depression | | Elevation and Depression | |
| | | | Elevated CK (n = 508) | Normal CK (n = 2723) | Elevated CK (n = 444) | Normal CK (n = 3643) | Elevated CK (n = 195) | Normal CK (n = 1500) |
| 30 Days | | | | | | | | |
| Death or reinfarction | 5.3 (3.0-8.6) | 5.6 (4.7-6.6) | 13.2 (10.4-16.5) | 8.6 (7.6-9.8) | 16.7 (13.4-20.5) | 9.7 (8.8-10.8) | 16.4 (11.6-22.6) | 11.9 (10.4-13.7) |
| Death | 1.8 (0.6-4.1) | 1.7 (1.2-2.3) | 8.7 (6.4-11.6) | 4.5 (3.7-5.3) | 11.3 (8.5-14.7) | 4.3 (3.7-5.0) | 14.4 (9.9-20.3) | 5.7 (4.6-7.0) |
| 6 Months | | | | | | | | |
| Death or reinfarction | 8.0 (5.2-12.0) | 8.3 (7.2-9.5) | 16.4 (13.4-20.0) | 11.4 (10.3-12.7) | 21.7 (18.0-26.0) | 14.6 (13.5-15.8) | 18.7 (13.5-25.1) | 15.6 (13.8-17.5) |
| Death | 3.2 (1.5-6.1) | 3.5 (2.8-4.4) | 11.2 (8.7-14.4) | 6.0 (5.2-7.0) | 14.8 (11.7-18.6) | 8.0 (7.2-9.0) | 15.4 (10.8-21.4) | 8.5 (7.1-10.1) |

*Elevated CK levels are defined as a level greater than twice the upper limit of normal for the local laboratory for the admission sample. All data are presented as percentage (95% confidence interval).

elevation and depression were similar with regard to baseline characteristics, risk factors, and most treatments. Nevertheless, the angiographic data show that they had more severe coronary artery disease. In addition, the present data and a recent study from the Global Utilization of Streptokinase and TPA (alteplase) for Occluded Coronary Arteries (GUSTO-I) database¹⁷ show that patients with ST-segment elevation and depression have larger infarctions, as shown by higher peak CK levels, more congestive heart failure symptoms, and worse left ventricular ejection fractions. Thus, in patients presenting with ST-segment elevation, associated ST-segment depression is a marker of worse prognosis, particularly in the long term, perhaps deserving more intensive treatment and follow-up.

The patients with isolated T-wave inversion had a relatively benign prognosis compared with the other groups, particularly in terms of mortality. This group showed less severe coronary disease at angiography, with about 20% of patients having nonsignificantly diseased arteries. However, the prevalence of risk factors and previous cardiac events was similar to that of patients with ST-segment depression and, during follow-up, they underwent revascularization procedures at a rate similar to that of the groups with a worse prognosis.

In this large multicenter trial, we used a simple classification of the presenting ECG, suitable to be used by any physician in the emergency department; this qualitative classification allows an immediate stratification of the risk over time of death and reinfarction. Although it was not the intent of the current analysis, possibly a more sophisticated gradation of risk could be determined within each ECG category by accounting for the magnitude and location of ST-segment shift and T-wave inversion.^{2,5,18-20} Later during a hospital stay, the development of Q waves in multiple leads²¹ and the persistence of ST-segment depression could provide additional²² ECG predictors of death.

The prognostic importance of myocardial necrosis is well-known and has been recently confirmed across the spectrum of acute coronary syndromes.²³ The

simple baseline ECG classification used in this study provides an immediate estimate of the likelihood that the patient is experiencing an acute MI, which is 32% in patients with T-wave inversion, 48% in those with ST-segment depression, 81% in those with ST-segment elevation, and 89% in those with ST-segment elevation and depression. However, even among patients who had evolving acute MI with CK elevation during the first 16 hours, CK levels at presentation were elevated in only a minority. The CK elevation at presentation was associated with a worse prognosis, especially among patients with ST-segment shifts. Further investigation is warranted to determine the reason for worse outcomes with CK elevation at presentation even among patients with ST-segment elevation.

A worse outcome in patients with myocardial damage has been shown in smaller studies of more sensitive biochemical markers of myocyte injury, such as troponin T,²⁴⁻²⁶ troponin I,²⁷ and myosin light chains.²⁸ These more specific markers extend the continuum of myocardial damage to lower levels of cell necrosis, and recent studies have shown their incremental prognostic value in comparison with CK.²⁵⁻²⁸ Although these markers may improve the power of enzymatic-risk stratification, the simple approach suggested by our present study has these advantages: (1) it can be more immediately and more widely applied, and (2) it is valid across the spectrum of acute coronary syndromes. In the present study (carried out in 373 hospitals in 13 countries), CK-MB was determined in only 56% of the cases; in the more recent GUSTO-III trial (conducted in 807 hospitals in 20 countries, and comparing 2 thrombolytic agents in acute MI), this percentage was even lower at 34%.²⁹ These data underscore the fact that, in most cases, the initial approach to acute coronary syndromes is based solely on the standard 12-lead ECG and total serum CK determinations.

In conclusion, this study demonstrates that the ECG result and CK level on admission can identify a difference in mortality between 1.7% (in the group with T-wave inversion and normal CK level) and

14.4% (in the group with ST-segment elevation plus depression and elevated CK level). The simple stratification model offered by the 2 diagnostic tools most widely available at the time of hospital admission may be extremely useful for more effective targeting of intervention trials in acute coronary syndromes.

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Knowledge is static; wisdom is active and moves knowledge, making it effective.

—William J. Mayo (1861-1939)

The essence of wisdom is the ability to make the right decision on the basis of inadequate evidence.

—Alan Gregg (1890-1957)

Knowledge is a process of piling up facts; wisdom lies in their simplification.

—Martin H. Fischer (1879-1962)