MISSED DIAGNOSES OF ACUTE CARDIAC ISCHEMIA IN THE EMERGENCY DEPARTMENT

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ABSTRACT

Background Discharging patients with acute myocardial infarction or unstable angina from the emergency department because of missed diagnoses can have dire consequences. We studied the incidence of, factors related to, and clinical outcomes of failure to hospitalize patients with acute cardiac ischemia.

Methods We analyzed clinical data from a multicenter, prospective clinical trial of all patients with chest pain or other symptoms suggesting acute cardiac ischemia who presented to the emergency departments of 10 U.S. hospitals.

Results Of 10,689 patients, 17 percent ultimately met the criteria for acute cardiac ischemia (8 percent had acute myocardial infarction and 9 percent had unstable angina), 6 percent had stable angina, 21 percent had other cardiac problems, and 55 percent had noncardiac problems. Among the 889 patients with acute myocardial infarction, 19 (2.1 percent) were mistakenly discharged from the emergency department (95 percent confidence interval, 1.1 to 3.1 percent); among the 966 patients with unstable angina, 22 (2.3 percent) were mistakenly discharged (95 percent confidence interval, 1.3 to 3.2 percent). Multivariable analysis showed that patients who presented to the emergency department with acute cardiac ischemia were more likely not to be hospitalized if they were women less than 55 years old (odds ratio for discharge, 6.7; 95 percent confidence interval, 1.4 to 32.5), were nonwhite (odds ratio, 2.2; 1.1 to 4.3), reported shortness of breath as their chief symptom (odds ratio, 2.7; 1.1 to 6.5), or had a normal or nondiagnostic electrocardiogram (odds ratio, 3.3; 1.7 to 6.3). Patients with acute infarction were more likely not to be hospitalized if they were nonwhite (odds ratio for discharge, 4.5; 95 percent confidence interval, 1.8 to 11.8) or had a normal or nondiagnostic electrocardiogram (odds ratio, 7.7; 95 percent confidence interval, 2.9 to 20.2). For the patients with acute infarction, the risk-adjusted mortality ratio for those who were not hospitalized, as compared with those who were, was 1.9 (95 percent confidence interval, 0.7 to 5.2), and for the patients with unstable angina, it was 1.7 (95 percent confidence interval, 0.2 to 17.0).

Conclusions The percentage of patients who present to the emergency department with acute myocardial infarction or unstable angina who are not hospitalized is low, but the discharge of such patients may be associated with increased mortality. Failure to hospitalize is related to race, sex, and the absence of typical features of cardiac ischemia. Efforts to reduce the number of missed diagnoses are warranted. (N Engl J Med 2000;342:1163-70.)

THE failure to hospitalize patients with acute myocardial infarction or unstable angina who present to the emergency department is a serious public health issue. Previous studies have found that between 2 percent and 8 percent of patients with acute myocardial infarction who present to the emergency department are sent home.[1-4] As many as 1.1 million patients have myocardial infarctions annually in the United States,[5] about half of whom come to emergency departments. The rate of discharge of such patients represents at least 11,000 missed diagnoses of myocardial infarction per year. In addition, nearly twice as many patients come to emergency departments with unstable angina pectoris,[2] but the rates of missed diagnosis and failure to hospitalize such patients are not known.

We undertook this study to determine the incidence of failure to hospitalize patients who presented to the emergency department with acute cardiac ischemia (i.e., either acute myocardial infarction or unstable angina, also known as acute coronary syndromes), to identify factors related to inadvertent discharge from the emergency department, and to analyze the clinical outcomes of patients who were sent home.

METHODS

Study Patients

Included in this study were the 10,689 patients in the prospective, multicenter Acute Cardiac Ischemia Time-Insensitive Predictive Instrument (ACI-TIPI) trial.[6] To be eligible for the study, patients had to be at least 30 years old and had to have come to the emergency department with a chief symptom of chest, left-arm, jaw, or epigastric pain or discomfort; shortness of breath; dizziness; palpitations; syncope; or other symptoms suggestive of acute ischemia. Of all 11,618 eligible patients, 92 percent were included in the study. The patients who were excluded did not differ significantly from the study patients with regard to either sex or race.

Collection of Data

For 7 months beginning in May 1993, data were collected on patients on arrival in the emergency department, during hospitalization, and at 30 days of follow-up. The data of interest included

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sociodemographic information, clinical features at presentation and at follow-up, electrocardiographic findings, and the results of serial measurements of creatine kinase MB (CK-MB). The patients who were not hospitalized returned within 24 to 72 hours after their initial presentation for repeated evaluation, 12-lead electrocardiography, and CK-MB measurement. The follow-up rate for the collection of data needed for the definitive assignment of a diagnosis, including data on patients who were not hospitalized, was 99 percent.[6]

Analysis of Data

Confirmed diagnoses were assigned by the physicians at the study sites according to the criteria of the World Health Organization[7] on the basis of symptoms and signs at presentation, clinical course, initial and follow-up electrocardiography, and CK-MB measurements. The severity of myocardial infarction was rated according to Killip class,[8] and the severity of angina according to both Canadian Cardiovascular Society class[9] and time elapsed since the onset or worsening of symptoms. According to the criteria of the ACI-TIPI trial,[6] unstable angina was defined as Canadian Cardiovascular Society class 4 or as class 3 with new symptoms or symptoms that changed within three days after onset; stable angina was defined as Canadian Cardiovascular Society class 3 without changes in symptoms within three days before presentation, or as class 2 or class 1.

The electrocardiographic variables designated as indicating ischemia or infarction when present in at least two anatomically contiguous leads were as follows: pathologic Q waves (≥1 mm in depth and 0.3 second in duration), ST-segment elevation or depression of 1 mm or more, and elevated or inverted T waves. The ST-segment and T-wave abnormalities were not considered potentially indicative of ischemia when any of the following were present: left ventricular hypertrophy, left or right bundle-branch block, early repolarization variant, or an implanted pacemaker.

Electrocardiograms were considered to be normal or nondiagnostic if they showed less than 1 mm of ST-segment elevation or depression, no T-wave inversion, and no pathologic Q waves in two contiguous leads and if they showed no evidence of second- or third-degree heart block or of a new conduction abnormality.

Study Sites

The 10 study hospitals included public, private, community, and tertiary care hospitals with urban, suburban, and semirural catchment areas in the midwestern, southeastern, and northeastern United States. All sites employed residents in internal medicine; four employed residents in emergency medicine. The sites were Baystate Medical Center, Springfield, Mass.; Boston City Hospital, Boston; Boston University Medical Center, Boston; Medical College of Virginia, Richmond; Medical College of Wisconsin, Milwaukee; New England Medical Center, Boston; Newton–Wellesley Hospital, Newton, Mass.; Rhode Island Hospital, Providence; the University of Cincinnati Medical Center, Cincinnati; and the University of North Carolina Hospitals, Chapel Hill.

Statistical Analysis

Rates of mistaken discharge were compared among groups of patients with different demographic or clinical characteristics with the use of chi-square tests for dichotomous variables and Fisher's exact tests for nominal variables with more than two categories (race or ethnic group, location of rales, Killip class, age group, and the presence or absence of ST-segment and T-wave abnormalities). Logistic regression was used to explore univariate associations between continuous variables (age and blood pressure) and outcome. All statistical tests were two-sided. Stepwise regression was used to build multivariable models, in which age, sex, presence of rales, history with respect to diabetes, history with respect to hypertension, race or ethnic group, presence or absence of shortness of breath as the chief symptom, presence or absence of abdominal pain, and electrocardiographic features could be included.

Risk-adjusted mortality ratios and 95 percent confidence intervals were computed with use of the results from a mortality-prediction model, published elsewhere.[10] This logistic-regression model calculates expected probabilities of death associated with acute ischemia among patients who present to the emergency department, on the basis of age, systolic blood pressure, and electrocardiographic features. We multiplied the probability of death calculated with the use of the model (which was based on data from 1980) by a constant, so that the overall predicted mortality was consistent with the data from this study. There was good calibration of predicted and actual mortality rates across the entire range of probabilities of mortality.

RESULTS

Of the 10,689 study patients, 1866 (17 percent) ultimately met the criteria for acute cardiac ischemia: 894 (8 percent) had acute myocardial infarction, and 972 (9 percent) had unstable angina. In addition, 673 patients (6 percent) had stable angina, 2241 (21 percent) had nonischemic cardiac problems, and 5909 (55 percent) had noncardiac problems. Of the 894 patients with acute myocardial infarction, 5 left the hospital against medical advice, leaving 889 patients; thus the rate of missed diagnoses of myocardial infarction for those who were not hospitalized was 2.1 percent (19 of 889) (95 percent confidence interval, 1.1 to 3.1 percent). Of the 972 patients with unstable angina, 6 left against medical advice; thus the rate of missed diagnosis of unstable angina for those who were not hospitalized was 2.3 percent (22 of 966) (95 percent confidence interval, 1.3 to 3.2 percent). Rates of missed diagnoses of acute myocardial infarction at the 10 sites ranged from 0 to 11.1 percent, with 4 sites having rates of more than 1 percent (1.4 percent, 5.1 percent, 5.2 percent, and 11.1 percent). Rates of missed diagnosis of unstable angina ranged from 0 to 4.3 percent, with five sites having rates of more than 1 percent (2.0 percent, 3.1 percent, 3.8 percent, 4.3 percent, and 4.3 percent).

A review of the medical records of all 19 patients with a missed diagnosis of acute myocardial infarction showed that 79 percent (15 patients) were seen by an attending physician, either alone or with a resident. The most common diagnoses given to these patients at discharge from the emergency department were noncardiac chest pain (47 percent [nine patients]), pulmonary conditions (16 percent [three patients]), and stable angina (11 percent [two patients]). A previously recorded electrocardiogram was available in the emergency department for comparison in the cases of 26 percent (five patients). Review of the 19 patients' electrocardiograms by an experienced cardiologist who was unaware of the patients' outcomes yielded disagreement with the interpretations by emergency department physicians in the cases of 2 patients (11 percent). In one case, the emergency department physician interpreted the electrocardiogram as showing left ventricular hypertrophy with strain, but the cardiologist interpreted it as showing left ventricular hypertrophy with ischemia. In the other case, the find-

ings interpreted by the emergency department physician as indicating right bundle-branch block were found, on review, to show old inferior infarction and new anterior infarction. Among the remaining 17 patients with myocardial infarction who were sent home, for whom there was agreement in interpretation of the electrocardiograms between the emergency department clinician and the cardiologist, the most frequent findings at presentation were secondary ST-segment or T-wave abnormalities in association with left ventricular hypertrophy, left bundle-branch block, early repolarization variant, or pericarditis (47 percent [8 patients]); minor ST-segment abnormalities with less than 1 mm of ST-segment deviation (41 percent [7 patients]); and no abnormalities (12 percent [2 patients]). Even after follow-up electrocardiograms were taken into account, 14 of the 19 patients with myocardial infarction who were discharged (74 percent) had non–Q-wave infarctions that could not be ascribed to a specific location.

Records of the patients with unstable angina who were sent home (21 of the 22 records were available) showed that 86 percent (18 patients) were evaluated by an attending physician and 29 percent (6 patients) by a consulting cardiologist; some patients were evaluated by both. The most common diagnoses made in the emergency department were stable angina (48 percent [10 patients]), atypical chest pain (24 percent [5 patients]), and unstable angina (14 percent [3 patients]). Of the three patients given a diagnosis of unstable angina, one was discharged by the consulting cardiologist, one was discharged by the emergency department physician but was scheduled to return for a stress test on an outpatient basis, and one was discharged by his internist but scheduled to return for follow-up in 24 hours. A previously recorded electrocardiogram was available in the emergency department for comparison for 24 percent (five patients). Review of the patients' electrocardiograms by an experienced cardiologist who was unaware of the patients' outcomes produced disagreement with the interpretations by the emergency department physician for 3 of the 19 patients for whom records were available who were sent home (16 percent): three electrocardiograms interpreted as normal by the emergency department clinician were interpreted by the cardiologist as showing nondiagnostic ST-segment or T-wave abnormalities. Among the 16 patients with electrocardiograms for which there was agreement in interpretation, 50 percent (8 patients) had nondiagnostic ST-segment or T-wave abnormalities, 25 percent (4 patients) had secondary ST-segment or T-wave abnormalities (i.e., left ventricular hypertrophy, left bundle-branch block, early repolarization variant, or pericarditis), 12 percent (2 patients) had previous myocardial damage, and 12 percent (2 patients) were normal.

Table 1 shows the rates of failure to hospitalize patients with acute cardiac ischemia according to clinical features. The patients who were not hospitalized were more likely to have been nonwhite, to have had a chief symptom of shortness of breath, and to have had a normal electrocardiogram. Among those with acute myocardial infarction, women were more likely not to have been hospitalized, as were those who were nonwhite and those with a chief symptom of shortness of breath or a normal electrocardiogram. Among the patients with unstable angina, those with Canadian Cardiovascular Society class 3 unstable angina were more likely to have been discharged than those with class 4 unstable angina.

Multivariable analyses (Table 2) for all the patients with acute cardiac ischemia showed that the following factors were independently associated with not being hospitalized: female sex combined with an age of less than 55 years, nonwhite race, a chief reported symptom of shortness of breath (rather than chest pain), and a normal electrocardiogram. Among the patients with acute myocardial infarction, not being hospitalized was associated with nonwhite race and a normal electrocardiogram.

Among the patients with acute myocardial infarction who presented to the emergency department, the readmission rate within 30 days after presentation for those not hospitalized was 72 percent, as compared with a readmission rate of 17 percent for those who were initially hospitalized. Among the patients with unstable angina, the 30-day admission rate for those not hospitalized was 50 percent, as compared with a readmission rate of 21 percent for those who were initially hospitalized. No patient with acute myocardial infarction who was discharged was lost to follow-up, and only one patient with unstable angina who was discharged was lost to follow-up.

As Table 3 shows, for the patients with acute myocardial infarction, the unadjusted 30-day mortality rates were nearly identical for those who were not hospitalized and those who were: 10.5 percent and 9.7 percent, respectively. However, the predicted 30-day mortality rates adjusted for risk were 5.5 percent and 9.8 percent. Thus, the risk-adjusted ratio of observed to predicted mortality showed that the nonhospitalized patients with myocardial infarction had a risk of death that was 1.9 times that of the patients who were hospitalized (95 percent confidence interval, 0.7 to 5.2). For the patients with unstable angina, the 30-day mortality rates were 5.0 percent for those who were not hospitalized and 2.1 percent for those who were. The adjusted risk of death for those who were not hospitalized was 1.7 times that of those who were hospitalized (95 percent confidence interval, 0.2 to 17.0).

DISCUSSION

We undertook an evaluation of patients who presented to the emergency department with acute myocardial infarction or unstable angina but in whom

TABLE 1. RATES OF FAILURE TO HOSPITALIZE AMONG PATIENTS WITH ACUTE CARDIAC ISCHEMIA ACCORDING TO CLINICAL FEATURES AT PRESENTATION.*

VARIABLE	ALL PATIENTS			PATIENTS WITH ACUTE MYOCARDIAL INFARCTION			PATIENTS WITH UNSTABLE ANGINA		
	TOTAL NO. OF PATIENTS	PERCENTAGE NOT HOSPITALIZED (NO.)	P VALUE	TOTAL NO. OF PATIENTS	PERCENTAGE NOT HOSPITALIZED (NO.)	P VALUE	TOTAL NO. OF PATIENTS	PERCENTAGE NOT HOSPITALIZED (NO.)	P VALUE
Final diagnosis of acute cardiac ischemia	1855	2.2 (41)		889	2.1 (19)		966	2.3 (22)	
Acute myocardial infarction									
Killip class 1				602	2.8 (17)	0.28			
Killip class 2				153	1.3 (2)				
Killip class 3				100	0				
Killip class 4				34	0				
Unstable angina†									0.11
CCS class 3							289	3.5 (10)	
CCS class 4							677	1.8 (12)	
Age‡			0.61 (0.98)			0.62 (0.97)			0.94 (0.93)
30–39 yr	35	0		15	0		20	0	
40–49 yr	223	3.1 (7)		120	3.3 (4)		103	2.9 (3)	
50–59 yr	340	2.1 (7)		170	2.4 (4)		170	1.8 (3)	
60–69 yr	472	1.7 (8)		221	0.9 (2)		251	2.4 (6)	
70–79 yr	523	2.1 (11)		234	2.1 (5)		289	2.1 (6)	
80–89 yr	234	3.4 (8)		114	3.5 (4)		120	3.3 (4)	
≥90 yr	28	0		15	0		13	0	
Sex			0.46			0.05			0.43
Male	1101	2.0 (22)		567	1.4 (8)		534	2.6 (14)	
Female	754	2.5 (19)		322	3.4 (11)		432	1.9 (8)	
Race or ethnic group			0.01			0.001			0.70
White	1404	1.7 (24)		676	1.2 (8)		728	2.2 (16)	
Black	372	4.3 (16)		174	5.8 (10)		198	3.0 (6)	
Hispanic	57	0		23	0		34	0	
Other	19	5 (1)		14	7.1 (1)		5	0	
Chief symptom									
Chest pain			0.17			0.13			0.74
Yes	1624	2.0 (33)		728	1.8 (13)		896	2.2 (20)	
No	231	3.5 (8)		161	3.7 (6)		70	2.9 (2)	
Shortness of breath			0.04			0.04			0.41
Yes	153	4.6 (7)		103	4.9 (5)		50	4.0 (2)	
No	1702	2.0 (34)		786	1.8 (14)		916	2.2 (20)	
Presenting symptoms									
Chest pain			0.37			0.66			0.29
Yes	1701	2.1 (36)		778	2.1 (16)		923	2.2 (20)	
No	154	3.3 (5)		111	2.7 (3)		43	4.7 (2)	
Shortness of breath			0.14			0.27			0.32
Yes	1025	1.8 (18)		485	1.7 (8)		540	1.9 (10)	
No	827	2.8 (23)		402	2.7 (11)		425	2.8 (12)	
Abdominal pain			0.28			0.09			0.77
Yes	142	3.5 (5)		84	4.8 (4)		58	1.7 (1)	
No	1710	2.1 (36)		803	1.9 (15)		907	2.3 (21)	
Nausea			0.29			0.60			0.34
Yes	545	1.7 (9)		283	1.8 (5)		262	1.5 (4)	
No	1307	2.5 (32)		604	2.3 (14)		703	2.6 (18)	
Vomiting			0.51			0.26			0.69
Yes	194	1.6 (3)		127	0.8 (1)		67	3.0 (2)	
No	1658	2.3 (38)		760	2.4 (18)		898	2.2 (20)	
Dizziness			0.48			0.71			0.54
Yes	250	1.6 (4)		119	1.7 (2)		131	1.5 (2)	
No	1602	2.3 (37)		768	2.2 (17)		834	2.4 (20)	
Fainting			0.65			0.46			0.71
Yes	29	3.5 (1)		23	4.4 (1)		6	0	
No	1823	2.2 (40)		864	2.1 (18)		959	2.3 (22)	

*Numbers of patients vary because of incomplete data.

†CCS denotes Canadian Cardiovascular Society.

‡Logistic-regression analysis was used to explore univariate associations between continuous variables and outcome. P values for these comparisons appear in parentheses.

§Groups were determined according to the median values for patients with acute cardiac ischemia.

TABLE 1. CONTINUED.

VARIABLE	ALL PATIENTS			PATIENTS WITH ACUTE MYOCARDIAL INFARCTION			PATIENTS WITH UNSTABLE ANGINA		
	TOTAL NO. OF PATIENTS	PERCENTAGE NOT HOSPITALIZED (NO.)	P VALUE	TOTAL NO. OF PATIENTS	PERCENTAGE NOT HOSPITALIZED (NO.)	P VALUE	TOTAL NO. OF PATIENTS	PERCENTAGE NOT HOSPITALIZED (NO.)	P VALUE
Medical history									
Hypertension			0.61			0.88			0.56
Yes	1147	2.1 (24)		523	2.1 (11)		624	2.1 (13)	
No	690	2.5 (17)		354	2.3 (8)		336	2.7 (9)	
Diabetes			0.53			0.48			0.14
Yes	567	1.9 (11)		254	2.8 (7)		313	1.3 (4)	
No	1242	2.4 (30)		606	2.0 (12)		636	2.8 (18)	
Myocardial infarction			0.66			0.14			0.50
Yes	820	2.1 (17)		325	1.2 (4)		495	2.6 (13)	
No	1006	2.4 (24)		547	2.7 (15)		459	2.0 (9)	
Angina pectoris			0.14			0.56			0.09
Yes	1089	1.8 (20)		375	1.9 (7)		714	1.8 (13)	
No	728	2.9 (21)		487	2.5 (12)		241	3.7 (9)	
Initial clinical characteristics§									
Heart rate‡			0.34 (0.22)			0.64 (0.29)			0.30 (0.51)
≤79 beats/min	743	3.2 (24)		320	3.1 (10)		423	3.3 (14)	
>79 beats/min	697	2.3 (16)		357	2.5 (9)		340	2.1 (7)	
Systolic pressure‡			0.93 (0.76)			0.32 (0.58)			0.28 (0.27)
≤147 mm Hg	936	2.2 (21)		476	1.7 (8)		460	2.8 (13)	
>147 mm Hg	917	2.2 (20)		413	2.7 (11)		504	1.8 (9)	
Diastolic pressure‡			0.32 (0.34)			0.39 (0.84)			0.58 (0.11)
≤83 mm Hg	929	2.6 (24)		417	2.6 (11)		512	2.5 (13)	
>83 mm Hg	901	1.9 (17)		450	1.8 (8)		451	2.0 (9)	
Physical findings									
Rales			0.86			0.96			0.44
None	1342	2.5 (33)		612	2.3 (14)		730	2.6 (19)	
Basilar	320	1.6 (5)		162	2.5 (4)		158	0.6 (1)	
More than basilar	120	1.7 (2)		66	1.5 (1)		54	1.9 (1)	
Entire lung	27	0		21	0		6	0	
S_3 gallop			0.23			0.32			0.51
Present	51	0		35	0		16	0	
Absent	1426	2.8 (40)		665	2.9 (19)		761	2.8 (21)	
Electrocardiographic features									
ST segments			0.04			0.05			0.70
Elevated >2 mm	99	0		96	0		3	0	
Elevated 1–2 mm	149	2.7 (4)		106	2.8 (3)		43	2.3 (1)	
Normal	837	3.8 (32)		285	4.9 (14)		552	3.3 (18)	
Depressed 0.5–1 mm	198	1.0 (2)		97	1.0 (1)		101	1.0 (1)	
Depressed >1 mm	162	1.2 (2)		97	1.0 (1)		65	1.5 (1)	
T waves			0.02			0.02			0.50
Flat	261	3.5 (9)		94	3.2 (3)		167	3.6 (6)	
Elevated	72	0		65	0		7	0	
Normal	598	4.0 (24)		255	5.1 (13)		343	3.2 (11)	
Inverted ≥1 mm	514	1.4 (7)		267	1.1 (3)		247	1.6 (4)	
Q waves			0.60			0.08			0.31
Present	378	2.4 (9)		195	1.0 (2)		183	3.8 (7)	
Absent	1067	2.9 (31)		486	3.5 (17)		581	2.4 (14)	
Combined findings			0.001			0.001			0.35
Nondiagnostic electrocardiogram	388	5.4 (21)		133	9.0 (12)		255	3.5 (9)	
Abnormal ST segments or T waves or Q waves	1057	1.8 (19)		548	1.3 (7)		509	2.4 (12)	

the diagnosis was not made correctly. Because the study reevaluated more than 99 percent of all discharged patients within 24 to 72 hours after initial presentation, the reliable detection of missed diagnoses was possible. Because our study also included patients with symptoms other than chest pain, we were able to assess the role of other presenting symptoms that are suggestive of acute cardiac ischemia, as well as other clinical features.

We found a low rate of missed diagnoses of acute myocardial infarction in the emergency department (2.1 percent), thus confirming the rate found in our previous study in the 1980s[1] (2 percent). This rate is somewhat lower than those found by Lee et al.[3]

TABLE 2. FACTORS ASSOCIATED WITH FAILURE TO HOSPITALIZE PATIENTS WITH ACUTE CARDIAC ISCHEMIA WHO PRESENTED TO THE EMERGENCY DEPARTMENT, ACCORDING TO MULTIVARIABLE MODELS.*

FACTOR	ODDS RATIO FOR DISCHARGE (95% CI)	P VALUE
All patients (n=1855)†		
Chief symptom of shortness of breath	2.7 (1.1–6.5)	0.02
Male sex ≥55 yr	3.7 (0.8–16.2)‡	0.08
Female sex <55 yr	6.7 (1.4–32.5)‡	0.02
Female sex ≥55 yr	1.9 (0.4–9.1)‡	0.40
Nonwhite race	2.2 (1.1–4.3)	0.03
Normal ECG	3.3 (1.7–6.3)	<0.001
Patients with acute myocardial infarction (n=889)§		
Nonwhite race	4.5 (1.8–11.8)	0.002
Normal ECG	7.7 (2.9–20.2)	<0.001

*Patients with incomplete data were not included. CI denotes confidence interval, and ECG electrocardiogram.

†The multivariable model included 1443 patients, 40 of whom were discharged.

‡Men <55 years of age served as the reference group.

§The multivariable model included 630 patients, 19 of whom were discharged.

in the early 1980s (3.8 percent) and by Schor et al.[4] in the 1970s (7.7 percent). Nonetheless, like the earlier studies, our current study found a small but important incidence of failure by the emergency department clinician to detect ST-segment elevations of 1 to 2 mm in the electrocardiograms of patients with myocardial infarction (11 percent). This incidence represents an important and potentially preventable contribution to the failure to admit such patients.

Another finding was that among the patients with acute infarction who presented to the emergency department, women were more likely than men to have been discharged. Perceived and real sex bias in the evaluation and treatment of acute cardiac ischemia has received considerable attention, especially since coronary disease is the primary cause of death among U.S. women.[11-16] Women have been reported to have higher rates of atypical symptoms or presentations, such as abdominal pain, shortness of breath, and congestive heart failure, a fact that might contribute to missed diagnoses.[17-21] We found that among all the patients with acute cardiac ischemia, women under the age of 55 years were at highest risk for not being hospitalized.

Another new finding was that among the patients with acute cardiac ischemia, the adjusted risk of being sent home was more than two times as high among nonwhites as among whites; among those with acute myocardial infarction, the risk was more than four times as high among nonwhites as among whites. In this study, 5.8 percent of the black patients with acute myocardial infarction were not hospitalized, as compared with 1.2 percent of the white patients with infarction. Blacks have more risk factors for coronary artery disease than whites,[22,23] but this fact did not appear to have a strong influence on the diagnostic impressions of the physicians.[24] In a previous analysis of the data from this study, we found that black patients were 8 to 10 years younger and that a higher percentage were women than was the case among white patients,[24] which may partially explain why physicians might be less inclined to suspect the presence of acute cardiac ischemia in black patients.

Among the patients who proved to have unstable angina, 2.3 percent were not hospitalized. Over three fourths of the patients were evaluated by an attending physician, and more than one fourth by a consulting cardiologist. Although there was disagreement over the interpretation of 16 percent of the electrocardiograms on subsequent review by an experienced cardiologist, this was not believed to be clinically significant in any of the cases. Given that most of the patients who were not hospitalized had Canadian

TABLE 3. MORTALITY AT 30 DAYS AMONG PATIENTS WITH ACUTE CARDIAC ISCHEMIA.*

VARIABLE	ALL PATIENTS			PATIENTS WITH ACUTE MYOCARDIAL INFARCTION			PATIENTS WITH UNSTABLE ANGINA		
	NOT HOSPITALIZED (N=41)	HOSPITALIZED (N=1814)	RISK RATIO (95% CI)	NOT HOSPITALIZED (N=19)	HOSPITALIZED (N=870)	RISK RATIO (95% CI)	NOT HOSPITALIZED (N=22)	HOSPITALIZED (N=944)	RISK RATIO (95% CI)
No. of cases in risk-adjusted mortality analysis	39	1334		19	630		20	704	
30-Day mortality									
Observed (%)	7.7	5.7	1.4 (0.4–4.1)	10.5	9.7	1.1 (0.3–4.1)	5.0	2.1	2.4 (0.3–16.9)
Predicted (%)	4.1	5.8	0.7 (0.1–3.3)	5.5	9.8	0.6 (0.1–3.7)	3.0	2.2	1.4 (0.1–17.4)
Observed:predicted ratio	1.9	1.0	1.9 (0.7–4.8)	1.9	1.0	1.9 (0.7–5.2)	1.7	1.0	1.7 (0.2–17.0)

*Patients with incomplete data were not included. CI denotes confidence interval.

Cardiovascular Society class 3 angina with new symptoms or symptoms that changed within three days before presentation, inaccuracies in the clinical assessment of the dynamic nature of anginal symptoms may have contributed to the failure to hospitalize patients with unstable angina.

Although the patients with a missed diagnosis of acute myocardial infarction had clinical features that are typical of the condition, such as shortness of breath, presence of rales, and evident congestive failure or pulmonary congestion, many also had pulmonary symptoms and atypical presentations, and those with a missed diagnosis of acute cardiac ischemia were more often than not relatively young women. Also, 53 percent of the patients with a missed diagnosis of acute myocardial infarction had normal or nondiagnostic electrocardiograms, as did 62 percent of the patients with a missed diagnosis of unstable angina. Indeed, on follow-up, 74 percent of missed acute myocardial infarctions were found to be non–Q-wave infarctions that could not be ascribed to a specific location.

The risk-adjusted mortality ratio for the nonhospitalized patients with acute myocardial infarction was 1.9, as compared with the patients who were hospitalized, and for the patients with unstable angina it was 1.7; overall, the risk-adjusted mortality for all the patients with acute cardiac ischemia was 1.9 times as high among the nonhospitalized patients as among those who were hospitalized. These differences in mortality, however, were not statistically significant. Nevertheless, our findings suggest that more accurate identification of patients with acute cardiac ischemia could result in improved clinical outcome and lower mortality.

Further reduction in the current relatively low rate of missed diagnoses of acute myocardial infarction and unstable angina will be difficult. A small portion of patients with missed acute myocardial infarction or unstable angina might be identified by improved detection of electrocardiographic abnormalities. Missed cases of unstable angina were most often of Canadian Cardiovascular Society class 3, which possibly could be identified more accurately by careful assessment of clinical symptoms. Among the patients with acute myocardial infarction, the percentage who were not hospitalized was 4.5 times as high among nonwhites as among whites, and 7.7 times as high among those with normal or nondiagnostic electrocardiograms as among those with abnormal electrocardiograms.

Whether the availability of a variety of techniques for the diagnosis of acute cardiac ischemia, such as serial measurements of cardiac enzymes, noninvasive cardiac imaging, and predictive instruments, or the use of "chest pain programs" will help reduce the number of missed diagnoses of myocardial infarction or unstable angina is still an unanswered question.[25,26] It is noteworthy that, in this study, the presence of a well-established chest-pain unit was not related to lower rates of missed diagnosis of acute cardiac ischemia. There is a need to evaluate further what, if any, effect such programs have on the failure to hospitalize patients.[26] The use of predictive instruments that determine precisely the probability that a patient is having an acute myocardial infarction or has unstable angina may help correct physicians' incorrect estimates.[6,27,28] However, a trial examining the effect of such diagnostic tests that could detect a reduction in the rate of missed diagnoses from the current 2 percent to, for example, 1 percent, would require tens of thousands of patients.

This study had several limitations. First, the small number of patients with acute myocardial infarction and unstable angina who were discharged limited the number of features that could be studied in our multivariable models of factors contributing to the failure to hospitalize such patients. We prospectively studied 10,689 patients who presented to the emergency departments of 10 hospitals and identified 19 patients with a missed diagnosis of acute infarction and 22 patients with a missed diagnosis of unstable angina. Second, this study included no rural hospitals and no hospitals without emergency physicians on site. However, similar rates of missed diagnosis with respect to myocardial infarction were found in rural hospitals in our earlier study, which used the same inclusion criteria and follow-up methods.[1] Third, there may have been changes in the practice of emergency medicine since these data were collected in 1993 that may have improved the rate of diagnosis of acute cardiac ischemia.

In conclusion, this large, multicenter study found that the incidence of unintentional failure to hospitalize patients with acute infarction or unstable angina who presented to the emergency department was low but may be associated with a poor outcome. It appears that the incidence of missed diagnoses of acute cardiac ischemia in the emergency department may be reduced by interpreting the electrocardiogram more accurately; addressing clinical factors or preconceptions that obscure the recognition of acute myocardial infarction and unstable angina in women and nonwhite patients; considering the possibility that acute cardiac ischemia may be present in patients with chief symptoms other than chest pain; and assessing recent changes in the clinical course of angina more carefully.

Whether advances in the diagnostic techniques and evaluation strategies used in the emergency department for patients who present with symptoms suggestive of acute cardiac ischemia will improve current rates of diagnosis remains to be seen.[25] Given the importance of this condition, such techniques and strategies deserve evaluation despite the large size of the studies that would be required. Given the aging of our population, the increase in racial and ethnic diversity,

and the increasing public awareness of the importance of promptly going to emergency departments when possible cardiac symptoms occur, combined with growing pressures to reduce the number of unnecessary hospitalizations, an understanding of the factors associated with the misdiagnosis of acute cardiac ischemia, and how to improve diagnosis and triage, will become increasingly important.

Supported by a grant (RO1 HS07360) from the Agency for Healthcare Research and Quality and by the General Clinical Research Center at New England Medical Center, funded by a grant (M01-RR00054) from the National Center for Research Resources of the National Institutes of Health.

We are indebted to Dr. Ralph Gianelly for his assistance with the interpretation of the electrocardiograms; to the investigators other than the present authors for their dedication to the success of the ACI-TIPI trial from which the data for this study came (Daniel S. Ballin, M.D., Sheilah A. Bernard, M.D., Steven G. Crespo, M.D., Susan S. Fish, Pharm.D., W. Brian Gibler, M.D., Debra A. Kiez, M.D., Robert A. McNutt, M.D., Anne W. Moulton, M.D., Joseph P. Ornato, M.D., Philip J. Podrid, M.D., Deeb N. Salem, M.D., and Michael R. Sayre, M.D.); to Dr. Cam Cushing for the analysis of data on unstable angina; to Drs. Phillip Henneman and Howard Smithline for their review of the manuscript; and to Julie S. Sullivan and Deborah Crane for their assistance in preparing the manuscript.

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