

# Missed Diagnoses of Acute Myocardial Infarction in the Emergency Department: Results From a Multicenter Study

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**Study objective:** To determine the rate of missed acute myocardial infarction (AMI) in the emergency department and the factors related to missed diagnoses.

**Study design:** Observational and case-control study.

**Setting:** Data were analyzed from a multicenter study of coronary care unit admitting practices that included patients who presented to the ED with chest pain or other symptoms suggestive of acute cardiac ischemia (N = 5,773). Patients with missed AMI (cases) were compared with control patients admitted with AMI and to a second control group of patients discharged without AMI.

**Results:** Of 1,050 patients with AMI, 20 (1.9%; 95% confidence interval, 1.2-2.9%) were not admitted. Patients with missed AMI were significantly less likely to have ECG changes and a history of AMI or nitroglycerin use than patients admitted with AMI. However, they were significantly more likely to have ECG changes than patients discharged without AMI. Five patients with missed AMI (25%) had ST-segment elevation, and seven (35%) were discharged with a diagnosis of ischemic heart disease by the physician in the ED. Death or potentially lethal complications occurred in 25% of missed AMI patients.

**Conclusion:** The rate of missed AMI in the ED was only 1.9%. However, 25% of these might have been prevented had ST-elevation not been missed, and another 25% might have been prevented had patients who were recognized to have ischemic heart disease by the physician in the ED been admitted.

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## INTRODUCTION

The decision whether to admit a patient presenting to the emergency department with symptoms suggestive of acute myocardial infarction (AMI) is often a difficult one. Previous studies have shown that between 4% and 8% of patients

with AMI who present to the ED with chest pain are sent home.<sup>1,2</sup> With approximately 650,000 AMI patients diagnosed in the United States annually,<sup>3</sup> more than 25,000 AMI patients may be missed in the ED each year. However, previous studies have been restricted to patients presenting with chest pain. Patients with atypical symptoms, which comprise up to 25% of patients with AMI in population studies,<sup>4</sup> may be even more difficult to diagnose in the ED. Therefore, using data from a prospective, multicenter study of ED patients with chest pain and other symptoms suggestive of ischemia, we sought to determine the prevalence of missed AMI in the ED, the factors related to missed diagnoses, and the outcome of patients with AMI who are sent home.

## MATERIALS AND METHODS

We analyzed data from a prospective, multicenter study of coronary care unit admitting practices conducted from 1979 to 1981.<sup>5</sup> Six New England hospitals participated, including two urban university teaching hospitals, two medical school-affiliated teaching hospitals in smaller cities, and two nonteaching hospitals in rural settings. In the ED, patients were seen primarily by internal medicine residents supervised by attending physicians at the university hospitals (where residents had more autonomy in decision making), by full-time emergency physicians and residents under their close supervision at the university-affiliated hospitals, and by full-time emergency physicians at the nonteaching hospitals. Men 30 or more years old and women 40 or more years old were eligible if they presented with any of the following chief complaints: chest discomfort, pressure, or pain; upper abdominal pain or nausea; dizziness, lightheadedness, or syncope; or shortness of breath or difficulty breathing. More than 92% of eligible patients agreed to participate (N = 5,773).

In the ED, research assistants collected clinical information through a structured interview and from the ED record, an ECG, and blood for creatine kinase and aspartate amino transaminase determinations. Follow-up ECGs, cardiac enzyme tests, and clinical information were obtained at 48 to 72 hours. For discharged patients this was done either at a return ED visit or in their home. Blinded reviewers interpreted all ECGs. Inter-rater agreement for all items on a given ECG was 90%. The diagnosis of AMI was based on the clinical presentation, serial ECGs, and cardiac enzyme tests, using World Health Organization criteria.<sup>6</sup> Patients who refused admission or were admitted to "holding units" in the ED were not considered to be missed AMI patients.

Initial complete follow-up information was available for 89% of subjects. To identify any missed AMI patients among discharged patients lost to follow-up in the original data collection, we obtained the names of these patients from the original hospital logbooks (which were available for three hospitals, accounting for 68% of patients in the study). We then reviewed their medical records to determine if an AMI may have occurred within three days of the ED visit. For patients without subsequent information in the medical record, we searched the Massachusetts and New Hampshire Death Registries and the National Death Index. Any deaths within three days not explained by other reasons were assumed to be due to AMI.

Results of this search showed that 68.2% of those lost to follow-up had no evidence of AMI at later hospital visits. Assessment of vital status for a further 29.2% revealed one death. This occurred one day after the ED visit, and AMI was listed as the cause of death. The remaining 2.6% could not be traced from the original logbooks or hospital records. Thus, a more intensive follow-up effort for three of the hospitals revealed only one additional case of missed AMI not identified during the original study.

To determine how patients discharged with AMI ("missed AMI patients") differed from patients admitted from the ED with AMI ("admitted AMI patients") in terms of age, sex, history of coronary artery disease, symptoms, and ECG findings, we compared the 20 missed AMI patients with a control group of 200 admitted AMI patients matched by study site. To determine how missed AMI patients differed from nonAMI patients with similar symptoms also discharged from the ED ("discharged nonAMI patients") in terms of age, sex, history of coronary artery disease, and ECG findings, the missed AMI patients were compared in a separate analysis with a control group of 100 discharged nonAMI patients matched by study site and by first and second most important symptom. These controls were matched by symptoms because many of the discharged patients in the original study had very low likelihoods of AMI as a result of the broad inclusion criteria. The result was a control group that was more likely to have AMI based on symptoms, making any differences on the other variables more clinically meaningful.

To determine the cause of discharge, each ED record was reviewed and the emergency physician's ECG interpretation was compared with that of the blinded reviewer. Comparisons between the cases and each control group were made with the  $\chi^2$  test and Student's *t*-test for categorical and continuous variables, respectively. Confidence intervals were calculated with Fisher's exact test for Poisson or binomial distributions, as appropriate. All *P* values are two-tailed.

## RESULTS

Of 1,050 patients with AMI, 20 were discharged from the ED, yielding a missed AMI rate of 1.9% (95% confidence interval [CI], 1.2-2.9%). The range at the six hospitals was 0.8% to 3.0% ( $P = \text{NS}$ ). The missed AMI rate for university hospitals (1.7%), where residents had more autonomy in decision making, was similar to the missed AMI rate (1.9%) at the other hospitals. Seventeen of the missed AMI patients were Killip class I, and three were Killip class II based on initial presentation.<sup>7</sup> Comparisons of missed AMI patients with admitted AMI patients and with discharged nonAMI patients are shown (Table). Missed AMI patients were less likely than admitted AMI patients to have a history of coronary artery disease as evidenced by a history of AMI or of nitroglycerin use. The missed AMI patients tended to have less radiation of pain to the arms and neck than admitted AMI patients, but this difference did not reach statistical significance. Otherwise similar proportions of missed AMI and admitted AMI patients reported chest pain and other symptoms. The discharged nonAMI control group was matched by symptoms and therefore showed no significant differences on this dimension.

Missed AMI patients were less likely to have Q-waves, ST-segment elevation, T-wave changes, and ST-segment and/or T-wave changes (Table) than admitted AMI patients. On the other hand, missed AMI patients were more likely to have ECG changes than discharged nonAMI patients. Twenty-five percent of missed AMI patients had ST-segment elevation versus 0% of discharged nonAMI patients ( $P < .001$ ).

Review of the ED records showed that the ECG interpretations were correct in 12 cases. For three cases slight abnormalities (ST-segment straightening or depression of 0.5 mm or less) were read as normal or nonspecific, and for five cases ST-segment elevation of 1 mm or more was not recognized (although one physician noted only "no changes from other ECGs"). Of the 20 missed AMI

**Table.**

Demographic characteristics and medical history for missed AMI patients, admitted AMI patients, and discharged nonAMI patients

	Missed AMI Patients (N = 20)	Admitted AMI Patients (N = 200)	Discharged AMI Patients (N = 100)
Mean age (yr)	60	66	54
% Male	70	54	56
History of AMI (%)	20	37	12
History of nitroglycerin use (%)	15	32	17
History of AMI and nitroglycerin use (%)	25	48*	23

\* $P = .05$ , for comparison with missed AMI patients.

patients, four (20%) were diagnosed with gastrointestinal complaints, four (20%) with chest pain of unknown etiology, two (10%) with musculoskeletal pain, and one each with pulmonary disease, arrhythmia, and congestive heart failure. Seven missed AMI patients (35%) were diagnosed with some form of ischemic heart disease, including two who also had ST-segment elevation that was not recognized. Ischemic heart disease diagnoses included "presyncopal episode, coronary artery disease," "unstable angina," "angina, congestive heart failure," "angina de novo," "atherosclerotic heart disease with coronary insufficiency," and "angina pectoris—without further pain in ED" (the written diagnosis was not available for one case).

Nineteen of the 20 missed AMI patients were subsequently admitted for the following reasons: three were called back because of an elevated creatine kinase level drawn by study protocol, one had an abnormal ECG at follow-up, 11 returned because of symptoms, and four returned for unknown reasons.

Five patients with missed AMI (25%) either died or suffered potentially lethal adverse outcomes: one suffered cardiac arrest outside the hospital and was resuscitated, one returned in pulmonary edema and had a respiratory arrest in the ED, two suffered ventricular fibrillation within hours of admission (one died), and one died of an AMI (according to death certificate) within 24 hours of ED discharge. Mortality was 10% for missed AMI patients (95% CI, 1.2-30.9%), compared with 15% for admitted AMI patients ( $P = \text{NS}$ ); none of the discharged nonAMI patients died.

## DISCUSSION

Approximately 2% of patients with AMI presenting to six EDs were discharged. Our findings confirm the relatively low rate of missed AMI patients reported by Lee et al<sup>1</sup> (the missed diagnosis rate in that study was 3.8% [95% CI, 2.2-5.9%]) and extend their findings to include both patients who present with chest pain and those who present with other symptoms. In the only other large study,<sup>2</sup> a higher missed AMI rate of 7.7% (95% CI, 5.4-10.5%) was found among patients presenting to an Israeli hospital with chest pain in 1970. We did not find that missed diagnoses were associated with atypical presentations of AMI.

The patients with missed AMI may have been more difficult to diagnose because they were less likely than admitted AMI patients to have a history of AMI or nitroglycerin use, leading to a lower prior probability of ischemic heart disease, and because they were less likely to have ECG changes. However, only 30% of patients with missed AMI had normal or nonspecific ECGs, and missed AMI patients were much more likely to have ECG changes than patients

discharged without AMI. This suggests that either the ECGs were misread, leading to erroneous discharge, or perhaps in the context of a history not strongly suggestive of acute ischemia, the importance of the ECG changes was minimized. In fact, five patients (25%) with missed AMI had ST-segment elevation, and at least four might have been admitted if the ECG changes had been recognized in the ED. This is consistent with the finding of Lee et al that 23% of missed diagnoses of AMI in their series were due to misread ECGs.<sup>1</sup>

Some missed diagnoses of AMI may have been related to inappropriate disposition decisions. We found that 35% of patients with missed AMI were diagnosed in the ED as having some form of ischemic heart disease. Discharge may be appropriate for patients whose symptoms are due to stable angina (eg, 6% of discharged nonAMI patients had a diagnosis of ischemic heart disease); however, it is prudent to be cautious when making the diagnosis of stable angina in the ED. In the entire original study data set, AMI was present in seven of 114 discharged patients (6%) diagnosed with ischemic heart disease.

Two (10%) of 20 patients with AMI died. This is similar to the 9.4% mortality rate of all patients with Killip class I AMI in the entire original study data set. However, given the small number of cases, we cannot say definitively that patients for whom the diagnosis of AMI is missed do as well as patients admitted with AMI. This is reflected in the 95% confidence level for mortality rate of 1% to 31%. Furthermore, 25% of missed AMI patients either died or had potentially life-threatening complications. For comparison, nine of 35 patients (26%) with missed AMI in the study by Lee et al died.<sup>1</sup> This suggests that there is considerable risk for patients with missed AMI.

There were several limitations to this study. First, although follow-up rates with both ECG and cardiac enzymes were very high, it is still possible that a small number of cases could have been missed. Later searching of medical records and state and national death registries for two-thirds of discharged patients lost to follow-up revealed only one additional AMI, but this method may not have detected some patients with mild AMI who had no further symptoms. A second limitation was the relatively small number of cases, which results in wide confidence intervals. However, this is largely a (fortunate) result of the relative infrequency of missed AMI patients; we prospectively studied 5,773 ED patients to identify 20 missed AMI cases. Another limitation was that the original data collection was concluded in 1981. However, although in-hospital disposition (eg, coronary care unit versus monitored bed) has changed, there have been no major changes in the way physicians try to distinguish between acute ischemic heart disease and symptoms due

to other causes.<sup>8</sup> Furthermore, we know of no other studies that have examined the effect of nonchest pain presentations on the missed AMI rate. Future studies are needed to determine whether recent trends such as the increased emphasis on closer resident supervision, the pressures of cost containment, or increased fears of litigation have led to a change in disposition decisions for patients with symptoms suggestive of AMI. Our results, and those of others,<sup>1</sup> may be useful for comparison.

## CONCLUSION

Although the rate of missed AMI in the ED is low, in this study 25% of missed AMIs might have been prevented by correctly interpreting the ECG. An additional 25% of missed AMIs might have been prevented by not sending home patients with symptoms believed to be due to ischemic heart disease. This reinforces the idea that unstable angina is a condition requiring hospital treatment and should provoke discussion among emergency physicians about the distinction between unstable and stable angina among patients presenting to the ED. The high rate of life-threatening complications we observed among missed AMI patients emphasizes the importance of trying to yet further reduce the number of missed AMIs.

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