Use of Emergency Medical Services in Acute Myocardial Infarction and Subsequent Quality of Care
Observations From the National Registry of Myocardial Infarction 2

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Background—National practice guidelines strongly recommend activation of the 9-1-1 Emergency Medical Systems (EMS) by patients with symptoms consistent with an acute myocardial infarction (MI). We examined use of the EMS in the United States and ascertained the factors that may influence its use by patients with acute MI.

Methods and Results—From June 1994 to March 1998, the National Registry of Myocardial Infarction 2 enrolled 772,586 patients hospitalized with MI. We excluded those who transferred in, arrived at the hospital >6 hours from symptom onset, or who were in cardiogenic shock. We compared baseline characteristics and initial management for patients who arrived by ambulance versus self-transport. EMS was used in 53.4% of patients with MI, a proportion that did not vary significantly over the 4-year study period. Nonusers of the EMS were on average younger, male, and at relatively lower risk on presentation. In addition, payer status was significantly associated with EMS use. Use of EMS was independently associated with slightly wider use of acute reperfusion therapies and faster time intervals from door to fibrinolytic therapy (12.1 minutes faster, P<0.001) or to urgent PTCA (31.2 minutes faster, P<0.001).

Conclusions—Only half of patients with MI were transported to the hospital by ambulance, and these patients had greater and significantly faster receipt of initial reperfusion therapies. Wider use of EMS by patients with suspected MI may offer considerable opportunity for improvement in public health. (Circulation. 2002;106:3018-3023.)

Key Words: myocardial infarction ■ chest pain ■ ambulances ■ emergency medical services

Myocardial infarction (MI) is the single largest killer of men and women in the United States, resulting in more than 475,000 deaths each year.1 Of those who experience a fatal MI, more than half will die within the first hour without receiving medical attention.2 Thus, national practice guidelines strongly recommend activation of the 9-1-1 Emergency Medical Systems (EMS) by patients who have symptoms consistent with an acute MI.2,3 The EMS may dispatch providers who are trained to treat life-threatening complications, such as cardiac arrest, with rapid defibrillation, if needed.

Improved outcomes have been demonstrated with the early use of acute reperfusion therapies in the treatment of patients with ST-elevation MI.4-8 Some experts have suggested that greater utilization of EMS may lead to faster administration of fibrinolytic therapy,9 although this has not been proven conclusively. The Rapid Early Action for Coronary Treatment (REACT) study, which used an aggressive community intervention to attempt to reduce patient delay in accessing the healthcare system for MI, did not show a significant decrease in time to patient presentation despite a 20% higher EMS utilization rate among communities that received aggressive marketing campaigns.10

It has been suggested that death and disability can be greatly reduced if patients are educated and motivated to call 9-1-1 at the earliest suggestion of an acute MI.11 The National Registry of Myocardial Infarction (NRMI) is an observational study that has enrolled patients hospitalized at >25% of all acute-care hospitals in the United States and that has been tracking the management of patients with MI, including the contemporary utilization of EMS. The primary objective of this study was to examine the prevalence of EMS use by acute MI patients in this country and to ascertain the trends and factors that may influence its use. A secondary objective was

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to examine the impact of the EMS on actual receipt of timely acute reperfusion therapies.

**Methods**

**National Registry and Study Population**

The NRMI 2 was a voluntary, prospective registry that collected cross-sectional data on patients admitted to the hospital with confirmed MI. Trained abstractors collected detailed data from the hospital records of 772,586 patients from June 1994 to March 1998 at 1,674 participating hospitals. Characteristics of the NRMI’s data gathering procedures and reliability have been described previously. Using a hierarchical exclusion design, we excluded the following patients (57.4% in total): those transferred into a registry hospital from another facility (171,808; 22.1%); those who presented >6 hours from symptom onset to hospital arrival (263,343; 34.1%); those whose mode of transport was either unknown or involved transport by air (3941; 0.5%); those who were in cardiogenic shock, because these patients would not likely be able to arrive via self-transport (5340; 0.7%); and those who developed MI >24 hours after initial hospitalization. Patients who presented ≤6 hours after symptom onset were arbitrarily selected because they represented patients about whom physicians would have fewer doubts regarding the appropriateness of acute reperfusion therapies. The remainder were then grouped according to their primary mode of transport to the initial hospital (either ambulance or self-transport).

**Study Variables and Definitions**

Information on study variables included in this analysis are listed in Tables 1 through 5. EMS was defined as transportation to the initial hospital by ambulance and self-transport as any variation of transportation that did not involve an ambulance or air transport, such as a taxi, public transportation, those who drove themselves to the hospital, those who were driven by another individual, and walk-ins. The definitions of the remaining variables are described elsewhere. There were few variables that were missing in excess of 5%, and they included time intervals from symptom onset to hospital arrival and from hospital arrival to initial ECG (10%).

**Outcome Measures**

The main outcome measure was use of EMS. Secondary outcome measures were receipt of reperfusion (by fibrinolytic or primary PTCA) among eligible patients and the time interval from hospital arrival to reperfusion.

**Statistical Methods**

The χ² test was used to study associations between categorical data, and ANOVA was used to report the mean and nonparametric test for median when the variable of interest was continuous. Logistic regression models were developed to ascertain the factors associated with EMS use (dependent variable). Only variables that would have preceded the activation of EMS were included in this model, such as demographics, cardiac risk factors, and past medical history; these are presented in Table 2. We also developed a multivariate model to ascertain whether EMS use was associated with a greater likelihood of receiving acute reperfusion therapies in the cohort eligible to receive these life-saving therapies. Then, we developed a multivariate model to predict whether ambulance transport was more likely to be associated with receipt of fibrinolytic therapy within 30 minutes and receipt of primary PTCA/balloon inflation within 90 minutes after hospital arrival. Lastly, logistic regression models for mortality were developed to examine whether EMS use was associated with survival. Covariates included in these 3 multivariate models are listed in Table 1. Analyses were performed with SAS version 6.12 (SAS Institute).

**Results**

**Baseline Characteristics and Presentation Characteristics**

As shown in Table 1, only 1 of every 2 patients with MI was transported to the hospital by EMS. On average, these patients were significantly older. There was a lower use of EMS among men but little difference by race. Patients who used EMS were more likely to have prior histories of heart failure, stroke, or coronary artery disease and more likely to have Medicare than to have commercial insurance. Patients who called for an ambulance were more likely to present to the hospital sooner after the onset of symptoms (mean time 114.0 versus 126.0 minutes, P<0.001) and to be in a higher Killip classification or TIMI risk (suggesting a much sicker cohort) than those who presented by self-transport. Also, patients transported by EMS were more likely to have Q-wave and anterior infarctions and to have sustained ventricular tachycardia or ventricular fibrillation.

**Trends in EMS Use**

We observed no important temporal variations in EMS use from 1994 to 1998 over 6-month intervals (P for trend=0.24).

**Predictors of EMS Use**

After multivariate adjustment, younger patients were significantly less likely to call 9-1-1, and the odds of EMS use were 21% higher with each increasing decade of life. Men had 19% lower odds of using EMS than women, and Hispanics, Asian–Pacific Islanders, and Native Americans were all less likely to call for an ambulance than blacks and whites. Patients who were enrolled in health maintenance organizations (HMOs) were more likely to use EMS than those with commercial insurance. Patients who were the least likely to be able to afford transport by EMS (uninsured individuals and Medicaid recipients) were also the most likely to use them. Patients with stroke and with a cardiac history, such as those with known angina, MI, PTCA, or coronary artery bypass surgery, were more likely to use EMS. (See Table 2.)

**Process-of-Care Indicators**

**Receipt of Initial Reperfusion Therapies**

Overall, after adjusting for differences in baseline and presenting characteristics, patients who presented to the hospital by ambulance had 24% higher odds of receiving fibrinolytic therapy or primary PTCA when eligibility criteria were fulfilled (odds ratio 1.24, 95% CI 1.21 to 1.28, P<0.001).

**Treatment Time Intervals for Initial Reperfusion Therapies**

Use of the EMS system was significantly associated with faster receipt of acute reperfusion therapies after arrival in the emergency department than with the self-transport group (Table 3). The mean difference in the time interval from door to fibrinolytic therapy administration was 12 minutes faster in the EMS group, and from door to urgent primary PTCA, it was 31 minutes faster. The overall mean time interval from symptom onset to receipt of initial reperfusion therapies was significantly shorter for the group of patients who arrived via EMS (P<0.001). Overall, after multivariate adjustment (Table 4), patients who arrived by EMS had a 59% greater chance of receiving fibrinolytic therapy within the National Heart Attack Alert Program goal of 30 minutes after hospital arrival (odds ratio 1.59, 95% CI 1.55 to 1.64, P<0.001) and a 56% greater chance of receiving primary PTCA within the...
American College of Cardiology/American Heart Association national practice guidelines recommendation of 90 minutes after hospital arrival (odds ratio 1.56, 95% CI 1.46 to 1.68, *P* \(< 0.001\)).

Symptom Onset to Hospital Presentation: 6 to 12 Hours
When the data were reanalyzed to include those who presented to the hospital from 6 to 12 hours after the onset of MI symptoms, the prevalence of EMS use, prevalence of reperfusion therapy, and time delay to reperfusion therapy by EMS transport did not change appreciably.

Hospital Mortality
The crude mortality rate among patients transported by EMS was significantly higher (14.3% versus 5.5%, *P* <0.001) than for patients who were self-transported. Among the EMS group, the odds of death were 2- to 3-fold higher than for those in the self-transport group. However, about two thirds of the increased odds of death in the EMS transported group (eg, as shown in Table 5, 189% excess odds of death reduced to 56% after adjustment) was explained by measured confounders (consistent with the EMS group representing a much sicker cohort).

**Discussion**

**Summary of Results**
The primary finding in this large observational analysis was that only 1 of every 2 patients with MI was transported to the hospital within 90 minutes of presenting symptoms.
hospital by EMS, a proportion that did not change over the 4-year study period. MI patients who did use EMS were older, more frequently female, and at higher risk on initial presentation. Ability to pay for ambulance service may influence EMS use, although we did not observe relative underutilization of this service among HMO members. Importantly, use of the EMS was significantly associated with more frequent and faster receipt of acute reperfusion therapies (fibrinolytic therapy or primary PTCA).

**Prior Studies**
Becker et al\(^{14}\) reported that 59% of patients with cardiac symptoms were transported by EMS in King County, Washington. In another report,\(^{15}\) the REACT investigators found that only 33% of patients with chest discomfort who were admitted for evaluation of suspected acute ischemic heart disease arrived via EMS. The primary REACT study popu-

<table>
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<tr>
<th>Variable</th>
<th>Odds Ratio</th>
<th>95% CI</th>
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<tbody>
<tr>
<td>Demographics</td>
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<tr>
<td>Men (vs women)</td>
<td>0.81*</td>
<td>0.79–0.82</td>
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<td>Black (vs whites)</td>
<td>1.12*</td>
<td>1.08–1.16</td>
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<td>0.83*</td>
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<tr>
<td>Native Americans (vs whites)</td>
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<tr>
<td>Other</td>
<td>1.03§</td>
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<tr>
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<td>Prior stroke</td>
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<td>Night (vs morning)</td>
<td>1.02†</td>
<td>1.00–1.04</td>
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Table presents a single multiple logistic regression model. The number of observations in this model is 312 868. Factors with odds ratios >1 were associated with a higher likelihood of EMS use.

\*P<0.001, †P=0.001 to <0.01, ‡P=0.01 to 0.05, §P=NS. C statistic for model=0.676.

patients who underutilized EMS among HMO members. Importantly, use of the EMS was significantly associated with more frequent and faster receipt of acute reperfusion therapies (fibrinolytic therapy or primary PTCA).

**Potential Advantages of EMS in the Management of Patients With MI**
Use of EMS was associated with higher mortality, an association that persisted, although it was attenuated by about two thirds, after adjustment for clinical history and presentation. The higher mortality rates observed for this group are not surprising, and the persistent effect is most likely due to residual confounding in that our measures of severity and comorbidity likely did not fully capture these constructs. In
addition, the nature of the NRMI 2 data set is such that patients who did not call 9-1-1 and died before reaching the hospital were excluded from this analysis, thus biasing our results toward a lower measured mortality in the self-transport group.

We believe that EMS use may be advantageous in reducing mortality for several reasons. First, EMS may provide rapid availability of advanced cardiac life support personnel for out-of-hospital cardiac arrest. Second, EMS may transport patients to the best cardiac hospitals to treat patients with suspected MI. Third, EMS may potentially shorten the time to reperfusion therapy by heightening the sense of urgency perceived by the emergency department personnel, as well as through advance notification via the prehospital ECG.9,17

Predictors of EMS Use and Nonuse
Higher use of the EMS by women, especially older women, may be related to their age or because they are more likely to be living alone than men. The surprisingly higher use in blacks and the lower use among Hispanics, Asian–Pacific Islanders, and Native Americans compared with whites may warrant additional study. In the adjusted analyses, patients with HMO insurance, the uninsured, and those with Medicaid insurance were more likely to use EMS than those with commercial insurance. This finding may support those of Siepman et al,18 who reported that patients residing in low-income areas were 2.6 times more likely to use EMS when a prepayment system was available. Furthermore, a tax-based or prepayment system increased EMS use 3.8 times for low-income patients lacking health insurance.18 The association between payer and EMS use certainly warrants further investigation.

Reasons for EMS Underutilization
The reasons for underutilization of EMS by patients with acute MI are not entirely understood. It has been reported that the lack of knowledge of the clinical symptoms of MI was strongly associated with delay before hospital arrival.19 Brown et al20 in a random-digit-dial survey of 875 patients enrolled in the REACT trial (<5% of the overall study population), reported that 89% of patients indicated that they would call 9-1-1 if they witnessed a cardiac event, but only 23% actually called EMS when they experienced their symptoms of suspected acute coronary syndrome. Meischke et al21 reported that many patients may fail to use EMS because they think that self-transport would be faster or they do not perceive their symptoms as being life-threatening. In the present study, patients who arrived via self-transport generally tended to be at lower risk, and perhaps some of these patients with milder or ambiguous symptoms may not have chosen to call for an ambulance. Lastly, various psychological factors, such as patient denial, loss of control, and embarrassment, may also be important considerations and merit further study.

Study Limitations
The principal limitation of this study is its observational design, which may lead to concerns of residual confounding or bias. In addition, we did not collect data on the distance each patient lived from hospital or the type of EMS service provided (whether capable of basic or advanced cardiac life support). However, these limitations do not compromise our observation that EMS use during MI is likely underused in the United States. Finally, this study represented only MI patients who were transported to the hospital and did not include those who were pronounced dead in the field and not transported to the hospital.

Conclusions
A 9-1-1 system is currently available to >90% of the US population.22 Our data provide independent confirmation from those of other studies that have reported underutilization of EMS during MI and reinforce the larger role of EMS in the overall care of the patient with cardiac symptoms. Wider use of EMS for patients with suspected MI during the present era of acute reperfusion may offer considerable opportunity for improvement in public health.

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References


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