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Prehospital Transport of Patients with Acute Myocardial Infarction: A Community-Wide Perspective

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Abstract

Objective—The objectives of this population-based study were to examine the use of emergency medical services (EMS) in greater Worcester (MA) residents (2000 census = 478,000) hospitalized with acute myocardial infarction (AMI) at all metropolitan Worcester medical centers in 4 biennial periods between 1997 and 2003. A secondary study aim was to describe the demographic and clinical characteristics of patients with AMI transported to metropolitan Worcester hospitals by EMS, as compared to those transported by other means, and their hospital outcomes.

Methods—We reviewed the medical records of 3,805 patients hospitalized for confirmed AMI at 11 greater Worcester medical centers during 1997, 1999, 2001, and 2003. Information about the use of EMS, patient characteristics, and hospital outcomes was obtained through the review of hospital charts.

Results—A total of 2,693 greater Worcester residents with AMI (70.8%) were transported to area hospitals by ambulance. Patients transported by ambulance were older, more likely to be women, have a greater prevalence of comorbidities, and a different symptom profile than patients transported by other means. Patients arriving at greater Worcester hospitals by ambulance were more likely to develop serious clinical complications, including heart failure and cardiogenic shock, and die during hospitalization compared with patients not transported by EMS.

Conclusions—Our results suggest that the majority of greater Worcester residents seeking care for AMI are transported by EMS. Patients transported by ambulance differ from patients transported by other means and are more likely to experience adverse hospital outcomes. The reasons why patients utilize EMS in the setting of AMI need to be further explored and patient's care seeking behavior enhanced.

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Keywords

acute myocardial infarction; prehospital transport; emergency care seeking behavior

Introduction

Acute myocardial infarction (AMI) remains a leading cause of morbidity and mortality throughout the industrialized world (1,2). The effective management of patients with AMI is directly linked to time: the more rapidly patients are treated with coronary reperfusion therapy, the greater their survival (3–5). Approximately one-half of the deaths attributed to AMI occur from cardiac arrest in the out-of-hospital setting, reinforcing the importance of the early activation of emergency medical services in persons experiencing signs and symptoms of acute coronary disease (1,2). Given this background, it remains of continuing importance for the large number of patients with acute coronary disease to seek medical care as soon as possible after the development of acute symptoms and receive emergency treatment in a timely manner; disappointingly, most studies suggest that patients with AMI exhibit considerable delay in seeking acute hospital care and that their care seeking behavior has not changed appreciably over the past several decades (6–8). Moreover, most patients with signs and symptoms of acute coronary disease do not call for an ambulance and more research is needed to understand the reasons why these high risk patients utilize alternative means of transportation to the hospital. Contemporary data remain particularly lacking about the use of emergency medical services in the setting of AMI, particularly from the more generalizable perspective of a community-based investigation, as well as information about the characteristics and hospital outcomes of patients transported by ambulance as compared to those presenting to the hospital by other means.

The purpose of this population-based investigation is to describe the use of emergency medical services (EMS) in patients hospitalized with AMI at all greater Worcester (MA) hospitals in 4 annual periods between 1997 and 2003. A secondary study objective is to describe the demographic and clinical characteristics of greater Worcester residents who are transported to hospitals in the Worcester metropolitan area by ambulance as compared to other means of transportation. The final aim of this study, using data from an ongoing coronary disease surveillance project among residents of this large central New England community, is to examine differences in the management and hospital outcomes of patients who were transported by ambulance as compared to other modes of transport.

Methods

Study Population

The Worcester Heart Attack Study is an ongoing population-based investigation examining changes over time in the incidence rates, hospital and post discharge death rates, as well as management practices utilized in metropolitan Worcester residents (2000 census = 478,000) hospitalized with independently validated AMI at all greater Worcester medical centers (9–12). Details of this study have been previously published as well as our principal findings to date describing changing trends in the incidence rates, hospital and long-term death rates,

and use of different treatment modalities in patients hospitalized with independently confirmed AMI (9–12). In brief, the medical records of greater Worcester residents hospitalized for possible AMI at all 11 area medical centers on an alternate yearly basis were individually reviewed and validated according to pre-defined standardized criteria based on acute symptomatology, electrocardiographic changes, and serial increases in serum enzyme findings. Data were collected on a biennial basis due to the availability of funding support and for purposes of examining changes in our principal study endpoints on an approximate alternate yearly basis. While we have previously collected information about changing trends in community mortality attributed to coronary disease in the greater Worcester population (13,14), detailed information about out-of-hospital cardiac deaths in this community, and the care seeking behavior of patients dying from cardiac disease outside of the acute care setting, is not collected.

Data Collection

Information about patient's demographic, medical history, and clinical characteristics was abstracted from hospital medical records by trained nurse and physician reviewers. These data abstractors received extensive training in the standardized review of hospital medical records and quality control checks on these individuals were carried out on a regular ongoing basis. The variables abstracted from hospital charts by our team of trained reviewers included patient's age, sex, race, medical insurance status, comorbidities, acute clinical symptoms, AMI associated characteristics including AMI type (Q wave vs non-Q wave) and AMI order (initial vs prior event) (15,16), development of heart failure, cardiogenic shock and atrial fibrillation at any time during hospitalization for AMI (17–19), and the use of different hospital treatment regimens including cardiac medications as well as coronary interventional procedures (20). Information about the means of transportation to the hospital was obtained by review of hospital and emergency department medical records as well as EMS transport notes. Since few (n=32) patients were transported by helicopter during the 4 years under study, these patients were eliminated from further consideration. Patients with unknown mode of transport were also excluded (n= 195) as were interfacility transfers arriving by EMS (n=482).

The final study sample utilized for purposes of this report consisted of 3,805 greater Worcester residents hospitalized with independently validated AMI during 4 annual periods: 1997 (n=908), 1999 (n=817), 2001 (n=1,067) and 2003 (n=1,013).

Data Analysis

Differences in the distribution of various categorical and continuous variables between the 2 primary comparison groups (patients transported to Central Massachusetts hospitals by ambulance as compared to those transported by other means) were examined using chi-square and t-tests as appropriate for categorical and continuous variables respectively. Logistic regression analysis was used to examine factors associated with the use of EMS. The multivariable regression model included factors potentially associated with acute care seeking behavior including patient's age, sex, insurance status, history of cardiovascular disease, AMI associated characteristics, time of acute symptom onset, time period of hospitalization, and hospital survival status. Multivariable adjusted odds ratios and

accompanying 95% confidence intervals were calculated in a standard manner. Regression modeling was also utilized to examine the association between means of hospital transport and short-term outcomes, including the development of atrial fibrillation, heart failure, cardiogenic shock during hospitalization, as well as dying, while simultaneously controlling for the effect of a number of potentially confounding demographic and clinical variables. These variables were controlled for either because they differed between the 2 primary comparison groups or because they have been previously shown to be associated with EMS use or with an adverse prognosis in the setting of AMI. C statistics for our regression models are reported.

Results

A total of 3,805 greater Worcester residents were hospitalized with independently validated AMI during the 6 year period under study. Of these, 2,693 patients (70.8%) were transported by ambulance. The remainder of the study sample was transported either by personal car, taxi, or public transportation to greater Worcester hospitals for symptoms of AMI. The proportion of patients transported by ambulance to greater Worcester hospitals for AMI remained relatively constant over time. In 1997, 66.9% of patients with AMI were transported by ambulance; this percentage was 72.2% in 1999, 70.3% in 2001, and 73.6% in 2003.

Characteristics of Patients Hospitalized with AMI According to Mode of Transport

Patients transported by EMS were older, more likely to be women, insured by Medicare, have been previously diagnosed with each of the comorbid conditions examined, and been previously diagnosed with a prior AMI (Table 1). Patients transported by ambulance were more likely to present with dyspnea/diaphoresis, cough/fever/headache, and vomiting; on the other hand, these patients were less likely to complain of chest pain and arm or shoulder pain than patients transported by other means. While information about the extent of prehospital delay was missing in a large proportion of the charts of eligible study patients (48%), the average duration of time from the onset of acute coronary symptoms to the seeking of hospital care was significantly shorter in patients transported by ambulance versus other means (3.9 vs. 4.7 hours) ($p < .001$). Similar characteristics were associated with EMS transport when we examined the demographic and clinical characteristics of patients transported by ambulance during each of the 4 years under study.

We carried out a multivariable logistic regression analysis to examine the independence of previously observed univariate associations with ambulance use (Table 1). After controlling for a variety of demographic and clinical factors possibly associated with EMS use, older age, female sex, history of heart failure, appearance of a new Q wave AMI, and the absence of chest pain and/or arm or shoulder pain were significantly associated with the use of ambulance services in the setting of evolving AMI. Patients reporting dyspnea and/or diaphoresis at the time of hospital presentation for AMI were more likely to call for an ambulance than patients who did not report these symptoms (model C statistic = 0.72).

Hospital Treatment Practices

In terms of differences in hospital treatment practices, patients transported to metropolitan Worcester hospitals by ambulance were significantly less likely to be treated with aspirin, beta blockers, lipid lowering agents, nitrates, and thrombolytic therapy during hospitalization than patients transported by other means (Table 2). Patients brought to greater Worcester hospitals by ambulance were significantly less likely to undergo cardiac catheterization, and coronary angioplasty, than patients brought in to area hospitals by means other than EMS.

Use of Emergency Medical Services and Hospital Outcomes

We examined the association between means of hospital transport and the development of important clinical complications, including atrial fibrillation, heart failure, and cardiogenic shock, and hospital survival in both crude and multivariable adjusted analyses (Table 3). Patients transported by ambulance were more likely to develop each of the clinical complications examined during the acute hospitalization and were also more likely to die. When we adjusted for the potentially confounding effects of other demographic, medical history, and clinical prognostic factors in a series of multivariable adjusted regression analyses (Table 2), patients transported by ambulance remained at greater risk for experiencing each of these endpoints, although the risks became attenuated after adjustment for several different factors that could affect the risk of these hospital outcomes. In our last multivariable adjusted regression model, we controlled for previously described demographic and clinical factors, as well as for patient's acute symptomatology, area of residence (urban vs. rural), as well as whether they developed any of the other hospital outcomes under study.

Discussion

The results of this population-based investigation carried out in residents of a large New England metropolitan area suggest that nearly 7 out of every 10 patients with independently validated AMI were transported by EMS. Patients transported by ambulance to area hospitals for acute medical care have different sociodemographic and clinical characteristics than patients transported by other means. Differences in the incidence rates of several clinically relevant hospital outcomes were observed according to the means of hospital transport.

Extent of Ambulance Use

Given the time-dependent benefits associated with early reperfusion therapy in patients with evolving AMI, practice guidelines in the U.S. strongly recommend the early activation of EMS in response to symptoms consistent with the presence of AMI (21). Moreover, the EMS system provides an important and vital link between patients with an acute coronary event and the receipt of more definitive diagnosis and treatment in a timely manner. Despite this background, most observational studies and randomized controlled trials have found that upwards of only one-half of patients with AMI are transported by ambulance (5,6,7,8,22–24). In the Atherosclerosis Risk in Communities study (ARIC) of individuals from 4 large U.S. communities hospitalized with AMI, the percentage of patients with AMI

who utilized EMS increased from 37% in 1987 to 44% in 2000 (7). Investigators from the Second National Registry of Myocardial Infarction (NRMI-2), which included patients hospitalized with AMI over the period 1994 to 1998, found that only slightly more than one half (53%) of patients included in this large coronary disease registry utilized the ambulance for hospital transport, with no significant changes in the use of EMS noted over the period under study (8).

Our findings demonstrate that, between 1997 and 2003, approximately 70% of greater Worcester residents hospitalized with AMI were transported by ambulance; this proportion is considerably higher than previous estimates from the published literature. While the reasons for the relatively high ambulance usage in this population remain unknown, possible contributory factors include positive previous experiences with EMS by residents of this New England metropolitan area and perceived more rapid response to the hospital, and enhanced receipt of timely diagnostic services and treatment practices, by using the ambulance versus other means of hospital transport.

Characteristics of Patients Transported by Ambulance

Although there is a relatively extensive literature describing extent of, and factors associated with, prehospital delay and care seeking behavior in patients with AMI, there is relatively little known about the characteristics of patients using EMS in the setting of AMI.

With respect to specific individual attributes, patients in the NRMI-2 study who used EMS were more likely to be older, female, at higher risk for adverse outcomes at the time of hospital presentation, HMO subscribers, black or white race, and with a history of stroke or heart disease (8). In the ARIC study, women, older individuals, patients who presented without chest pain, and those with a history of stroke were more likely to use EMS than respective comparison groups (7). In a recent study carried out in Ottawa, Canada, patients with ST segment elevation AMI transported by ambulance were significantly older and presented with a higher Killip class score than patients who were self-transported (24). In several studies of King County, Washington, residents presenting to area emergency departments with chest pain, persons who did not use EMS were more highly educated, did not perceive their symptoms to be life threatening, and either did not think to call 911 or thought that self-transport to the hospital would be faster (6,25). In a telephone and medical record survey of a sample of patients included in the Rapid Early Action for Coronary Treatment (REACT) trial, older patients, whites, those living alone, and individuals residing in areas with a prepaid EMS system were more likely to call for an ambulance than respective comparison groups (26). In terms of situational factors, patients in this study who reported taking an antacid or aspirin at the time of onset of acute symptoms, and those who believed their condition was heart related, were more likely to use EMS. In our study, older patients, women, and patients with prior heart failure were more likely to call an ambulance than respective comparison groups.

Interestingly, in our study patients with less classical symptoms of AMI were more likely to activate the EMS system. Women have been previously shown to experience or report less typical symptoms of AMI which may also partially explain their care seeking behavior. Several studies have shown that the risk for acute coronary events is not associated with an

increased knowledge of the symptoms of AMI (23,27). It, therefore, remains of considerable importance to educate these high risk patients, their relatives, and their health care providers regarding the appropriate recognition of, and prompt response to, their acute symptoms be they the more typically perceived symptoms of acute coronary disease or otherwise.

Several studies have shown that patients who do not call EMS commonly believe that private transportation by car or taxi to the hospital is the faster choice (25,28). Although many patients may think that self-transport to the hospital is the quickest option for seeking rapid medical care, recent studies have demonstrated that time to reperfusion therapy is significantly reduced in patients transported by ambulance compared with those utilizing self-transport (8,28). In the present study, while information about duration of prehospital delay was missing in approximately one half of all medical records reviewed, patients transported to the hospital by ambulance arrived at greater Worcester hospitals almost 1 hour earlier than patients transported by other means. Data from the REACT trial demonstrated that EMS users received thrombolytics 17 minutes earlier than other patients (28). In NRMI-2, eligible EMS users received reperfusion therapy approximately 24% more often, in addition to receiving thrombolytics and PCI appreciably earlier, than patients transported to participating NRMI-2 hospitals by other means (8).

In contrast to the NRMI-2 data, our findings during a more recent time period and in a more restrictive population of residents from a single New England community suggest that patients presenting by ambulance with an AMI were significantly less likely to receive all forms of coronary reperfusion therapy, including thrombolytics and coronary angioplasty. While the reasons for these discrepant study findings are unknown, our data suggest that factors other than the mode of hospital transport, such as MI severity, patient eligibility criteria, and physician's treatment practices likely affect the administration of these and other effective cardiac therapies.

Use of EMS and Hospital Outcomes

We a priori hypothesized that patients with an evolving AMI who were transported by ambulance would experience better short-term (hospital) outcomes than patients transported by other means. The published literature on this topic, however, fails to provide supportive evidence for this hypothesis. In NRMI-2, patients transported by ambulance were significantly more likely to die than patients presenting to the hospital by other means (8). The magnitude of this association, however, was markedly reduced after controlling for other important prognostic factors. Our study found that patients transported by ambulance were significantly more likely to develop heart failure, cardiogenic shock, and atrial fibrillation during the acute hospitalization than patients who presented to greater Worcester hospitals by other modes of transport. Patients transported by EMS were also more likely to die during hospitalization than patients who presented to greater Worcester hospitals by other means of transport. While these trends persisted after adjustment for other potentially confounding factors, the magnitude of these differences was attenuated after controlling for other factors that affect the development of these hospital outcomes.

While we are unable to provide a satisfactory explanation for these counterintuitive findings, it may be that patients transported by EMS are more ill and present with more extensive

myocardial damage than patients transported by other means. Even though we adjusted for age (as well as for other potentially confounding prognostic factors) in our regression analyses, patients transported by ambulance were, on average, 8 years older than those transported by other means and advanced age has consistently been shown to be associated with poor hospital outcomes in numerous prior studies.

Multiple studies of patients with chest pain and acute coronary syndromes have found that ambulance use is associated with both the likelihood of AMI and worse hospital outcomes, including increased mortality (24,29,30). In the ACI-TIPI Trial of 6,604 patients presenting to U.S. hospitals with chest pain, the frequency of ambulance use increased with increasing levels of AMI severity (30), further suggesting that patients transported by EMS are indeed more ill.

Study Limitations

As mentioned previously, while we have described the magnitude of, and changing trends in, out-of-hospital deaths attributed to coronary disease in the greater Worcester population (13,14), we did not collect information about the care seeking behavior of persons dying from coronary disease outside of the acute care setting. We did not collect information about patient's beliefs about the importance of rapid care-seeking, situational factors that may have influenced patient's decisions to call for an ambulance, and the reasons why patients called (or did not call for) EMS in the context of acute coronary symptoms. It is also possible that either unmeasured, or inadequately measured, factors which may have been differentially distributed between our respective comparison groups may have contributed to observed differences in the principal hospital outcomes between patients transported by EMS as compared to those utilizing other means of hospital transport. In addition, we were unable to adequately characterize factors associated with the severity of the AMI, such as peak enzyme findings and extent of acute myocardial necrosis, which may have affected patient's care seeking behavior and the occurrence of the hospital complications examined. We also did not collect information about patient's prior experiences with acute care transport and/or their experiences and thoughts about utilizing hospital emergency departments.

Conclusions

The present results suggest that approximately 7 out of every 10 patients in the greater Worcester area hospitalized with AMI were transported by EMS during the late 1990's and early years of the 21st century. Despite the relatively high use of EMS in this large New England population, innovative and population-based approaches towards increasing EMS utilization among younger patients, those with selected comorbidities, and patients who are experiencing more classical symptoms of AMI remain warranted. The finding that patients in the greater Worcester area with AMI utilize ambulance services far more often than the national average is of considerable interest since national efforts to increase both the awareness of AMI symptoms and the benefits associated with activation of the EMS system have yielded mixed results. Several population-based community campaigns in the U.S. and Europe have found a significant decrease in only pre-hospital delay in patients with signs

and symptoms of AMI (31) whereas others have observed an increase in only EMS use (23,24); other studies have failed to observe a significant improvement in either endpoint (32). Given the time dependent benefits associated with the early treatment of patients with AMI, and increased risk of sudden cardiac death during the first several hours of acute symptom onset, further investigation is needed to identify those factors facilitating the use of EMS in patients with AMI.

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Table 1

Characteristics of Patients Hospitalized with Acute Myocardial Infarction (AMI) According to Means of Hospital Transportation

Characteristic	Ambulance (n=2,693)	Non-EMS (n=1,112)	P Value	Multivariable Adjusted OR
Age (mean, yrs)	73.9 (±13.3)	66.0 (±13.8)	<.001	--
Age (yrs) (%)				
<55	10.2	23.1		1.0
55–64	13.6	21.5		1.34 (1.04,1.72)
65–74	21.0	24.9	<.001	1.54 (1.20,1.99)
75	55.3	30.5		2.95 (2.28,3.80)
Female sex (%)	48.7	34.0	<.001	1.34 (1.14,1.57)
White race (%)	92.6	92.1	0.67	0.91 (0.68,1.20)
Insurance Status (%)				
Private Insurance/Blue Cross	6.6	9.7		1.00 (0.69,1.46)
Medicare	50.8	37.3	<.001	1.16 (0.88, 1.54)
Medicaid	2.8	3.6		1.29 (0.81,2.06)
HMO	33.8	39.8		1.15 (0.88,1.49)
Medical history (%)				
Angina	23.9	21.0	0.06	1.05 (0.87,1.27)
Diabetes	33.9	29.1	<.01	1.07 (0.90,1.27)
Heart failure	29.2	14.0	<.001	1.77 (1.37,2.11)
Hypertension	69.5	62.4	<.001	0.98 (0.83,1.16)
Stroke	13.9	8.5	<.001	1.21 (0.94,1.55)
AMI Characteristics (%)				
Initial	61.4	69.7	<.001	0.86 (0.72,1.02)
Q wave	23.7	25.7	0.18	1.30 (1.08,1.56)
Symptoms (%)				
Chest pain	67.0	80.2	<.001	0.68 (0.55,0.83)
Dyspnea/diaphoresis	72.0	68.1	<.05	1.34 (1.13, 1.58)
Arm/shoulder pain	26.5	39.7	<.001	0.72 (0.58, 0.89)
Left arm pain	34.7	46.1	<.001	0.93 (0.73, 1.10)
Cough/fever/headache	21.6	18.9	<.05	0.90 (0.76, 1.13)
Jaw or back pain	17.9	22.8	<.001	0.94 (0.78, 1.13)
Nausea/indigestion	32.8	35.3	0.12	1.02 (0.85, 1.21)
Vomiting	19.6	15.3	<.01	1.19 (0.94, 1.51)
Time of Acute Symptom Onset (%)				
6:00 a.m. –11:59 a.m.	25.4	28.3		1.16 (0.92, 1.45)
12:00 p.m. –5:59 p.m.	21.7	22.0	0.53	1.25 (0.98, 1.59)
6:00 p.m. –11:59 p.m.	26.1	24.7		1.11 (0.89, 1.40)

* 95% CI

° respective referent categories: age <55 years, male sex, nonwhite race, lack of insurance, absence of selected medical history factors, prior, non-Q wave AMI, absence of selected symptoms, and occurrence of acute symptoms between 12:00 and 5:59 a.m.

Table 2

Treatment Characteristics of Patients Hospitalized With Acute Myocardial Infarction According to Means of Hospital Transportation

Medications (%)	Ambulance (n=2,693)	Non-EMS (n=1,112)	P value
Angiotensin converting enzyme inhibitors	57.4	54.7	0.13
Aspirin	88.6	93.8	<.001
Beta blockers	82.0	88.9	<.001
Calcium channel antagonists	27.0	24.7	0.04
Digoxin	30.2	20.0	<.001
Lipid lowering agents	45.7	55.9	<.001
Nitrates	42.4	51.2	<.001
Thrombolytics	10.6	13.3	<.05
Procedures (%)			
Coronary angioplasty	22.6	31.4	<.001
Cardiac catheterization	38.5	57.0	<.001
Coronary artery bypass surgery	4.9	6.1	0.13

Table 3
Differences in Hospital Outcomes in Patients with Acute Myocardial Infarction According to Means of Hospital Transportation

Clinical Complication (%)	Ambulance (n=2,693)	Non-EMS (n=1,112)	Regression Model #1	Regression Model #2	Regression Model #3
Heart failure*	42.7	26.4	1.33 (1.12, 1.58)	1.28 (1.07, 1.53)	1.20 (1.00, 1.45)
Cardiogenic shock*	6.5	2.8	1.75 (1.14,2.68)	1.93 (1.23,3.02)	1.83 (1.14,2.94)
Atrial fibrillation*	20.7	12.1	1.37 (1.10,1.70)	1.36 (1.08,1.71)	1.31 (1.04, 1.65)
Death	13.8	4.8	2.30 (1.69,3.12)	2.10 (1.52,2.91)	1.87 (1.32, 2.65)

∞
95% confidence interval

Model #1: Adjusted for age, sex, medical insurance, comorbidities (angina, diabetes, heart failure, hypertension, stroke), clinical characteristics (AMI order and type), and hospital survival

Model #2: Adjusted for age, sex, medical insurance, comorbidities, clinical characteristics, hospital survival, and treatment practices (hospital receipt of aspirin, ACE inhibitors, beta blockers, lipid lowering agents, thrombolytics, PCI, and CABG).

Model #3: Adjusted for age, sex, medical insurance, comorbidities, clinical characteristics, treatment practices, geographic residence, hospital complications, and acute clinical symptoms.

C statistics for the first, second, and third regression models, respectively, are the following: Heart failure (0.75, 0.79, 0.81); cardiogenic shock (0.67, 0.88, 0.90); atrial fibrillation (0.67, 0.78, 0.78); and hospital mortality (0.69, 0.81, 0.86).