

The Prevalence and Outcomes of In-Hospital Acute Myocardial Infarction in the Department of Veterans Affairs Health System

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Background: Most studies of the epidemiology and treatment of acute myocardial infarction (AMI) have focused on patients who experienced onset of their symptoms in the community and then presented to the hospital. There are, however, patients whose symptoms of AMI begin after hospitalization for other medical conditions. The purposes of this study were to determine the prevalence of in-hospital AMI in the Veterans Health Administration (VHA) and to compare baseline characteristics, treatments, and outcomes according to whether individuals presented with AMI or had an in-hospital AMI.

Methods: This was a retrospective cohort study of 7054 veterans who were hospitalized for AMI in 127 VHA medical centers between July 2003 and August 2004. The main outcome measure was 30-day mortality. Key covariates included age, body mass index, admission systolic blood pressure, heart rate, previous use of lipid-lowering drugs, elevated admission troponin value, prolonged and/or

atypical chest pain on admission, and ST-segment elevation on the initial electrocardiogram.

Results: There were 792 patients (11.2%) who had AMI while hospitalized for other medical conditions. These patients differed substantially from those who presented to the hospital with AMI. The odds of 30-day mortality were greater in the in-hospital group (odds ratio, 3.6; 95% confidence interval, 3.1-4.3; $P < .001$) and remained higher after statistical adjustment (odds ratio, 2.0; 95% confidence interval, 1.7-2.4; $P < .001$).

Conclusion: Although most attention has been paid to patients with AMI admitted via the community emergency medical system or through the emergency department, AMI occurring during hospitalization for other medical problems is an important clinical problem.

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MOST RECENT STUDIES OF the epidemiology and treatment of acute myocardial infarction (AMI) have focused on patients who had onset of their symptoms in the community and then arrived at a hospital for evaluation and treatment. There are, however, patients whose symptoms of AMI begin after being hospitalized for other medical conditions. To our knowledge, few studies¹⁻³ have addressed the clinical epidemiology of in-hospital AMI. One such recent study¹ conducted in 54 German hospitals reported that 7% of patients had an in-hospital AMI, and in-hospital mortality for these patients was about twice that of patients presenting with AMI (27% vs 14%). However, information about the admission diagnosis was available for only 22% of the in-hospital patients and was either unstable or stable angina pectoris for 70% of this group.¹ Ultimately, little is known about the prevalence, clinical characteristics, and outcomes of patients experiencing in-

hospital AMI, and there is little or no specific guidance about the management of this problem in current practice guidelines.

Although it is germane to all hospitals that provide care for acutely ill patients with heart disease, the clinical epidemiology of in-hospital AMI may be particularly relevant to systems such as the Veterans Health Administration (VHA), which admits patients with a heavier burden of comorbid conditions. Furthermore, most VHA hospitals do not directly receive patients who have symptoms of AMI and are transported via the emergency medical system.^{4,5} The importance of this phenomenon was highlighted in a recent study⁶ reporting higher 1-year mortality for VHA patients with AMI compared with Medicare patients. A possible explanation for this difference was the higher relative frequency of in-hospital AMI in VHA compared with non-VHA hospitals, but little is known about the prevalence of this problem. The current study was undertaken to (1) determine the prevalence of in-hospital AMI in the VHA and (2) compare

baseline characteristics, treatments, and outcomes of veterans according to whether they presented with AMI or had an in-hospital AMI.

METHODS

PATIENT POPULATION

Between July 20, 2003, and August 19, 2004, 8033 index cases of AMI were documented by standard electrocardiographic, troponin, and/or other clinical evidence. We excluded 406 patients (5.1%) who were transferred to VHA hospitals from other medical facilities because important baseline information was unavailable. Also excluded were 164 patients (2.0%) who were admitted with a diagnosis of acute coronary syndrome or ischemic heart disease but were not documented to have had AMI (ie, they had unstable angina). For the present analysis, we removed 409 patients (5.1%) who developed AMI during the post-operative period because there is already an extensive literature on this subject. On the other hand, little is known about AMI in patients admitted with other medical conditions. As a result of these exclusions, there were 7054 individuals who had documented AMI and were discharged from VHA medical centers during the period of study.

Information for this study was collected as part of the VHA External Peer Review Program (EPRP) for quality monitoring and improvement for a variety of medical conditions and procedures, including AMI. Patients with *International Classification of Diseases, Ninth Revision (ICD-9)*, diagnosis codes 410.xx were identified from administrative data housed at the Austin Automation Center, Austin, Tex. Working with the EPRP abstraction contractor, West Virginia Medical Institute (Charleston), the VHA Office of Quality and Performance generated a list of patients that was transmitted to VHA facilities, where both paper and electronic medical records were manually abstracted by trained abstractors using standard reporting forms. Abstracted data were then entered into a database maintained by the contractor.

STUDY VARIABLES

We used data from the EPRP database and US Department of Veterans Affairs workload files to describe demographic and personal characteristics (eg, age, sex, ethnicity, body mass index, distance from the veteran's residence to the medical center), receipt of reperfusion therapy, vital status, and use of cardiac procedures.^{7,8} Ethnicity was obtained from workload files and was classified as Hispanic, African American, white, other, or unknown. Individual medical centers were classified according to type of invasive cardiac procedures offered: no cardiac catheterization, cardiac catheterization only, percutaneous coronary intervention (PCI), or a full range of procedures, including coronary artery bypass graft surgery. Clinical information, such as medical history, cardiac medications used, time from symptom onset to hospital admission, initial heart rate, systolic and diastolic blood pressures, and initial symptoms, was obtained from the medical record. The initial electrocardiographic diagnosis of ST-segment elevation AMI included patients with ST-segment elevation of 1 mV or higher in 2 or more contiguous leads and/or left bundle branch block. The remainder of patients had non-ST-segment elevation AMI. Both the initial and highest troponin values were recorded; positive tests were determined according to criteria for the particular type of assay used. In both groups, more than 99% of the AMIs were confirmed by troponin level elevations.

Classification as to whether an AMI occurred in the hospital was initially performed by the abstractor and confirmed by

evaluation of the admitting diagnosis from VHA bed section files, which track patients as they move during the course of their hospital stay. For each stay in a bed section, ICD-9 diagnosis and procedure codes were used to determine conditions that were present prior to the onset of AMI. Conditions were classified as cardiovascular (codes 390-459), respiratory (460-519), genitourinary (580-629), gastrointestinal (520-579), ill-defined (780-799), injury (800-999), cancer (140-210), endocrine-metabolic (240-279), or other. Patients with a diagnosis of possible cardiac ischemia or infarction (codes 410-414) were excluded because they clearly presented with signs or symptoms suggestive of AMI.

Cardiac treatments and procedures were recorded as part of chart abstraction, but VHA workload data were also accessed to ascertain the use of cardiac procedures after discharge. The use of fibrinolytic therapy was recorded, as were contraindications to therapy. For in-patient AMI, we determined whether PCI was performed within 12 hours of symptom onset for patients with ST-segment elevation AMI. In addition, 30-day rates of cardiac catheterization, PCI, and coronary artery bypass graft surgery were calculated. Length of stay was defined as the number of days from admission to discharge for those admitted with AMI and the number of days from symptom onset to discharge for those with in-hospital AMI. In-hospital events such as recurrent ischemia, reinfarction, cardiogenic shock, cardiac arrest, stroke, and death were assessed as part of chart abstraction. The Beneficiary Identification Record Locator System death file and the medical in-patient files were used to determine vital status after hospital discharge.⁷

STATISTICAL METHODS

Comparisons between patients who presented with AMI and those who had an in-hospital AMI were made with the χ^2 test for categorical variables and the 2-sample *t* test for continuous measures. Logistic regression was used to estimate the association between in-hospital AMI vs AMI on presentation and 30-day mortality after adjusting for potential confounders. Previously, we developed and tested unpublished logistic regression models for 30-day mortality using earlier versions of EPRP data (C.M., E.L., and A.E.S., unpublished data, July 2005). These models were developed in a randomly selected patient group and tested in a separate group. Model discrimination and calibration were assessed with the C statistic and the Hosmer-Lemeshow goodness-of-fit test. Variables from the 30-day mortality model were first entered into the model, and then the in-hospital AMI variable was forced in to determine its association with mortality. Logistic regression analyses were run with and without a cluster correction for medical center. Missing values of body mass index were imputed from a linear regression model. Both SPSS version 13.0 and Stata version 9.0 statistical software (SPSS Inc, Chicago, Ill, and StataCorp, College Station, Tex, respectively) were used for data analyses.

Using our 30-day mortality model, we adjusted for the following statistically significant predictors: history of cancer; congestive heart failure; age; age squared; body mass index; body mass index squared; admission systolic blood pressure; admission systolic blood pressure squared; admission heart rate; previous use of lipid-lowering drugs; elevated admission troponin value; prolonged chest pain on admission; chest pain characterized by typical symptoms such as crushing, pressure, belching, or radiating to the shoulders; atypical pain described as dyspnea, nausea, or diaphoresis; and ST-segment elevation or left bundle branch block on the initial electrocardiogram.

This study was approved by the University of Washington, Seattle, institutional review board, and waiver of informed consent was granted.

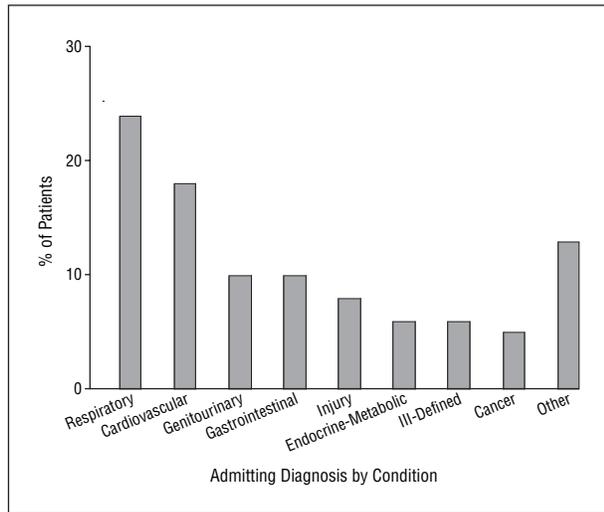


Figure 1. Admitting diagnosis in veterans with in-hospital acute myocardial infarction.

RESULTS

BASELINE CHARACTERISTICS

There were 792 patients (11.2%) who had an AMI while hospitalized for other medical conditions. Respiratory, genitourinary, gastrointestinal, injury, endocrine-metabolic conditions, and cancer accounted for 63.0% of original admitting diagnoses (**Figure 1**). Cardiovascular conditions (excluding AMI and angina) constituted 18.0% of admission diagnoses, and congestive heart failure and cerebrovascular diagnoses accounted for about half of these conditions. Individuals with in-hospital AMI were hospitalized a median of 2 days prior to the onset of AMI symptoms.

With few exceptions, patients with in-hospital AMI differed substantially from patients who presented to the hospital with AMI (**Table 1**). In addition to being older, the in-hospital group more often had congestive heart failure, diabetes mellitus, renal disease, cerebrovascular disease, chronic obstructive pulmonary disease, dementia, or cancer. The in-hospital group was less likely to have a history of previous myocardial infarction, coronary angioplasty, or lipid disorders, or to have smoked cigarettes during the past year. With regard to medications used before hospitalization, patients with in-hospital AMI were more often receiving insulin, whereas use of aspirin and lipid-lowering drugs was more frequent in patients who presented with AMI.

Of the 127 hospitals in which all patients with AMI were treated, 61 (48.0%) had no cardiac catheterization facilities, 16 (12.6%) performed catheterization only, 7 (5.5%) provided PCI only but had surgical backup nearby, and 43 (33.9%) maintained full cardiac services including coronary artery bypass graft surgery. Almost 24.5% of the veterans in this sample were hospitalized in facilities without cardiac catheterization, while more than half (52.0%) were in facilities with full cardiac services. There was no statistically significant association between whether a patient experienced an in-hospital AMI and the type of cardiac facilities available at the hospital (**Figure 2**)

Table 1. Baseline Demographics, Medical Histories, and Prior Cardiac Medications

Variable	In-Hospital AMI (n = 792)	Presented With AMI (n = 6262)	P Value
Mean age, mean ± SD, y	73.5 ± 10.0	68.9 ± 11.9	<.001
Age, %			<.001
<50 y	1.4	4.9	
50-59 y	11.0	21.5	
60-64 y	7.3	11.8	
65-69 y	11.9	10.6	
70-79 y	37.6	28.7	
80-89 y	27.4	20.5	
≥90 y	3.4	2.0	
Men, %	98.5	98.3	.69
Ethnicity, %			<.001
Hispanic	9.3	5.6	
African American	8.3	10.9	
White	61.1	56.4	
Other	0.7	0.6	
Unknown	20.7	26.5	
BMI, mean ± SD	26.4 ± 6.1	27.9 ± 6.0	<.001
Distance from home to hospital, km, mean ± SD	52.3 ± 102.1	61.4 ± 190.4	.03
Geographic region of medical center, %			.08
Northeast	13.5	14.4	
South	44.2	45.1	
Midwest	23.4	19.6	
West	18.9	20.9	
Medical history, %			
Myocardial infarction	22.2	25.7	.04
Lipid disorder	52.3	60.3	<.001
Coronary angioplasty	5.9	13.1	<.001
Coronary artery bypass surgery	17.3	19.8	.10
Congestive heart failure	35.6	27.3	<.001
Diabetes mellitus	28.7	21.7	<.001
Renal disease	19.2	12.1	<.001
Cerebrovascular disease	10.5	7.4	.002
Chronic obstructive pulmonary disease	30.3	18.4	<.001
Dementia	19.8	13.5	<.001
Cancer	18.6	2.8	<.001
Cigarette smoking in past year	24.7	32.8	<.001
Previous medications, %			
Aspirin	39.4	45.8	.001
β-Blockers	47.7	49.7	.30
Angiotensin-converting enzyme inhibitors	43.9	44.9	.59
Lipid-lowering drugs	44.9	48.7	.046
Insulin	20.5	13.1	<.001
Platelet inhibitors	11.0	11.9	.47

Abbreviations: AMI, acute myocardial infarction; BMI, body mass index (calculated as weight in kilograms divided by the square of height in meters).

($P = .08$). Although cardiology consultation was available at all hospitals, the in-hospital group was less likely to have an attending cardiologist (**Figure 3**) (20.8% vs 42.2%, $P < .001$).

PRESENTATION AND MANAGEMENT

Among patients who presented to the hospital with AMI, almost half were admitted more than 12 hours after the onset of symptoms (**Table 2**). Patients with an in-

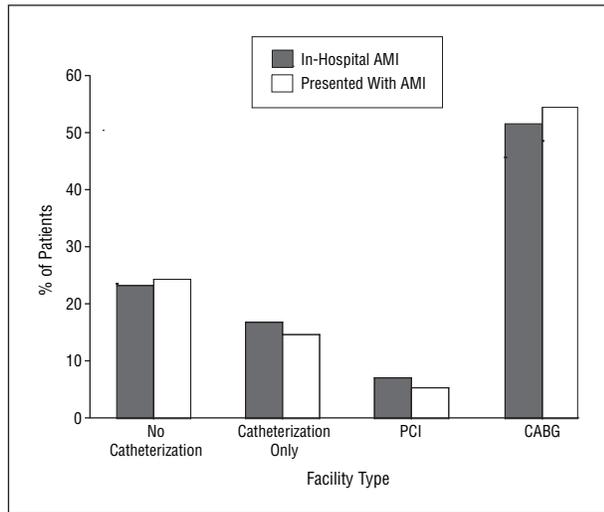


Figure 2. Type of cardiac facilities available in hospitals where veterans were treated for acute myocardial infarction (AMI). CABG indicates coronary artery bypass graft; PCI, percutaneous coronary intervention.

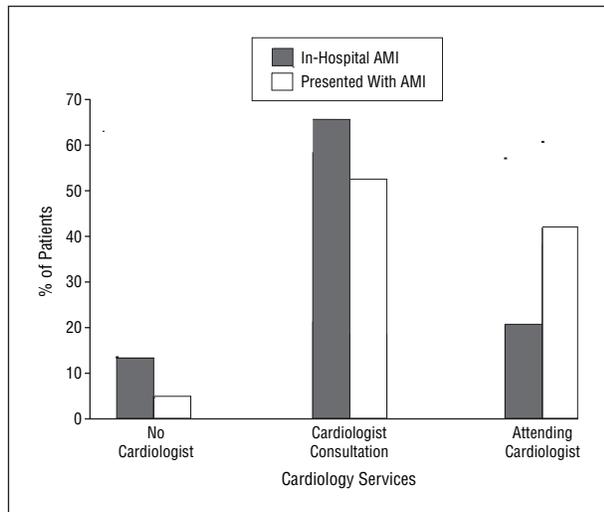


Figure 3. Cardiology services received by veterans with acute myocardial infarction (AMI).

hospital AMI had fewer symptoms typical of cardiac ischemia, including chest pain, shoulder pain, or nausea. These patients also tended to have lower systolic and diastolic blood pressures. Overall, 19.3% of the patients who presented with AMI and 9.5% of patients who experienced an in-hospital AMI had ST-segment elevation AMI (**Table 3**). The first troponin value obtained was more often elevated in the in-hospital group, indicating possible delay in diagnosis.

Among patients with ST-segment elevation AMI and no contraindications to therapy, 38.1% of the patients with an in-hospital AMI and 30.2% of the patients who presented to the hospital with an AMI received fibrinolytic therapy ($P=.44$). Among the 75 patients who experienced an in-hospital AMI with ST-segment elevation, 54 (72%) had contraindications to therapy. For 1209 patients who presented to the hospital with ST-segment elevation, 516 (42.7%) had contraindications to fibrinolytic therapy, a significantly smaller proportion.

Table 2. Presenting Signs and Symptoms

Variable	In-Hospital AMI (n = 792)	Presented With AMI (n = 6262)	P Value
Hours from symptom onset to hospital admission, %			
≤1		6.7	
>1-2		10.5	
>2-6		22.7	
>6-12		12.8	
>12-24		13.6	
>24		33.6	
Heart rate, beats/min, mean ± SD	94.5 ± 25.5	86.8 ± 23.4	<.001
Systolic blood pressure, mm Hg, mean ± SD	126.1 ± 30.8	139.5 ± 30.4	<.001
Diastolic blood pressure, mm Hg, mean ± SD	67.3 ± 18.1	76.8 ± 18.7	<.001
Symptoms, %			
Chest pain	29.2	59.2	<.001
Pressure	5.7	18.4	<.001
Belching	1.3	4.8	<.001
Shoulder pain	9.0	29.9	<.001
Nausea	9.0	19.0	<.001
Diaphoresis	7.2	18.2	<.001
Dyspnea	39.5	42.4	.13

Abbreviation: AMI, acute myocardial infarction.

Table 3. Diagnosis of Acute Myocardial Infarction (AMI)

Variable	In-Hospital AMI (n = 792)	Presented With AMI (n = 6262)	P Value
Initial diagnosis, %			
ST-segment elevation	9.5	19.3	<.001
Non-ST-segment elevation	90.5	80.7	
First troponin value elevated, %	81.9	70.7	<.001
Highest troponin value elevated, %	99.5	99.1	.30

Percutaneous coronary intervention within 12 hours of hospital arrival was performed in 30.9% of the patients who presented to the hospital with ST-segment elevation AMI. Among patients with an in-hospital ST-segment elevation AMI, only 6.7% underwent PCI within 12 hours of symptom onset ($P<.001$). Within 30 days of the event, a much higher proportion of patients who presented with AMI also underwent cardiac catheterization (58.9% vs 21.2%, $P<.001$), PCI (38.8% vs 9.5%, $P<.001$), or coronary artery bypass graft surgery (9.1% vs 1.6%, $P<.001$) compared with patients with an in-hospital AMI.

OUTCOMES

In-hospital events such as cardiogenic shock, cardiac arrest, and death were more frequent in patients with in-hospital AMI, and the mean time from AMI to hospital discharge was 5 days longer for patients who experienced an in-hospital AMI (**Table 4**). The only major cardiovascular outcome that was more common among patients who presented with AMI was recurrent ischemia. The odds of dying in the hospital were nearly 4 times

Table 4. Length of Stay, Transfer Status, In-Hospital Events, and Mortality

Variable	In-Hospital AMI (n = 792)	Presented With AMI (n = 6262)	P Value
Days from event to hospital discharge, mean \pm SD	12.2 \pm 15.1	7.0 \pm 10.1	<.001
Transferred to another hospital for PCI, %	4.0	13.5	<.001
Recurrent ischemia, %	6.3	10.1	.001
Reinfarction, %	1.8	1.1	.08
Cardiogenic shock, %	3.8	1.7	<.001
Cardiac arrest, %	10.6	3.8	<.001
Stroke, %	0.9	1.4	.23
Died in the hospital, %	27.3	8.6	<.001
Died <30 d from event, %	33.0	11.9	<.001

Abbreviations: AMI, acute myocardial infarction; PCI, percutaneous coronary intervention.

higher for patients with in-hospital AMI (odds ratio [OR], 4.0; 95% confidence interval [CI], 3.3-4.7; $P < .001$), as were the odds of dying within 30 days of the acute event (OR, 3.6; 95% CI, 3.1-4.3; $P < .001$). Even after excluding deaths occurring in the hospital, 30-day mortality was significantly higher among patients with an in-hospital AMI (7.8% vs 3.6%, $P < .001$).

We used multivariable logistic regression to estimate the risk-adjusted association between an in-hospital AMI and 30-day mortality in 6822 individuals with complete information. Relative to presenting to the hospital with AMI, having an in-hospital AMI remained significantly associated with 30-day mortality after adjustment for covariates (adjusted OR, 2.0; 95% CI, 1.7-2.4; $P < .001$), with no appreciable change in 95% CIs after adjusting for the clustering of patients within medical centers.

COMMENT

In this study, we found that of all patients who were hospitalized with AMI in VHA facilities, the event occurred in 11.2% while the patient was hospitalized for another medical condition. Compared with patients who presented to the hospital with AMI, patients with an in-hospital AMI were significantly older and more likely to have a history of comorbid medical conditions such as diabetes mellitus, chronic obstructive pulmonary disease, or congestive heart failure. Most patients were hospitalized for respiratory, genitourinary, gastrointestinal, cancer, or endocrine-metabolic conditions or for injury. Patients with an in-hospital AMI were less likely to be cared for by a cardiologist, less likely to receive coronary reperfusion therapy, and less likely to undergo cardiac catheterization and/or coronary revascularization within 30 days. Finally, patients with an in-hospital AMI were at a much higher risk of in-hospital and 30-day mortality. It is important to recognize that in this observational study it was not possible to determine whether higher mortality in the in-hospital group was due to the underlying condition or AMI. Moreover, unmeasured vari-

ables could in part explain the association between in-hospital AMI and mortality.

It has been recognized for several decades that AMI occurring during the postoperative period is characterized by more insidious symptoms and substantially higher mortality than for AMI occurring outside the hospital.^{9,10} Similarly, groups of patients, such as those with diabetes or the very old, are likely to present without typical symptoms of AMI and have a greater risk of mortality.^{11,12} Our observations suggest that another group may be at risk for delayed recognition, complications, and death. Yet, surprisingly, there have been few reports, to our knowledge, about the incidence and clinical course of AMI among patients hospitalized for other medical conditions.

We were able to locate only 3 published reports on this topic, 2 of which were published 20 years ago or more.^{2,3} Because the single recent study is from Germany,¹ little is known about in-hospital AMI in the United States today. Articles describing large registries of myocardial infarction either fail to mention in-hospital patients or remove them from reporting.^{13,14} Large administrative databases such as those for Medicare and the Health Care Cost and Utilization Project (state-level hospital data) do not include this information because it cannot be determined from ICD-9 diagnosis codes or standard variables recorded on the uniform billing form.

As noted in Table 4, the in-hospital mortality rate for veterans with in-hospital AMI was 27.3%, which is remarkably higher than the rates of 9% to 12% in the National Registry of Myocardial Infarction¹³ and the rate of 8.6% that we found among patients who presented with AMI. The rate of 27.3% that we observed was comparable to the 27.3% rate for individuals hospitalized in 54 centers in southwest Germany from 1994 to 1997.¹ However, for those in-hospital patients with a known diagnosis in the German study, 70% had an initial diagnosis of stable or unstable angina. In the present study, individuals with angina pectoris were excluded. Investigators in the German study determined the admission diagnosis for only 22% of the in-hospital group, whereas we were able to identify the admission diagnosis for virtually all participants.

The high in-hospital and 30-day mortality rates for patients with an in-hospital AMI are all the more remarkable given the relatively low proportion of patients with ST-segment elevation AMI, which is generally associated with higher mortality than is non-ST-segment elevation AMI. This suggests that other factors, most notably a concurrent medical illness, may have been responsible, directly or indirectly, for higher mortality among patients with an in-hospital AMI.

The relatively low incidence of ST-segment elevation AMI among patients who presented with AMI likely reflects the fact that veterans with this type of infarction were transported to nearby hospitals, often outside the VHA. These hospitals more often had the capacity to perform primary PCIs 24 hours a day.^{4,5} About half of the VHA hospitals in this study had cardiac catheterization laboratories, but only 39.4% had the capability to perform PCI. It is likely that even fewer centers were capable of providing this service around the clock.

Another possible explanation for the higher mortality from in-hospital AMI is that, given the often complex and atypical presentations of cardiac disease in patients with other significant comorbidities, these events were not promptly recognized and treated. We found that aggressive interventions such as thrombolysis and revascularization were used less commonly than among eligible patients presenting to the hospital with AMI. It would be premature, however, to conclude that this represents undertreatment, because these patients were significantly older and had other complicating medical illnesses that may have reasonably prevented them from receiving fibrinolytic therapy. Medical problems such as mechanical ventilation or gastrointestinal bleeding inhibit the use of aggressive therapy. Moreover, if AMI occurred when a critically ill patient was already dying from another cause, aggressive therapy would not have been warranted. Thus, further studies are necessary to better understand the epidemiology and outcomes of in-hospital AMI.

The observation that invasive therapies were used less often among patients with an in-hospital AMI may also shed light on previous studies^{6,15,16} demonstrating lower rates of revascularization in VHA hospitals than among similar, older patients admitted to US private sector hospitals. One study¹⁷ comparing treatment and outcomes of AMI in older veterans hospitalized in VHA facilities or Medicare-funded hospitals found that the use of cardiac catheterization and revascularization procedures was higher in Medicare hospitals, even after adjusting for significant covariates. Although the reasons for these discrepancies are related to a variety of patient and system factors,¹⁸ part of the explanation may reflect the relatively high proportion of patients with an in-hospital AMI, many of whom are severely ill and unsuitable candidates for revascularization.¹⁹

This study has several strengths. It was based on a large, national population of patients, using clinical and workload or administrative data. The former were abstracted from the electronic health record by trained, professional abstractors using a standard, validated set of criteria. We used standard, reliable, and valid criteria to identify patients with AMI, and vital status was ascertained using current and accurate information. In addition, we were able to adjust for a large set of well-documented covariates.

Nonetheless, the study also has limitations. The patients studied were restricted to VHA facilities. As a result, most of the patients were men and, as noted, patients admitted with AMI to VHA facilities differ in important ways from patients admitted to other types of hospitals. Furthermore, despite concerted efforts to maintain the quality of the abstraction process, the ultimate source of data was the clinical record, which could have occasionally provided inaccurate information or had missing information.

Because we studied only patients with documented AMI, it is impossible to know the true incidence of in-hospital AMI among patients hospitalized in VHA facilities. It is likely that the number of such events captured in this study represents a minimal estimate because a troponin assay was required for case identification. It is probable that there were additional older, acutely ill patients whose condition deteriorated but, because they had few overt signs or symp-

oms of cardiac ischemia, did not have an electrocardiogram or a troponin assay performed. Studies to evaluate screening for in-hospital AMI (eg, troponin assays performed 72 hours after admission in patients with certain medical conditions) should be considered.

It is also possible that some patients who were classified as having an in-hospital AMI may have had a so-called troponin leak related to their serious underlying illness.^{20,21} We did not have information on creatinine levels that could have been associated with elevated troponin levels. Nonetheless, even if such leaks were present in some patients, they were indicative of an extremely high mortality consistent with having a serious AMI. Nonetheless, further research could lead to defining troponin elevations that are different among acutely ill hospitalized patients.

It is almost certain that the problem of in-hospital AMI is not confined to VHA facilities but exists throughout private sector hospitals. Because the VHA performs a detailed, 100% medical record review of all patients with AMI, we were able to identify these patients. Were other health care systems to do likewise, they would doubtless identify similar patients, although the relative proportion in the VHA may be higher because many veterans with AMI are admitted to outside hospitals.

In summary, more than 1 in 10 patients with AMI in VHA facilities experienced AMI while hospitalized for another medical condition. Patients with an in-hospital AMI received less aggressive cardiac treatment and had significantly worse outcomes than did patients presenting to the hospital with AMI. As the population ages, the number of in-hospital AMIs will increase, presenting distinct challenges with respect to diagnosis and treatment. Thus, additional studies are needed to better define the epidemiology of in-hospital AMI and to evaluate therapies to improve outcomes for this high-risk group of patients.

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