Declining Length of Hospital Stay for Acute Myocardial Infarction and Postdischarge Outcomes

A Community-Wide Perspective

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Background: The objectives of this population-based study were to describe trends of more than a decade (1986-1999) in duration of hospitalization after acute myocardial infarction (AMI), patient characteristics associated with varying lengths of stay, and the impact of declining length of stay on postdischarge mortality.

Methods: The study sample consisted of 4551 patients discharged after AMI from all greater Worcester, Mass, hospitals in 8 annual periods during the study period. Regression models were used to examine the influence of demographic, clinical, and treatment variables on length of stay and the association between declining length of hospital stay and postdischarge mortality.

Results: Marked declines were observed in the average length of stay between the 1986-1988 (11.7 days) and 1997-1999 (5.9 days) periods. Factors associated with a longer hospital stay included advanced age, female sex, anterior and Q-wave MI, and occurrence of clinically important cardiac complications. Patients with health maintenance organization, Medicare, Medicaid, or no insurance coverage were less likely to have an increased length of stay. Increased 30- and 90-day mortality was associated with a length of stay of greater than 14 days (odds ratio, 2.08; 95% confidence interval, 1.18-3.66) relative to those with a length of stay of 6 to 8 days (odds ratio, 2.01; 95% confidence interval, 1.34-3.01). Patients with a length of stay of less than 6 days exhibited no significant increases in postdischarge mortality. Similar trends were observed in patients with a complicated AMI.

Conclusions: We found marked decreases in length of stay for patients hospitalized with AMI during the past decade. However, we found no negative association between declining length of stay and short-term mortality after hospital discharge for AMI.

Arch Intern Med. 2004;164:733-740

Duration of hospitalization for patients with acute myocardial infarction (AMI) has evolved from the prolonged bed rest and rehabilitation of longer than 6 weeks in the 1950s to present lengths of hospital stays of less than 1 week. The aggressive use of coronary revascularization approaches and the widespread acceptance of the psychological and medical benefits of early ambulation have resulted in significant reductions in length of hospital stay for patients with AMI. In the United States, the typical length of stay for patients with an uncomplicated AMI now approximates 5 days. However, considerable variation exists in the duration of hospitalization for patients with AMI. This variability is influenced by clinical, medical care, and socioeconomic factors. Most notably, physicians are under increasing pressure from health insurance providers and their own institutions to discharge patients from the hospital in as rapid a manner as possible.

Although clear trends in shorter hospital stays after AMI have been apparent during the past decade, the optimal timing of discharge has been the subject of considerable scrutiny because of the potential health and economic consequences of early vs late discharge. Support for early discharge policies in patients with acute coronary disease has been provided by data from clinical trials.1,2 The findings of these studies have suggested that hospital discharge after AMI may be safe in appropriately selected patients as early as 3 days after the acute index event.2 Although the potential cost savings associated with a reduced length of stay are significant, the impact of early hospital discharge after AMI on the use and titration of postinfarction medication therapy, provision of patient education, and detection and treatment of early and potentially serious clinical complications may be deleterious.

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Given the magnitude and the public health and clinical impacts of coronary heart disease in the United States and other industrialized countries, it is important to examine whether current trends in hospital discharge policies for patients with AMI have had an adverse impact on their postdischarge mortality rates. The purpose of the present study is to describe, from a multihospital, population-based perspective, trends for more than a decade of experience (1986-1999) in duration of hospitalization after AMI and the potential impact of declining length of stay on postdischarge mortality of hospital survivors. Our study period encompasses the thrombolytic era and increasingly aggressive management of AMI.

**METHODS**

Patients discharged from all 16 Worcester, Mass, standard metropolitan statistical area hospitals in 8 annual periods during 1986, 1988, 1990, 1991, 1993, 1995, 1997, and 1999 after hospitalization for a primary or secondary discharge diagnosis of AMI (International Classification of Diseases, Ninth Revision [ICD-9] code 410) constitute the study population of the present report. These study years were chosen on the basis of funding availability and for purposes of examining changes over time in our principal study end points on an approximate alternating yearly basis. The medical records of all patients with a discharge diagnosis of AMI from these hospitals were individually reviewed and validated according to preestablished diagnostic criteria that have been previously described in detail. In brief, these criteria included a clinical history of prolonged chest pain not relieved by rest or use of nitrates, serum enzyme level elevations in excess of the upper reference limit as specified by the laboratory at each hospital, and serial electrocardiographic tracings during hospitalization showing changes in the ST segment and/or Q waves typical of AMI. A random sample of medical records from additional diagnostic rubrics in which the diagnosis of AMI might have occurred (eg, ICD-9 codes 411-414) was also performed during each of the years under study to capture all geographically eligible patients hospitalized with AMI. Patients with perioperative AMI were excluded. Clinical complications of AMI were assessed on the basis of information available from medical records. These important clinical complications included heart failure, cardiogenic shock, complete heart block, recurrent angina, atrial fibrillation, and stroke.

The present report is based on the 4551 residents of the Worcester metropolitan area who satisfied the diagnostic criteria for AMI in the 8 study periods examined and were discharged from all area hospitals. Patients with a hospital length of stay of greater than 1 month, transfers (in or out of study hospitals), and those undergoing coronary artery bypass graft surgery were excluded. To make data analyses more interpretable, and to coincide with changes in the treatment of patients with AMI, these 8 individual study years were aggregated into 4 periods for purposes of analysis. A total of 896 Worcester metropolitan residents with validated AMI meeting these criteria were hospitalized in the 1986-1988 period, 1050 in the 1990-1991 period, 1275 in the 1993-1995 period, and 1330 in the 1997-1999 period.

**DATA COLLECTION**

The hospital records of patients with validated AMI were abstracted for demographic and clinical data, including age, sex, medical history, type of insurance coverage, complications during hospitalization (eg, congestive heart failure, cardiogenic shock, complete heart block, recurrent angina, atrial fibrillation, and stroke), AMI order (initial or prior), type (Q wave or non-Q wave), and location (anterior or inferior/posterior). Hospital records were also reviewed to identify the use of different cardiac medications and procedures (eg, catheterization, percutaneous coronary intervention) during the index hospitalization. The approaches used to ascertain survival status after discharge from each of the participating hospitals included a review of records for additional hospitalizations and a statewide and national search of death certificates for residents of the Worcester standard metropolitan statistical area. Some form of additional follow-up was performed in most discharged study patients (approximately 99%). Follow-up was performed through the end of calendar year 2001. For purposes of the present analysis, we examined survival status at 1 and 3 months after discharge from area wide hospitals. These time points were chosen so that we could examine periods in reasonably close proximity to the index hospitalization that might be affected by premature hospital discharge after AMI. We could not satisfactorily perform analyses examining the association between hospital length of stay and 7-day postdischarge death rates, given the small number of deaths occurring during this period. Despite higher death rates at 6 and 12 months after hospital discharge, and an increased number of fatal events with which to perform our analyses, we did not examine the relationship between length of hospital stay and these longer postdischarge periods. This was because of the potentially confounding influence of other clinical and treatment factors that may have affected these death rates and the difficulty in interpreting any observed associations between length of hospital stay and these more prolonged postdischarge deaths.

**DATA ANALYSIS**

We examined differences in the distribution of selected characteristics in patients with varying lengths of hospital stay according to χ² tests of statistical significance for trends in categorical variables and analysis of variance for continuous variables. We used a logistic multivariate regression analysis to examine the association between demographic, clinical, and treatment variables and a greater length of stay than the median. Variables controlled for in this analysis included age, sex, insurance payer status, medical history (eg, angina, stroke, hypertension, diabetes mellitus, and heart failure), AMI-associated characteristics (initial vs prior, anterior vs inferior/posterior, Q wave vs non-Q wave), hospital clinical complications (eg, heart failure, cardiogenic shock, complete heart block, recurrent angina, atrial fibrillation, and stroke), receipt of any effective cardiac medications (defined as administration of aspirin, β-blockers, angiotensin-converting enzyme [ACE] inhibitors, agents for lowering of lipid levels, or thrombolytics), receipt of other cardiac medications (calcium antagonists or antiarrhythmics), and receipt of a cardiac procedure (eg, cardiac catheterization or percutaneous revascularization) during the index hospitalization. Because the length of hospital stay and associated postdischarge outcomes are linked to the occurrence of clinical complications during the acute hospitalization, we also performed a subgroup analysis in patients with a complicated AMI. For purposes of this analysis, a complicated AMI was considered to be present when heart failure, cardiogenic shock, complete heart block, recurrent angina, atrial fibrillation, or stroke developed at any time during the index hospitalization.

We used a life-table approach to examine differences in postdischarge survival according to length of hospital stay while including patients from different time periods and with varying lengths of follow-up. Logistic multivariable adjusted regression analyses were used to examine the association be-
RESULTS

SAMPLE CHARACTERISTICS

Descriptive characteristics of the study sample according to varying duration of hospital length of stay are shown in Table 1. Duration of hospitalization was categorized into 6 strata based on the distribution of our length-of-stay data and on the basis of what might be considered to be a short vs a more prolonged hospitalization for patients with AMI.

Patients with shorter lengths of stay were younger, more likely to be men, and more likely to be enrolled in a health maintenance organization or to have no health insurance. These patients were less likely to present with an anterior or a Q-wave MI. They were significantly less likely to experience each of the clinical complications examined. Patients with shorter lengths of stay were more likely to be treated with aspirin, β-blockers, ACE inhibitors, or agents for lowering of lipid levels but less likely to be treated with calcium antagonists or antiarrhythmics. Use of percutaneous revascularization was greatest in patients at the extremes of length of stay compared with those with more intermediate stays.

There have been marked changes over time in the distribution of length of stay for patients with AMI since the mid-1980s (Figure). Average length of stay declined from 11.7 days in the 1986-1988 period to 5.9 days in the 1997-1999 period. In the 1986-1988 period, approximately 60% of patients were hospitalized for 10 or more days compared with approximately 10% of patients in the 1997-1999 period. On the other hand, less than 4% of patients with AMI were discharged from area hospitals in less than 6 days in the 1986-1988 period compared with more than half in the 1997-1999 period.

FACTORS ASSOCIATED WITH LONGER HOSPITAL STAY

Based on the univariate associations observed, the association between certain demographic and clinical variables with longer hospital stay (length of stay greater than the median for each study year) was examined through the use of logistic regression modeling (Table 2). Demographic factors associated with a more prolonged stay included advanced age and female sex. Occurrence of each of the clinical complications under study, particularly the development of stroke or cardiogenic shock, was strongly associated with increased length of stay. Patients with a Q-wave or anterior MI were more likely to have a prolonged hospital stay, as were patients receiving other cardiac medications or undergoing cardiac procedures. Compared with patients with Blue Cross/Blue Shield insurance, patients with health maintenance organization, Medicaid, Medicare, or no coverage were significantly less likely to have a longer hospital stay. Patients treated with effective cardiac medications were less likely to have a prolonged stay.

RELATION BETWEEN DECLINING LENGTH OF HOSPITAL STAY AND POSTDISCHARGE MORTALITY

All-cause death rates at 1 and 3 months after hospital discharge for AMI were examined to assess the relation between length of stay during the past decade and a half and postdischarge survival. Crude 30- and 90-day mortality rates did not change appreciably between the initial (1986-1988) and the most recent study periods (1997-1999) (30-day mortality, 3.5% vs 2.7%, respectively; 90-day mortality, 7.0% vs 5.9%, respectively) despite declining length of stay during this period. One hundred forty-nine patients (3.3%) died during the first month after hospital discharge, whereas 319 patients (7.0% of the total study sample) died during the first 3 months after hospital discharge.

We examined the association between length of stay and postdischarge mortality rates in a multivariable-adjusted regression model. After simultaneously controlling for a variety of demographic, medical history, and clinical characteristics, patients with a length of stay of 14 days or longer were at significantly increased risk for dying 30 and 90 days after hospital discharge compared with the referent category of patients with a length of stay ranging from 6 to 7.9 days (Table 3). Patients with a length of stay of less than 6 to 7.9 days did not have significantly different mortality rates at 30 and 90 days after being discharged from greater Worcester hospitals compared with the referent group. Although it was underpowered, owing to the comparatively few postdischarge deaths occurring in the first 7 days after hospital discharge, trends similar to our principal study findings were observed using this postdischarge time cut point. Patients with a hospital stay of less than 6 days were no more likely to die during the first week after hospital discharge than were patients discharged after a longer hospital stay. Multivariate regression analyses assessing the impact of declining length of stay over time on postdischarge mortality rates, controlling for similar demographic, medical history, and clinical variables, revealed no significant changes in the likelihood of death at 30 or 90 days after hospital discharge between the 1986-1988 and 1997-1999 periods (data not shown).
We also performed an additional analysis examining the relation between length of hospital stay and 30- and 90-day death rates as calculated from the time of hospital admission (as opposed to hospital discharge). Virtually identical trends to those previously observed using hospital discharge as our beginning point of analysis were noted. For example, the multivariable adjusted odds of dying in the first 90 days after hospital admission were 1.03 (95% CI, 0.55-1.95), 1.10 (95% CI, 0.71-1.72), 1.10 (95% CI, 0.72-1.69), 1.34 (95% CI, 0.88-2.02), and 2.01 (95% CI, 1.33-3.06) for patients who experienced lengths of hospital stay of less than 4, 4 to 5.9, 8 to 9.9, 10 to 13.9, and 14 or more days, respectively.

## ACUTE CLINICAL COMPLICATIONS AND POSTDISCHARGE DEATH RATES

Approximately three fifths of study patients experienced a complicated AMI during the study periods. These complication rates ranged from 54% in the 1986-1988 to 55% in the 1997-1999 periods. Since patients with a complicated AMI represent a group at particularly high risk for postdischarge mortality, we examined 30- and 90-day postdischarge mortality rates separately in hospital survivors of a complicated AMI according to hospital length of stay (Table 4). Compared with patients with a length of stay of 6 to 7.9 days, no adverse asso-
culation was observed between a shorter hospital stay and postdischarge prognosis for up to 90 days after hospital discharge in these high-risk patients. Similar associations were observed when more restrictive definitions of a complicated AMI were used or when these rates were calculated from the time of hospital admission instead of hospital discharge.

The results of this population-based observational study suggest marked changes over time in the median and in the distribution of length of stay in a community-wide sample of patients hospitalized with validated AMI in a representative northeast metropolitan area. The average length of stay declined from approximately 12 days in the 1986-1988 period to 6 days in the 1997-1999 period. Perhaps even more impressive was the greater than 10-fold increase in the proportion of patients discharged from area hospitals in less than 6 days during this period.

Much of the observed decline in hospital length of stay may be attributed to improvements in the management of AMI, including increased use of coronary reperfusion modalities. Previous findings from the Worcester Heart Attack Study have documented an approximate 10-fold increase in the use of thrombolytic therapy or percutaneous coronary interventions from the mid-1980s to late 1990s. Use of effective adjuvant therapies (aspirin, β-blockers, and ACE inhibitors) has grown even more dramatically during this period. Although a causal association cannot be inferred from these data, the receipt of 1 or more effective cardiac medications was protective against increased length of stay in the present study. Use of these beneficial therapies might be expected to have an impact on the rate of occurrence of most of the clinically significant AMI-associated complications, which were the strongest predictors of increased length of stay in our study.

We acknowledge that other nonclinical factors may be playing an important role in the observed decreases in length of hospital stay. Limited health care resources, fixed payments for a given diagnosis, and decreases in Medicare reimbursements are wreaking financial havoc on most hospital budgets. Not surprisingly, reduced length of stay for patients with AMI has become a popular budgetary agenda item for many hospital administrators. Even after controlling for other potentially confounding factors, patients with health maintenance organization or Medicare insurance were significantly less likely to have a prolonged length of stay than patients with Blue Cross/Blue Shield insurance.

### DECLINING LENGTH OF HOSPITAL STAY AND POSTDISCHARGE MORTALITY

A critical question addressed in our observational study is whether the declining length of stay over time is adversely associated with patient outcomes after hospital discharge. Given major advances in the therapeutic management of AMI over time, any potentially adverse effect of premature discharge from hospital is difficult to isolate.

The results of our crude and multivariable-adjusted regression analyses reveal no evidence of an association between decreased length of stay and postdischarge survival calculated from the time of hospital admission or discharge. Crude and multivariable adjusted 30- and 90-day postdischarge mortality rates did not significantly change from the mid-1980s to late 1990s. Even after adjusting for study year and various therapies (in addition to other potential prognostic confounders), we were unable to observe any negative association between decreased length of stay and postdischarge mortality. To the best of our knowledge, this is the first population-based study describing trends in length of stay for patients with AMI that has also examined the relation between length of stay and mortality after hospital discharge.

Previous studies have attempted to evaluate the impact of shorter length of stay on patient-associated outcomes by comparing hospitals or regions with different lengths of stay during the same time period. Unfortunately, these studies were limited by small sample size, limited outcome data, or distant study periods. In an analysis of Medicare patients hospitalized in 1985, the average length of stay for patients with AMI in California (8.1 days) was significantly shorter compared with that of patients from New York (12.4 days). Hospital case-fatality rates were lower in California (21% vs 24%), but...
outpatient mortality at 30 days was significantly increased in California (4%) compared with New York (1%), resulting in similar overall 30-day death rates. Another study of 394 patients with AMI identified significant variations in the average length of stay (approximately 2 days) between patients hospitalized in teaching hospitals in the Northeast compared with those on the West Coast.13 However, no significant differences in patient-associated morbidity or functional status were observed from 3 to 12 months after hospital discharge. A much larger analysis of 9600 patients with AMI from 87 hospitals in Ontario, Canada, identified even greater variability in hospital length of stay, with averages ranging from 6.6 to 12.9 days.14 Only 12% of this variation could be attributed to patient and hospital characteristics. Length of stay was not significantly associated with hospital mortality after controlling for other potentially confounding variables.

Unfortunately, postdischarge mortality rates were not analyzed in this study.

Alternatively, a number of investigators have attempted to identify subsets of patients with AMI in whom early hospital discharge might be considered feasible. In a study of 80 patients admitted to the University of Michigan Medical Center from 1986 to 1987 with uncomplicated AMI and without ischemia provoked by exercise stress testing, patients randomly assigned to early hospital discharge (day 3) had a similar incidence of hospital readmissions, reinfarction, or recurrent angina compared with patients assigned to conventional hospital discharge (days 7-10).13 There were no deaths in either group. In 1986, 358 patients with AMI who did not receive thrombolytic therapy underwent screening by Sanz et al.16 Of these, Q waves developed in 105, and they had an uncomplicated early hospital course. These patients underwent subsequent monitoring for an average of 12 days for the occurrence of any event that might have prompted hospital readmission if earlier discharge had been attempted. In the patients under study, a little more than one quarter (28%) experienced a cardiac event during this period, including 4 deaths and 1 reinfarction. These data suggested the need for more stringent criteria to identify patients truly at low risk for early hospital discharge.

Given continued improvements in reperfusion modalities and acute coronary care, the investigators of the Global Utilization of t-PA for Occluded Coronary Arteries Trial (GUSTO) reassessed the identification of a low-risk group of patients with AMI suitable for early hospital discharge nearly a decade later.2 Using a broader definition of uncomplicated MI, the investigators characterized approximately 57% of 64,511 patients as having had an uncomplicated AMI. In this study, the median length of stay for patients with a complicated or uncomplicated AMI was 9 days (8 days in the United States), and 25% of patients with an uncomplicated AMI stayed in the hospital for 12 or more days. Patients in the uncomplicated group had significantly lower 30-day mortality rates and hospital complications after day 4. The results of our study suggest that patients with a complicated AMI, irrespective of the working definition used, did not experience any increases in postdischarge death rates by being discharged from greater Worcester hospitals at an earlier time during their index hospitalization.

Extrapolation of findings from randomized trials (or from registries of patients enrolled in these trials) to clinical practice in the community setting is fraught with hazard. Frequently, practitioners fail to account for the limited generalizability of reported studies when approaching their own patients. The studies supporting a decreased length of stay in patients with AMI are largely derived from trials of thrombolytic therapy, use strict definitions of an uncomplicated MI, and ensure proper use of adjunct therapies. Our review of the characteristics of patients with a length of stay of less than 4 days in our study identified generalizability of reported studies when approaching their own patients. The studies supporting a decreased length of stay in patients with AMI are largely derived from trials of thrombolytic therapy, use strict definitions of an uncomplicated MI, and ensure proper use of adjunct therapies.
of stay of less than 4 days were 75 years and older, heart failure developed in 24% during their hospitalization, and 12% had 1 or more episodes of recurrent angina before hospital discharge. This issue warrants further examination if we are to minimize the potential hazards associated with policies of early hospital discharge in patients with AMI. Many of these high-risk patients are elderly, have a large burden of comorbidities, are increasingly frail, and have limited resources to assist them in their recovery.

### STUDY STRENGTHS AND LIMITATIONS

The study was performed in a population from a well-defined metropolitan area whose sociodemographic and economic characteristics reflect those of the US population as a whole. Additional strengths of this study are the inclusion of a large number of patients with validated AMI, its population-based perspective enhancing the generalizability of study findings, and the inclusion of patients admitted to all area-wide hospitals. However, this study has several limitations. Although we were able to describe multiple factors associated with early or late hospital discharge, there are likely to be other patient-, provider-, and health care system–related factors for which we were not able to assess the impact on length of stay. In addition, given continuing improvements in patient treatment over time, it remains difficult to isolate the impact of decreases on length of stay during the past decade on morbidity and mortality. Because of our methods of data collection, we were also unable to examine whether hospital readmissions or the risk for acute ischemic complications increased as the length of stay became shorter, findings of importance to clinicians and

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### Abbreviations:

*Adjusted for age, sex, payor status, year of hospitalization, history of cardiovascular disease, AMI-associated characteristics, and occurrence of any acute clinical complications.
†Adjusted for all variables in the previous model plus use of any cardiac medications and coronary interventional procedures.

Table 3. Likelihood of Dying After Hospital Discharge for AMI According to Length of Stay During the Index Hospitalization (Worcester Heart Attack Study)

Table 4. Likelihood of Dying in the First 30 and 90 Days After Hospital Discharge for Patients With Complicated AMI According to Length of Stay During Index Hospitalization (Worcester Heart Attack Study)
health policy advocates. Finally, one needs to be appropriately cautious in the interpretation of our study findings. This is because of the relatively small number of postdischarge deaths and lack of adequate statistical power to more systematically examine a number of the associations observed.

The results of this population-based study reveal marked decreases in length of hospital stay for patients with AMI during the past decade. Despite these trends, there is no evidence to support a negative association of these changing hospital policies on short-term mortality. It is apparent, however, that physicians are discharging an increasingly greater proportion of patients who have had a complicated hospital course and are at increased risk for adverse outcomes. The impact and safety of early discharge in these diverse patient subsets warrant further study, as do potential cost savings and psychological impact of these ongoing trends in the provision of health care.

Accepted for publication May 22, 2003.

This study was supported by grant RO1 HL35434 from the National Heart, Lung, and Blood Institute, Bethesda, Md.

We thank the administration and the medical records and cardiology departments of participating Worcester, Mass, metropolitan area hospitals for their cooperation.

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