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PETER STONE, M.D., JAMES MULLER, M.D., AND ANITA LOSCALZO, B.S.

SUMMARY  To investigate whether the reported 17% decline in the national rates of acute ischemic heart disease mortality between 1973 and 1978 was attributable to decreased in-hospital mortality for patients with acute myocardial infarction (MI), we surveyed all 63 acute care hospitals in the Boston, Massachusetts, area. Compared with 1973–1974, more 1978–1979 MI patients were admitted to hospitals in metropolitan Boston, and especially to the five university teaching hospitals. Between 1973–1974 and 1978–1979, hospital admission rates decreased for younger patients and increased for older patients, but overall admission rates were almost identical. In-hospital mortality rates from acute MI did not change significantly in any age group. Because overall MI mortality was declining while in-hospital MI mortality was unchanged, the proportion of acute MI deaths that occurred inside the hospital increased from about 30% to about 40%. Although current hospital care undoubtedly benefits many individual patients, this study suggests that improvements in the in-hospital care of acute MI patients are not a major explanation for nationwide mortality trends between 1973 and 1978.

SINCE 1968, the age-adjusted mortality rates for all types of ischemic heart disease and for acute myocardial infarction in the United States have fallen each year. In the 8-year period between 1968 and 1976, the overall decline was 20.7%; preliminary data suggest that this decline has continued at least through 1978, and that between 1973 and 1978, the mortality rate decreased by about 3% per year.

Although this decrease in acute ischemic heart disease mortality is not disputed, the explanations for the decline are not clear. Because the decline began before the popularization of coronary artery bypass surgery or the wide application of prehospital cardiopulmonary resuscitation, neither of these innovations are likely explanations. Some epidemiologists believe that the decline in mortality may be related to dietary changes resulting in falling serum cholesterol levels, to improved hypertension control, to a reduction in cigarette smoking in male adults, and perhaps to increased physical activity. Because recent studies also suggest that the prognosis of medically treated patients with angina pectoris may be better than it was a decade or so ago, such therapy may also be a factor.

Coronary care units have also been developed and used during the same period as the decrease in acute ischemic heart disease mortality. Although coronary care units have not been shown to benefit the specific types of patients who were deemed appropriate for randomization to home vs hospital care, the reduction in mortality that was noted in earlier, non-randomized studies of all types of patients might reflect an overall benefit of such units. These considerations have led to the assertion that coronary care units have probably contributed to the decrease in mortality rates.

One cannot determine the contribution of coronary care units and of other in-hospital care to the nationwide decline in mortality from acute myocardial infarction and acute ischemic heart disease on the basis of the experience of a single hospital. We therefore surveyed all acute care hospitals within a defined geographic area centered on Boston, Massachusetts, to determine the hospital admission rates, case-fatality rates, and mortality rates for acute myocardial infarction. In this geographic area, which includes a major city with its referral facilities and its surrounding hospitals, we also studied the distribution of patients among hospitals and the percent of available coronary care unit bed-days that were occupied by patients with acute myocardial infarctions. Thus, our data should not be confounded by shifts in care from one type of facility to another within the geographic area.

Methods

We identified all 63 acute care hospitals in the geographic area centered on Boston, Massachusetts, and bordered by Interstate 495 to the north and west and by U.S. Route 44 to the south. For all hospitals, we sought data pertaining to all patients hospitalized with acute myocardial infarction during consecutive 12-month periods in both 1973–1974 (usually July 1, 1973 through June 30, 1974) and 1978–1979 (usually July 1, 1978 through June 30, 1979). Data from these 63 hospitals were obtained in one of two ways. Thirty-three of the 63 hospitals (52%) (group A hospitals)
were members of the Massachusetts Hospital Association's Utilization Information Service for both fiscal years. Data regarding all patients with the primary or secondary discharge diagnosis of acute myocardial infarction (ICDA 410.92) were obtained for aggregates of hospitals by geographic distribution but could not be directly attributed to an individual hospital. The computerized data included the patients' primary and secondary diagnoses, age, sex, length of hospital stay, zip code and hospital outcome. Second, available data from 30 other hospitals (group B hospitals) were obtained directly from the hospitals' medical records departments because computerized patient data for the years in question were not available. For these 30 hospitals, the number of patients with a primary or secondary discharge diagnosis of acute myocardial infarction was obtained, but the other information was not available.

We also surveyed all group A and group B hospitals to determine the number of coronary care unit beds, medical intensive care unit beds, or medical-surgical intensive care unit beds that were available for patients with acute myocardial infarctions for both 1973-1974 and 1978-1979. Using the Directory of Medical Specialists, we determined the number of board-certified internists and cardiologists practicing in the Boston area described above during 1973-1974 and 1978-1979.

Age-specific and age-adjusted rates of hospital admission for the primary diagnosis of acute myocardial infarction were estimated for the "at-risk" population included in the catchment areas of the 33 group A hospitals for 1973-1974 and 1978-1979. The population at risk for an acute myocardial infarction admission to each of the 33 hospitals was estimated in the following manner. First, any city or town was at risk if at least 1% of its adult hospital discharges were from any of the 33 group A hospitals. We assumed that the overall pattern of hospital usage among the citizens of a given city or town would apply, uniformly over all ages, to acute myocardial infarction admissions and would be constant over the last 10 years. For each city or town in the area at risk, population figures for various age categories were obtained from the 1970 federal census and from the 1975 Massachusetts state census. Estimated population figures for 1973 and 1978 were obtained by linear interpolation and extrapolation. The population at risk in each age category for that city or town was obtained by multiplying the discharge percentages by the estimated population figures. A total population at risk was obtained for each age category by summing over all cities and towns at risk.

Using the age and zip code information for each primary acute myocardial infarction admission for each of the 33 hospitals, the total number of admissions (numerator) that were from the same areas included in the calculated population at risk (denominator) were obtained for various age categories, and the age-specific rates of admission for the primary diagnosis of acute myocardial infarction were computed. Age-adjusted rates of admission for acute myocardial infarction were then obtained by the direct method of standardization using the 1970 United States population as the standard.

In-hospital acute myocardial infarction mortality rates and case-fatality rates were determined for group A hospitals for both the first 48 hours of hospitalization and for the subsequent period. For comparison, annual age-adjusted national mortality rates of acute ischemic heart disease (1968-1978) and of acute myocardial infarction (1968-1977) were calculated using the 1970 United States population as the standard.

Coronary Care Unit Utilization

Coronary care unit utilization was calculated for all group B hospitals with coronary care units and for Peter Bent Brigham Hospital. Because reliable data on the length of coronary care unit or intensive care unit stay for patients with acute myocardial infarction were not available, this calculation of the percent of coronary care unit bed-days that were occupied by acute myocardial infarction patients required several assumptions. First, we assumed that the average length of intensive care at all hospitals for patients with a primary diagnosis of acute myocardial infarction would be similar to the 4-day average length of intensive care unit stay recently reported by one of our surveyed hospitals. Second, we assumed that for all hospitals with coronary care units, all patients with a primary diagnosis of acute myocardial infarction would be cared for in those units, although an unspecified number of such patients might be cared for in another area of the hospital because coronary care unit beds were temporarily unavailable. Third, we assumed that patients with a secondary diagnosis of acute myocardial infarction would use the same average number of intensive care unit days per patient that they used at our institution (see Results section). We then calculated the approximate percentage of a hospital's coronary care unit bed-days that were occupied by myocardial infarction patients by dividing the sum of (average length of stay for patients with a primary diagnosis of myocardial infarction × number of patients with the primary diagnosis of acute myocardial infarction) + (average length of stay for patients with a secondary diagnosis of acute myocardial infarction × number of patients with the secondary diagnosis of acute myocardial infarction)/(the number of coronary care unit beds × 365 days).

Statistical Analysis

Comparisons were made using chi-square statistics with the appropriate degrees of freedom.

Results

For both group A and group B hospitals, the overall number of patients hospitalized with the primary diagnosis of acute myocardial infarction was virtually identical in 1973-1974 and 1978-1979 (table 1). Based on the observed similar trends in group A and group B hospitals, we concluded that events that were oc-

<table>
<thead>
<tr>
<th>Period</th>
<th>Group A</th>
<th>Group B</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>1973–1974</td>
<td>4782 (56%)*</td>
<td>3742 (44%)</td>
<td>8524</td>
</tr>
<tr>
<td>1978–1979</td>
<td>4786 (56%)</td>
<td>3786 (44%)</td>
<td>8572</td>
</tr>
<tr>
<td>Change</td>
<td>4 (0.1%)</td>
<td>44 (1.2%)</td>
<td>48 (0.6%)</td>
</tr>
</tbody>
</table>

*As a percentage of all myocardial infarctions in both groups of hospitals for that year.

Occurring in one group of hospitals were likely to be occurring in the other.

Overall Trends, Group A Hospitals

Based on the detailed data available from the 33 group A hospitals and from the population that they served, the age-adjusted acute myocardial infarction hospital admission rate was 647 per 100,000 in 1973–1974, and 632 per 100,000 in 1978–1979 (table 2). The in-hospital case fatality rate for patients with acute myocardial infarction was 22% in 1973–1974. This increased slightly, to 23% in 1978–1979. When the admission rate was multiplied by the case-fatality rate, the in-hospital mortality rates actually increased insignificantly, from 142 per 100,000 in 1973–1974 to 147 per 100,000 in 1978–1979, at a time when national mortality rates from acute myocardial infarction and from acute ischemic heart disease showed a significant decline of about 17% (fig. 1). Because acute myocardial infarction and acute ischemic heart disease mortality trends in the Boston area were very similar to the national mortality trends, the overall decline in acute ischemic heart disease mortality clearly could not be explained on the basis of changes in the inhospital mortality for acute myocardial infarction patients. The data in figure 1 also suggest that about 70% of deaths from acute myocardial infarction occurred outside of the hospital in 1973–1974, but only about 60% occurred outside of the hospital in 1978–1979.

Age-specific Admission and Mortality Rates

Although the number of patients hospitalized with the primary diagnosis of acute myocardial infarction did not change from 1973–1974 to 1978–1979, the mean age of such patients was higher in 1978–1979. When the Boston-area admission and in-hospital mortality rates for group A hospitals were calculated on an age-specific basis, we noted strikingly different trends. For patients ages 40–69 years, admission rates decreased significantly, by 57 per 100,000 for the primary diagnosis of acute myocardial infarction (table 3). This decline paralleled the decline in national acute myocardial infarction and acute ischemic heart disease mortality rates, but the insignificant decrease of 0.22 per 100,000 in the


<table>
<thead>
<tr>
<th>Age (years)</th>
<th>Acute MI hospital admission rate (per 100,000)</th>
<th>Acute MI in-hospital case fatality rate*</th>
<th>In-hospital mortality rate (per 100,000)*</th>
</tr>
</thead>
<tbody>
<tr>
<td>1973–1974</td>
<td>647</td>
<td>22%</td>
<td>142</td>
</tr>
<tr>
<td>1978–1979</td>
<td>632</td>
<td>23%</td>
<td>147</td>
</tr>
</tbody>
</table>

*None of the differences between 1973 and 1978 were statistically significant.

Abbreviation: MI = myocardial infarction.

TABLE 3. Age-specific Hospital Admission Rates for Patients with a Primary Diagnosis of Acute Myocardial Infarction

<table>
<thead>
<tr>
<th>Age (years)</th>
<th>Myocardial infarction admission rate (per 100,000)</th>
<th>Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>40–49</td>
<td>250</td>
<td>178</td>
</tr>
<tr>
<td>50–59</td>
<td>516</td>
<td>506</td>
</tr>
<tr>
<td>60–69</td>
<td>884</td>
<td>795</td>
</tr>
<tr>
<td>70+</td>
<td>1233</td>
<td>1376</td>
</tr>
<tr>
<td>All 40+</td>
<td>647</td>
<td>632</td>
</tr>
</tbody>
</table>

*p < 0.001.
†p < 0.001.
‡Not significant.
TABLE 4. **Age-specific Hospital Mortality Rates for Patients with a Primary Diagnosis of Acute Myocardial Infarction**

<table>
<thead>
<tr>
<th>Age (years)</th>
<th>Myocardial infarction mortality rate (per 100,000)</th>
<th>1973–1974</th>
<th>1978–1979</th>
<th>Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>40–49</td>
<td>14</td>
<td>12</td>
<td>−11</td>
<td>−0.3*</td>
</tr>
<tr>
<td>50–59</td>
<td>52</td>
<td>66.09</td>
<td>48</td>
<td>65.87</td>
</tr>
<tr>
<td>60–69</td>
<td>165</td>
<td>166</td>
<td>+0.6</td>
<td></td>
</tr>
<tr>
<td>70+</td>
<td>457</td>
<td>476</td>
<td>+4*</td>
<td></td>
</tr>
<tr>
<td>All 40+</td>
<td>142</td>
<td>147</td>
<td>+4*</td>
<td></td>
</tr>
</tbody>
</table>

*None of the changes between 1973–1974 and 1978–1979 are statistically significant.

Hospital acute myocardial infarction mortality rates (table 4) constituted only 0.3% of the 68 per 100,000 decline in the overall acute myocardial infarction mortality rate for this age range (fig. 2).

For patients older than 70 years, the acute myocardial infarction admission rate for group A hospitals in the Boston area actually showed an increase of 143 per 100,000 (table 3), and the in-hospital acute myocardial infarction mortality rate rose slightly, by 19 per 100,000 (table 4). At the same time, the national acute myocardial infarction mortality rate for patients older than 70 years declined by about 296 per 100,000 and the acute ischemic heart disease mortality rate declined by 621 per 100,000 (fig. 3). Thus, for patients older than 70 years, national mortality trends were opposite to Boston-area admission and in-hospital mortality trends.

**Case-Fatality Rates**

The overall case-fatality rates of 22% in 1973–1974 and 23% in 1978–1979 were strongly dependent on age. For patients younger than 70 years, the case-fatality rates increased from 13% in 1973–1974 to 15% in 1978–1979 ($\chi^2 = 2.87, p = 0.09$). Almost all of this increase in case-fatality rates among patients younger than 70 years occurred 48 or more hours after admission, when case-fatality increased from 9% to 11% ($\chi^2 = 3.88, p < 0.05$). Conversely, for patients older than 70 years, case-fatality rates decreased from 37% in 1973–1974 to 34.5% in 1978–1979 ($\chi^2 = 2.33, p = 0.13$). Almost all of the decrease in case-fatality rates in patients older than 70 years occurred during the first 48 hours of hospitalization, when fatality rates fell from 11% to 9% ($\chi^2 = 3.61, p = 0.06$).

**Patient Distribution**

In our geographic area, 25 of the 63 hospitals (40%) have coronary care units that are specifically designated for the care of patients with acute myocardial infarctions. Most of these hospitals have other intensive care areas that sometimes care for patients with acute myocardial infarctions. Nevertheless, approximately 50% of patients with acute myocardial infarctions were admitted to hospitals with coronary care units. The mortality rates of patients younger than 70 years of age admitted to hospitals with coronary care units were significantly lower than those of patients admitted to hospitals without such units. For patients older than 70 years, the mortality rates of those admitted to hospitals with coronary care units were not significantly different from those admitted to hospitals without such units.
care units and 50% were admitted to hospitals that had other types of intensive care units without specific coronary care units.

A comparison of the distribution of patients with acute myocardial infarction in 1973–1974 vs 1978–1979 revealed a statistically significant shift of patients to hospitals located in the cities of Boston and Cambridge ($\chi^2 = 15.4, p < 0.005$). The shift was primarily related to a 14% increase, from 1018 patients to 1162 patients, in the number of patients at the five university teaching hospitals. The increase in acute myocardial infarction admissions for the Boston-Cambridge hospitals was not primarily a reflection of increased population: During this 5-year period, the population actually declined in metropolitan Boston, whereas it increased slightly in the suburban areas (table 5).

There also was no clear relationship between changes in the supply of physicians and the changes in the distribution of myocardial infarction patients. Although the largest absolute increases in internists and cardiologists occurred in the Boston-Cambridge area, the percentage changes were similar for all three geographic regions.

**Coronary Care Unit Utilization**

Among patients with the secondary diagnosis of acute myocardial infarction at Peter Bent Brigham Hospital, only 35% received care in a coronary care unit or intensive care unit; the overall average length of intensive care stay for patients with the secondary diagnosis of acute myocardial infarction was 1.41 days. Assuming an average of four coronary care unit days per primary diagnosis of acute myocardial infarction (see Methods section), and 1.41 days per secondary diagnosis, the estimated percentage of coronary care unit bed-days occupied by myocardial infarction patients in group B hospitals was 12–58%. Similar degrees of variation were found for both university teaching hospitals and community hospitals, and for hospitals in all three geographic areas. In fact, remarkable variations were found at individual hospitals: One hospital had only an estimated 17% of its coronary care unit bed-days occupied by myocardial infarction patients in 1973–1974 but had an estimated 58% of its coronary care unit bed-days occupied by such patients in 1978–1979.

Overall, the coronary care units in the group B hospitals had an estimated 35% of their coronary care unit bed-days occupied by myocardial infarction patients in 1973–1974 and an estimated 34% of their bed-days occupied by such patients in 1978–1979. The intrahospital and interhospital variations in the number of acute myocardial infarction admissions between 1973–1974 and 1978–1979 were not correlated with the size of the hospital's coronary care unit, with the presence or absence of a coronary care unit, or with the building of any new facilities during this 5-year period.

**Discussion**

Assuming that our data from the Boston area are representative of national events, the continued national decline in mortality from acute myocardial infarction between 1973–1974 and 1978–1979 cannot be explained on the basis of a decrease in mortality rates after patients reach the hospital. Because overall myocardial infarction mortality rates were declining substantially at a time when in-hospital mortality rates remained relatively constant, the percentage of myocardial infarction deaths that occurred in the hospital actually increased from about 30% in 1973–1974 to about 40% in 1978–1979.

The Boston-area case-fatality rates may seem higher than in other areas, but our reported rates include hospitalized patients who developed acute myocardial infarctions and may not have survived long enough to be transferred to intensive care. Because we do not have detailed data regarding the comparative severity of cases in the two years under

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<td><strong>Boston-</strong></td>
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<td><strong>Cambridge</strong></td>
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<tr>
<td>2. Population, 1978</td>
</tr>
<tr>
<td>3. Percent change in population</td>
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<tr>
<td>4. Percent change in number of hospitalized patients with a primary diagnosis of acute MI</td>
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<tr>
<td>5. Percent change in CCU or ICU beds available for MI patients</td>
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<tr>
<td>6. Percent change in supply of internists</td>
</tr>
<tr>
<td>7. Percent change in supply of cardiologists</td>
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</table>

*Includes all 63 hospitals from both group A and group B.

Abbreviations: MI = myocardial infarction; CCU = coronary care unit; ICU = intensive care unit.
study, we do not know if in-hospital mortality rates may have been declining for a select subgroup of patients.

The trends in admission rates, mortality rates, and case-fatality rates appear to be consistent with several hypotheses. The apparent decline in out-of-hospital mortality at a time when in-hospital mortality remained constant suggests that a greater percentage of patients with myocardial infarctions were reaching the hospital. These patients may be reaching the hospital because more patients with potential coronary symptoms go to a hospital emergency room on their own without prior physician referral, or because physicians have lowered their thresholds for suggesting hospitalization for suspected myocardial infarction, or because of improved prehospital emergency medical services. In most of the geographic area that we studied, advanced, organized, community-wide prehospital resuscitation and life-support systems were not available. Nevertheless, the increased case-fatality rate after 48 hours in the hospital in patients younger than 70 years in 1978–1979 compared to 1973–1974 suggests that these younger patients may have been sicker, perhaps because some patients survived to reach the hospital in 1978–1979, whereas they would not have reached the hospital in 1973–1974; improved in-hospital care may have delayed but not prevented death. However, the hospital admission rates for persons younger than 70 years who fell in a fashion that was directly parallel to the decline in myocardial infarction mortality trends. If improved prehospital care was salvaging a substantial number of patients, we would not have expected the decline in the admission rate for patients younger than 70 years to be as large as the declines in national mortality rates.

For patients older than 70 years, the declining in-hospital case fatality rate suggests that increased admission rates during a period of declining national mortality rates may have resulted in a less sick mix of admitted patients in this age group. The increased admission of less sick older patients may have been because of greater patient awareness or changing physician thresholds, or possibly because the decreased admission of younger patients left more beds available for patients who in an earlier era may sometimes have been denied admission on the basis of their age. Also, the availability of new diagnostic tests, such as creatine kinase isoenzymes or cardiac nuclear medicine procedures, may have increased diagnostic sensitivity, especially for myocardial infarctions that were less extensive and presumably less likely to be fatal; thus, the number of patients who were diagnosed as acute myocardial infarctions and who survived would tend to increase. Finally, our age-specific in-hospital admission rate trends may be related to a postponement, but not a prevention, of the manifestations of ischemic heart disease.

Patient Distribution and Coronary Care Unit Utilization

In the 5-year interval under study, the major change in the distribution of acute myocardial infarction admissions among hospitals was the trend for metropolitan Boston-Cambridge hospitals, especially the five major university teaching hospitals, to have increased numbers of patients. This increase, which could not be readily explained on the basis of an increase in population, an increase in the number of available beds, an improvement in the available facilities, or an increase in the number of available internists or cardiologists, may have been related to an increased referral of patients to hospitals with the latest technologic advances that might save an individual life, but seemed not to account for overall mortality trends.

The tremendous variability in the occupancy of coronary care unit beds by patients with true acute myocardial infarctions was present in both 1973–1974 and 1978–1979. In fact, individual group B hospitals had as much as a 3.5-fold change in the number of acute myocardial infarction patients between the two time periods. Our finding that only about 35% of coronary care unit bed-days were occupied by patients with acute myocardial infarctions was remarkably consistent with the data of Bloom and Peterson. Using the data in their report, 37% of coronary care unit bed-days were occupied by acute myocardial infarction patients in 32 New England and New York hospitals surveyed in 1969 and 1970.

The many innovations in coronary care between 1973 and 1978 may not have diffused into all the hospitals that we studied. Nevertheless, we, like others, could not demonstrate a marked impact of coronary care on the population's mortality from acute myocardial infarction. Rose noted that coronary care units would be unlikely to reduce acute ischemic heart disease mortality by more than 5%; almost all of this improvement is probably a function of the prevention and treatment of arrhythmias and was available before 1973.

Implications

Although we suspect that coronary care units may have contributed to mortality trends from 1969 to 1973, they have not played a major role in the continued decline in ischemic heart disease mortality between 1973 and 1978. This is not surprising, considering that the major benefit of coronary unit care, namely the treatment and prophylaxis of ventricular fibrillation, was available by 1973 and considering that about two-thirds of myocardial infarction deaths, and even a greater proportion of all acute ischemic heart disease deaths, occur outside of the hospital. Because the mortality trends also seem too marked to be ascribed readily to coronary artery bypass surgery or to prehospital resuscitation, we believe that recent nationwide trends are largely a result of a reduction in coronary risk factors, especially the treatment of hypertension, but probably also changes in diet, cigarette smoking, and exercise habits; but they may also be a result of improved medical therapy of patients with established ischemic heart disease.

The failure of the coronary care unit to contribute
to recent mortality trends, combined with their low rates of occupancy by acute myocardial infarction patients, indicate that such facilities need not be expanded. We do not propose that coronary care units or the other innovations in cardiac care be abandoned, but acute interventions that produce dramatic results in individual patients may not account for national mortality trends.

Acknowledgment

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