Trends in Incidence, Severity, and Outcome of Hospitalized Myocardial Infarction

Véronique L. Roger, MD, MPH; Susan A. Weston, MS; Yariv Gerber, PhD; Jill M. Killian, BS; Shannon M. Dunlay, MD; Allan S. Jaffe, MD; Malcolm R. Bell, MBBS, FRACP; Jan Kors, PhD; Barbara P. Yawn, MD, MS, MSc; Steven J. Jacobsen, MD, PhD

Background—In 2000, the definition of myocardial infarction (MI) changed to rely on troponin rather than creatine kinase (CK) and its MB fraction (CK-MB). The implications of this change on trends in MI incidence and outcome are not defined.

Methods and Results—This was a community study of 2816 patients hospitalized with incident MI from 1987 to 2006 in Olmsted County, Minnesota, with prospective measurements of troponin and CK-MB from August 2000 forward. Outcomes were MI incidence, severity, and survival. After troponin was introduced, 278 (25%) of 1127 incident MIs met only troponin-based criteria. When cases meeting only troponin criteria were included, incidence did not change between 1987 and 2006. When restricted to cases defined by CK/CK-MB, the incidence of MI declined by 20%. The incidence of non–ST-segment elevation MI increased markedly by relying on troponin, whereas that of ST-segment elevation MI declined regardless of troponin. The age- and sex-adjusted hazard ratio of death within 30 days for an infarction occurring in 2006 (compared with 1987) was 0.44 (95% confidence interval, 0.30 to 0.64). Among 30-day survivors, survival did not improve, but causes of death shifted from cardiovascular to noncardiovascular (P=0.001). Trends in long-term survival among 30-day survivors were similar regardless of troponin.

Conclusions—Over the last 2 decades, a substantial change in the epidemiology of MI occurred that was only partially mediated by the introduction of troponin. Non–ST-segment elevation MIs now constitute the majority of MIs. Although the 30-day case fatality improved markedly, long-term survival did not change, and the cause of death shifted from cardiovascular to noncardiovascular. (Circulation. 2010;121:863-869.)

Key Words: biomarkers ■ incidence ■ mortality ■ myocardial infarction

Evaluating temporal trends in the incidence and outcome of myocardial infarction (MI) is essential to monitor the burden of cardiovascular disease, the most common cause of death. However, the characterization of MI trends is challenging because the diagnosis of MI is evolving. In 2000, the European Society of Cardiology and the American College of Cardiology recommended a new definition that combines ischemic symptoms, ECG changes, and elevation of biochemical markers of myocardial necrosis, preferably troponins in part because of their prognostic value. This change, which has become operational as the universal definition, is expected to be evident in several ways. Compared with creatine kinase (CK) and its MB fraction (CK-MB), markers previously used to detect myocardial injury, troponins are more sensitive, enabling the detection of smaller amounts of necrosis. Thus, troponins were expected to increase the incidence of infarctions and to shift the clinical spectrum of the disease toward less severe forms. Because of the far-reaching clinical and public health implications of these changes and the necessity to rigorously document their impact, the European Society of Cardiology and the American College of Cardiology recommended that the previous definition “be retained” by sentinel centers. The importance of this recommendation was further supported by the considerable controversy that the new criteria generated. We responded to this stated need in our ongoing coronary disease community surveillance study in Olmsted County, Minnesota, by prospectively applying the CK-MB– and troponin-based criteria simultaneously to all patients with acute coronary syndrome since 2000. Shortly after the implementation of the new criteria, we detected a large increase in the number of infarctions related to the identification of cases by troponin-based criteria. The impact, however, on incidence trends remained to be defined. Hence, we sought to docu-
ment the impact of the new criteria on the incidence and outcome of MI and to test the following hypotheses: (1) There has been no overall decline in the incidence of MI over time, but the trends differed according to whether or not cases meeting only troponin-based criteria were considered; and (2) survival after incident MI improved over time, but the improvement differed according to whether or not cases meeting only troponin-based criteria were included.

Clinical Perspective on p 869

Methods

Study Setting

In Olmsted County, a few providers (chiefly Mayo Clinic and Olmsted Medical Center) deliver nearly all medical care to county residents. With the exception of a higher proportion employed in healthcare, the characteristics of this population are similar to those of US whites. Each provider uses a medical record that captures information for all encounters and can be retrieved because the Mayo Clinic maintains indices based on all diagnoses and procedures. Since 1966, similar indices have been implemented for non-Mayo providers through the Rochester Epidemiology Project, resulting in the linkage of medical records from all sources of care. This provides a unique infrastructure to analyze disease occurrence and outcomes at the population level.

Enumeration of Hospitalized Patients With MIs

Potential cases were identified as patients admitted to Olmsted County hospitals who were assigned diagnoses compatible with MI with the use of 3 data sources: the Rochester Epidemiology Project index of diagnoses, the Hospital Utilization Review, and the Decision Support System databases, administrative databases of hospitalizations maintained by the Mayo Clinic. In-hospital deaths were included, and the target codes from the International Classification of Diseases, Ninth Revision included 410 (acute MI) and 411 (other acute and subacute forms of ischemic heart disease). All events coded as 410 were reviewed from 1987 to 2006, and a 50% random sample of 411 codes from 1987 to 1998, a 10% random sample of 411 codes from 1999 to 2002, and 100% of 411 codes from 2003 to 2006 were reviewed, similar to other studies. The random sampling was designed without prespecified age or sex strata. Sampling of additional coronary disease codes resulted in an aggregate yield of 1.4%, and thus these codes were not included in the analyses. Validation relied on the presence of cardiac pain, biomarkers, and ECG. Biomarkers used in clinical practice included CK and CK-MB until 2000 and troponin thereafter. Importantly, in our prospective surveillance study, measurements of CK-MB were retained in all cases after troponin replaced CK and CK-MB in practice.

Biomarker values were recorded for up to 3 determinations on each of the first 3 days after admission or infarction onset, if the patient was already hospitalized. In addition, circumstances that might invalidate biomarker values were recorded. For CK and CK-MB, these included skeletal muscle injury, trauma, or surgery; for troponin, these included cardiac trauma (contusion, ablation, pacing, defibrillator firings, cardiovascular, endomyocardial biopsy, cardiac surgery), heart failure, renal failure, hypertension, hypotension, critical illness, drug toxicity, hypothyroidism, inflammatory or infiltrative diseases, pulmonary embolism, sepsis, extensive burns, acute neurological disease, and rhabdomyolysis. Troponin T, CK, and CK-MB were measured with a sandwich electrochemiluminescence immunoassay on the Elecsys 2010 (Roche Diagnostics Corp, Indianapolis, Ind) in the laboratories of the Department of Laboratory Medicine and Pathology, which is certified by the Clinical Laboratory Improvement Act of 1988 and the College of American Pathologists, with robust quality control in place. Three ECGs per episode were coded with the use of the Minnesota Code Modular ECG Analysis System.

Infarctions were classified with standard algorithms integrating cardiac pain and ECG and biomarker data. These methods, used by the World Health Organization and the Atherosclerosis Risk in Communities study, have excellent reliability. Before August 2000, cases were classified by CK or CK-MB. Thereafter, each case was classified by both CK-MB and troponin T. According to the new guidelines, the presence or absence of a change (rise or fall) between any 2 troponin measurements was defined by a difference of ≥0.05 ng/mL, which is greater than the level of imprecision of the assay at all concentrations. Because troponin can remain elevated for 2 weeks after events causing its rise, comorbid conditions were noted if they occurred within 2 weeks before the infarction, and, when present, the biomarker results were downgraded from abnormal to equivocal in the algorithm. Cardiopulmonary resuscitation and procedural rise in cardiac enzymes also led to a downgrading of the biomarker values, following standard approaches in epidemiological studies. Each episode was classified as definite, probable, suspect, or no infarction. Incidence was determined by searching the entire study period and possible episodes of prior infarction were validated or, if data were not available, described qualitatively. Only first-ever infarctions were considered as incident.

The severity of the event was evaluated with the use of several indicators. The Killip class served as the indicator of hemodynamic severity on admission. Cardiogenic shock (Killip class 4) was defined as a systolic blood pressure <90 mm Hg in the absence of hypovolemia. The presence of ST-segment elevation and Q waves was ascertained by the Minnesota code.

Follow-Up

Follow-up for death relied on death certificates filed in Olmsted County, autopsy reports, obituary notices, and electronic files of

<table>
<thead>
<tr>
<th>Table 1. Characteristics of MIs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age, mean±SD, y</td>
</tr>
<tr>
<td>Overall (n=2816)</td>
</tr>
<tr>
<td>-----------------</td>
</tr>
<tr>
<td>Women, %</td>
</tr>
<tr>
<td>Presence of cardiac pain, %</td>
</tr>
<tr>
<td>Comorbidity score</td>
</tr>
<tr>
<td>1–2 points, %</td>
</tr>
<tr>
<td>≥3 points, %</td>
</tr>
<tr>
<td>MI severity indicators</td>
</tr>
<tr>
<td>Killip class 2, 3, or 4, %</td>
</tr>
<tr>
<td>NSTE-MI, %</td>
</tr>
<tr>
<td>Presence of Q waves, %</td>
</tr>
<tr>
<td>Treatment</td>
</tr>
<tr>
<td>Reperfusion/ revascularization during hospitalization, %</td>
</tr>
<tr>
<td>Aspirin at dismissal, %</td>
</tr>
<tr>
<td>β-blocker at dismissal, %</td>
</tr>
<tr>
<td>Statins at dismissal, %</td>
</tr>
</tbody>
</table>

*Data by type of biomarker used in the diagnostic algorithm pertain to the 1127 events from August 2000 forward.

†From weighted logistic regression comparing MIs identified by troponin-based criteria only vs CK-MB–based criteria.
death certificates obtained from the State of Minnesota Department of Vital and Health Statistics. Causes of death were classified as cardiovascular, cancer, or other on the basis of codes from the International Classification of Disease, Ninth Revision,17 and the American Heart Association categories were used for cardiovascular deaths.1

**Statistical Analysis**

Baseline characteristics are presented as frequencies for categorical variables and mean (SD) for continuous variables. Baseline characteristics between groups were compared by logistic regression. Differences in infarction severity across time were tested by logistic regression for binary severity indicators and linear regression for the natural log of peak CK-MB ratio, defined as the ratio of the measured value divided by the upper limit of normal, and age. Age-, sex-, and year-specific incidence rates were calculated. The counts of all definite and probable incident infarctions were used as the numerators, and the denominators were the Olmsted County population as determined by census data for the years 1980, 1990, and 2000 with linear interpolation for the intercensus years and extrapolation as determined by census data for the years 1980, 1990, and 2000. The rates were directly standardized to the age distribution of the 2000 US population. Standard errors and 95% confidence intervals (CIs) were calculated on the basis of the Poisson error distribution. Temporal trends in incidence were assessed with Poisson regression. Specific counts for each calendar year, age, and sex were used as the unit of observation. A linear and a quadratic component were tested for year and age. All 2-way interactions were tested. The results of the final model, assuming a linear change over time, were summarized by presenting the relative risk of incident infarction in 2006 compared with 1987.

Survival was analyzed by the Kaplan-Meier method and compared with the expected survival of the Minnesota population. Proportional hazards modeling for death within 30 days and death among 30-day survivors examined the association of year with survival. Trends across age and between sexes were compared by including interaction terms between year and age and year and sex. The analyses were weighted to account for the different sampling fractions. The proportional hazards assumption, tested with the use of the Schoenfeld residuals, was found to be valid. All analyses were performed with the use of SAS version 8.2 (SAS Institute Inc, Cary, NC) and Splus version 8 (TIBCO Software Inc, Palo Alto, Calif). All aspects of the study were approved by the appropriate institutional review boards.

### Results

**The MI Incidence Cohort**

From 1987 to 2006, an estimated total of 2816 incident infarctions occurred in Olmsted County. Medical history available before the event covered a mean (SD) time of 39 (20) years. The mean (SD) age at index was 68 (15) years. Of the 2816 incident events, 1222 (43%) occurred among women (Table 1) and 1107 (39%) among persons aged ≥75 years. The distribution of age at index did not change over time, whereas the percentage of MIs experienced by women decreased over time (Table 2).

Of all incident events, 1689 occurred before the introduction of troponin in August 2000 and 1127 thereafter. Among these, 278 (25%) did not meet infarction criteria as defined by CK-MB and met only troponin-based criteria. Compared with cases identified by CK-MB–based criteria, those meeting only troponin-based criteria were older, were more likely to be women, and had more comorbidities (Table 1). They were less likely to experience pain and to present with Q waves and were in a lower Killip class. Most infarctions meeting only troponin-based criteria were non–ST-segment elevation MIs (NSTEMIs). These differences were independent of age and sex. With regard to treatment, MIs meeting only troponin-based criteria were less likely to receive evidence-based therapies. Among all MIs, the use of reperfusion/revascularization during hospitalization increased over time, without reaching statistical significance. The use of aspirin, β-blockers, and statins at dismissal increased over time (Table 2).

### Incidence of Hospitalized MI

Temporal trends differed according to the type of biomarker used for diagnosis (Figure 1). When all infarctions were included irrespective of the biomarker used for diagnosis, the incidence rates did not change between 1987 and 2006. The overall age- and sex-adjusted incidence rate of hospitalized infarctions was 186 per 100 000 (95% CI,150 to 221) in 1987 and 180 per 100 000 (95% CI, 151 to 209) in 2006 (P=0.171

| Table 2. Trends in Characteristics of MI From 1987 to 2006 in Olmsted County, Minnesota |
|---|---|---|---|---|---|---|
| **Age**, mean (SD), y | 68 (15) | 68 (14) | 69 (16) | 68 (15) | 0.405 |
| Women, % | 46 | 44 | 44 | 41 | 0.032 |
| **MI severity indicators** | | | | | |
| Killip class 2, 3, or 4, % | 35 | 33 | 29 | 28 | 0.002 |
| ST-segment elevation, % | 38 | 38 | 30 | 22 | <0.001 |
| Q waves, % | 45 | 62 | 61 | 55 | <0.001† |
| Peak CK-MB ratio, median (25th–75th percentile) | 6.8 (2.6–14.4) | 10.2 (3.5–22.6) | 6.8 (2.6–22.7) | 3.2 (1.3–10.8) | <0.001† |
| **Treatment** | | | | | |
| Reperfusion/revascularization during hospitalization, % | 55 | 60 | 61 | 60 | 0.059 |
| Aspirin at dismissal, % | 71 | 82 | 87 | 89 | <0.001 |
| β-blockers at dismissal, % | 47 | 65 | 79 | 87 | <0.001 |
| Statins at dismissal, % | 1 | 10 | 52 | 78 | <0.001 |

*From weighted logistic regression for dichotomous variables and weighted linear regression for continuous variables using continuous year.

†P value for year.
for the year effect). When only cases meeting CK/CK-MB criteria were considered, a significant temporal decline in the incidence of MI was detected (P = 0.020) as the age- and sex-adjusted incidence rate of hospitalized infarctions declined to 141 per 100,000 (95% CI, 115 to 167) in 2006. This represents a 1.1% per year decline in the incidence of infarctions meeting CK/CK-MB criteria. Thus, if a linear decline from 1987 to 2006 is assumed, the age- and sex-adjusted relative risk of experiencing an MI as defined by CK/CK-MB in 2006 compared with 1987 was 0.80 (95% CI, 0.67 to 0.98), indicating a 20% decline in incidence rates over the last 2 decades.

Although the incidence of MI was higher in men (Figure 1) and in older persons (data not shown), none of the aforementioned trends differed by age or sex. The incidence trends diverged markedly according to the presence or absence of ST elevation (Figure 2). The incidence rates of ST-segment elevation MI (STEMI) declined by 41% over the time period irrespective of troponin (relative risk, 0.59; 95% CI, 0.47 to 0.76 for STEMI including troponin-only cases versus relative risk, 0.56; 95% CI, 0.44 to 0.71 for STEMI excluding troponin-only cases). The incidence rates of NSTEMI increased by 49% over time when troponin-only cases were included (relative risk, 1.49; 95% CI, 1.23 to 1.81). Temporal trends in NSTEMI did not change when troponin-only cases were excluded.

The incidence rate analyses were repeated with the use of a minimum difference of 0.03 ng/mL between any 2 troponin measurements to define a change in values. Doing so increased the estimated number of incident infarctions by 1.2% without affecting temporal trends, which attests to their robustness.

MI Severity

When all infarctions irrespective of the biomarker used for diagnosis were analyzed, most patients were in Killip class 1, but the proportion of those in Killip class 2, 3, or 4 declined over time, as did the proportion of patients with ST-segment elevation (Table 2). ECG Q waves were observed in 54% of cases, and the frequency increased during the first half of the period, followed by a decrease thereafter. The CK-MB ratio showed a similar pattern.

The trends in hemodynamic presentation, ECG findings, and CK-MB ratio were similar when cases meeting only troponin criteria were excluded. The median time between symptom onset and first ECG (ascertained in 97% of cases) was 1.7 (25th to 75th percentile, 0.8 to 4.4) hours and did not change over time.

Fatality

Among all incident infarctions, the 30-day case fatality rate (Figure 3) was higher in women and in older persons and decreased markedly over time. Indeed, after adjustment for age and sex, the overall 30-day case fatality rate declined by 4.3% per year (P = 0.001). Thus, compared with the reference year of 1987, for an incident infarction occurring in 2006, the age- and sex-adjusted hazard ratio of death within 30 days of the event was 0.44 (95% CI, 0.30 to 0.64; P < 0.001), indicating a 56% decline in 30-day case fatality rate over the last 2 decades. The temporal trends in 30-day case fatality did not differ by age or sex (year×age interaction, P = 0.630;
year × sex interaction, \( P = 0.884 \) and were similar when cases meeting only troponin-based criteria were excluded.

Among all incident infarctions, the mean (SD) follow-up was 6.0 (5.3) years. Among persons who survived for 30 days after the incident infarction, survival did not improve further over time. Indeed, compared with 30-day survivors of an infarction occurring in 1987, the age- and sex-adjusted hazard ratio of death among 30-day survivors of an infarction occurring in 2006 was 1.04 (95% CI, 0.81 to 1.35; \( P = 0.717 \)). Further adjustment for cardiovascular risk factors, comorbidity, and Killip class yielded similar results. The temporal trends in long-term survival among 30-day survivors did not differ by age or sex (year × age interaction, \( P = 0.168 \); year × sex interaction, \( P = 0.798 \)) and were similar when cases meeting only troponin-based criteria were excluded.

The distribution of the causes of deaths after hospitalized MI changed over time (\( P = 0.001 \)). During the first year quartile (1987–1991), 62% of deaths were ascribed to cardiovascular causes compared with 50% during the most recent year quartile (2002–2006).

When cardiovascular death was examined among persons who survived at least 30 days, survival free of cardiovascular death improved over time. Indeed, compared with 30-day survivors of an infarction occurring in 1987, the age- and sex-adjusted hazard ratio of cardiovascular death among 30-day survivors of an infarction occurring in 2006 was 0.54 (95% CI, 0.38 to 0.75; \( P = 0.001 \)). These findings were similar when cases meeting only troponin criteria were excluded.

The 5-year Kaplan-Meier survival estimate (95% CI) after incident infarction was 67% (65% to 69%), lower than that expected among the Minnesota population of 79% (\( P < 0.001 \) for comparison between observed and expected survival). When the analysis was stratified by year groups, similar estimates of observed and expected survival were obtained over time.

### Discussion

These prospective data indicate that the epidemiology of MI changed markedly over the past 2 decades, a change only partly related to the introduction of troponin. Indeed, if troponin had not been adopted as part of the universal definition of MI, a 20% decline in incidence of infarctions (defined by CK/CK-MB) would have been observed over the past 2 decades. Although the substantial increase in NSTEMI is mediated by the preferential reliance on troponin, there has been a profound decline in STEMI not related to troponin. The severity of infarctions declined regardless of troponin. Whereas the 30-day case fatality improved markedly over time, long-term survival among 30-day survivors did not change, and the cause of death shifted from cardiovascular to noncardiovascular.

### Trends in Incidence of MI

The change in diagnostic biomarker challenges the interpretation of the trends of one of the key indicators of the burden of cardiovascular disease. Previous estimates relying mostly on convenience case series and single values of troponin suggested variable increases in the number of infarctions,\(^ {18,19} \) which were difficult to interpret because of differences across studies in type of biomarkers (troponin T versus I), assays, cut points, and reference criteria. The implications for the incidence of MI remained unknown because available US data on MI incidence extend only through the mid 1990s and do not reflect the use of troponin. The present data address this gap in knowledge and directly evaluate the impact of troponin because we classified all cases by both biomarkers (CK-MB and troponin). The findings build on our previous report that documented a large increase in the number of infarctions compared with what would have been detected with the use of criteria from the World Health Organization\(^ {1,4} \) and Atherosclerosis Risk in Communities study.\(^ {8} \) Herein, we have demonstrated that, over the past 2 decades, a 20% decline in the incidence of MI would have been detected if troponin had not been introduced. The present results resonate with reports from this community of a decline in the incidence of all manifestations of coronary disease\(^ {20} \) and of extensive coronary disease.\(^ {31} \) To this end, with the use of the World Health Organization criteria\(^ {1,4} \) also unaffected by troponin, the British Regional Heart Study reported a 62% decline in the incidence of MI among men over a similar period (1978–2004).\(^ {22} \) The magnitude of the decline was greater than that noted in Olmsted County, possibly reflecting the focus on men in the British Regional Heart Study versus the entire Olmsted County community. However, taken collectively, these data suggest a contribution of prevention to the decline in coronary disease mortality, a departure from earlier reports of no change in MI incidence.\(^ {23} \) The insights gained from the prospective measurement of the 2 diagnostic markers shown herein underscore that in fact the epidemiology of MI is changing fundamentally. Indeed, we report a profound decline in the incidence of STEMI predating the introduction of troponin, offset by a marked increase in the incidence of NSTEMI mediated by substituting troponin for CK-MB. These results extend the report of the Framingham Heart Study on an earlier time period (1960–1999) in which the rates of MI diagnosed by ECG only declined by 50%, whereas rates of infarction diagnosed by biomarkers doubled.\(^ {24} \)

### Case Mix and Outcomes

The present results indicate that the severity of infarctions decreased over time. The marked reduction in the proportion of infarctions in the community that present with ST-segment elevation is particularly noteworthy because it is consistent across studies and sustained over time.\(^ {25,26} \) Importantly, the beginning of this trend, the magnitude of which is striking, predates the introduction of troponin. Although explanations can only be speculative, one hypothesis is that the increasing use of medications such as aspirin and \( \beta \)-blockers before admission may reduce the size and severity of infarctions.\(^ {27} \) The new criteria identify older subjects who seldom present with ST-segment elevation and now constitute the vast majority of events. This underscores the importance of optimizing the care of NSTEMIs, which are less likely to receive evidence-based care than STEMI.\(^ {28} \)

Population studies all documented a favorable decline in early mortality among younger individuals contrasting with a persistently high fatality rate among the elderly over a period of time ranging from 1975 to 1995.\(^ {15,23,29,30} \) Importantly, the
mortality of infarction in the community remained high and was consistently higher than that reported in clinical trials, reflecting their inherent selection processes.31 Although only clinical trials can test the efficacy of a novel treatment, reports from community surveillance provide important complementary insights into the effectiveness of treatments once implemented. The present study demonstrates that the marked improvement in early fatalities after MI persisted over time and that notable survival gains were realized in women and the elderly, among whom disparities had been detected previously.15 Conversely, no further improvement in long-term survival was noted concomitantly with a shift in the assignment of death from cardiovascular to noncardiovascular causes.

Strengths, Limitations, and Implications

The prospective examination of the impact of the new definition using standardized criteria and the simultaneous measurement of both sets of biomarkers independent of clinical practice are unique strengths of this study, which responds to the call for “sentinel centers” deemed necessary to understand the implications of the new definition. The internal validity of the present data is robust because our ascertainment identified consecutive cases validated rigorously. Given the racial and ethnic composition of Olmsted County,10 these data need replication in other populations.

The goal of our study was to measure trends in hospitalized incident infarctions while focusing on the impact of biomarkers. We did not capture silent infarctions or sudden deaths. Because biomarkers would not have been measured in either entity, this does not affect the validity of our results. We previously reported on temporal trends in sudden death in Olmsted County.32,33 These studies indicated that out-of-hospital deaths related to coronary and cardiovascular disease declined by 1.8% per year since 1979. These findings are comparable to the 1.1% per year decline in the incidence of infarctions meeting CK/CK-MB criteria reported herein.

The present study has important implications to understanding trends in MI incidence in the face of changing definitions. We demonstrated a profound change in the epidemiology of MI only partially mediated by the introduction of a new biomarker.

Indeed, although the introduction of troponin masked a decrease in the incidence of MI that would have been observed if biomarkers had not changed, the declining incidence of STEMI is not related to the introduction of troponin. Moreover, the severity of infarctions declined, and the outcomes continued to improve over time, irrespective of the change in biomarkers. Importantly, the improvement in survival was detectable for early case fatality rate and long-term cardiovascular deaths but not for long-term survival among 30-day survivors.

Conclusion

This prospective community study delineates a substantial change in the epidemiology of MI only partially mediated by the introduction of troponin. NSTEMIs now constitute the vast majority of MIs in the community. Although the 30-day case fatality of infarctions improved markedly, long-term survival among 30-day survivors did not improve, and the cause of death shifted from cardiovascular to noncardiovascular. These data underscore the importance of community surveillance to understanding the burden of coronary disease in populations.

Sources of Funding

This study was supported in part by grants from the Public Health Service and the National Institutes of Health (AR30582 and RO1 HL 59205). The study sponsor had no role in study design, data collection, analysis, or interpretation of data. The sponsor did not participate in the writing of the report or in the decision to submit the paper for publication.

Disclosures

Dr Jaffe consults for the following companies: Beckman, Siemens, Critical Diagnostics, Ortho Clinical Diagnostics, Singulex, Nanosphere, Novartis, Inverness Medical, and GSK. The remaining authors report no conflicts.

References


11. White AD, Folsom AR, Chambless LE, Sharrett AR, Yang K, Conwell D, Higgins M, Williams OD, Tyroler HA. Community surveillance of coronary heart disease in the Atherosclerosis Risk in Communities (ARIC) study:
12. Jaffe AS. Elevations of troponin: false positive, the real truth. Cardiovasc
13. Kors JA, Crow RS, Hannan PJ, Rautaharju PM, Folsom AR. Comparison of
computer-assigned Minnesota codes with the visual standard method for
AM, Pajak A. Myocardial infarction and coronary deaths in the World
Health Organization MONICA Project: registration procedures, event
rates, and case-fatality rates in 38 populations from 21 countries in four
15. Roger VL, Jacobsen SJ, Weston S, Goraya TY, Killian J, Reeder GS,
Kottke TE, Yawn BP, Frye RL. Trends in the incidence and survival of
patients with hospitalized myocardial infarction, Olmsted County, Min-
16. Killip T, Kimball JT. Treatment of myocardial infarction in a coronary
care unit: a two year experience of 250 patients. Am J Cardiol. 1967;20:
457–463.
sification of Diseases, Injuries, and Causes of Death Based on the
Recommendations of the Ninth Revision Conference. 1975. Geneva, Swit-
Impact of the troponin standard on the prevalence of acute myocardial
Rantanen T, Pyorala K. Differences in the diagnosis of myocardial
infarction by troponin T compared with clinical and epidemiologic
20. Arciero TJ, Jacobsen SJ, Reeder GS, Frye RL, Weston SA, Killian JM,
21. Gerber Y, Rihal CS, Hannan PJ, Rautaharju PM, Folsom AR. Comparison of
computer-assigned Minnesota codes with the visual standard method for
new coronary heart disease events. Am J Epidemiol. 2000;151:
790–797.
Morris RW. How much of the recent decline in the incidence of myo-
cardial infarction in British men can be explained by changes in cardio-
vascular risk factors? Evidence from a prospective population-based
23. Rosamond WD, Chambless LE, Folsom AR, Cooper LS, Conwill DE,
Clegg L, Wang CH, Heiss G. Trends in the incidence of myocardial
24. Parikh NI, Gona P, Larson MG, Fox CS, Benjamin EJ, Murabito JM,
D’Ottaviano CI, Vasan RS, Levy D. Long-term trends in myocardial
infarction incidence and case fatality in the National Heart, Lung, and
Blood Institute’s Framingham Heart Study. Circulation. 2009;119:
1203–1210.
LS, Chambless LE. Trends in severity of hospitalized myocardial
infarction: the Atherosclerosis Risk in Communities (ARIC) study,
Has the severity of acute myocardial infarction changed over time? A
population-based study in Olmsted County, MN. Circulation. 2001;104:
II–787.
27. Col NF, Yarzbski J, Gore JM, Alpert JS, Goldberg RJ. Does aspirin
consumption affect the presentation or severity of acute myocardial
28. Peterson ED, Roe MT, Mulgund J, DeLong ER, Lytle BL, Brindis RG,
Smith SC Jr, Pollack CV Jr, Newby LK, Harrington RA, Gibler WB,
Ohman EM. Association between hospital process performance and
outcomes among patients with acute coronary syndromes. JAMA. 2006;
29. McGovern PG, Jacobs DR Jr, Shahar E, Arnett DK, Folsom AR,
Blackburn H, Luepker RV. Trends in acute coronary heart disease mor-
tality, morbidity, and medical care from 1985 through 1997: the Min-
Temporal trends in cardiogenic shock complicating acute myocardial
31. Steg PG, Lopez-Sendon J, Lopez de la Sla E, Goodman SG, Gore JM,
Anderson FA Jr, Himbert D, Allegrone J, Van de Werf F. External
validity of clinical trials in acute myocardial infarction. Arch Intern
Secular trends in deaths from cardiovascular diseases: a 25-year com-
33. Goraya TY, Jacobsen SJ, Kottke TE, Frye RL, Weston SA, Roger VL.
Coronary heart disease death and sudden cardiac death: a 20-year

CLINICAL PERSPECTIVE

In 2000, the definition of myocardial infarction (MI) changed to rely on troponin rather than creatine kinase (CK) and its
MB fraction (CK-MB). The implications of this change on trends in MI incidence and outcome are not defined. We studied
2816 community patients hospitalized with a first MI from 1987 to 2006 with prospective measurements of troponin and
CK-MB from August 2000 forward. Outcomes were MI incidence, severity, and survival. After troponin was introduced,
278 (25%) of 1127 incident MIs met only troponin-based criteria. When cases meeting only troponin criteria were included,
incidence did not change between 1987 and 2006. When restricted to cases defined by CK/CK-MB, the incidence of MI
deployed by 20%. The incidence of non–ST-segment elevation MI increased markedly by relying on troponin, whereas that
of ST-segment elevation MI declined regardless of troponin. The age- and sex-adjusted hazard ratio of death within 30 days
for an infarction occurring in 2006 (compared with 1987) was 0.44 (95% confidence interval, 0.30 to 0.64). Among 30-day
survivors, survival did not improve, but causes of death shifted from cardiovascular to noncardiovascular (P=0.001). Over
the last 2 decades, a substantial change in the epidemiology of MI occurred, with a decline in incidence that was partially
masked by the introduction of troponin. Non–ST-segment elevation MIs now constitute the majority of MIs. Although the
30-day case fatality improved markedly, long-term survival did not change, and the cause of death shifted from
unvascular to noncardiovascular.

Go to http://cme.ahajournals.org to take the CME quiz for this article.
Trends in Incidence, Severity, and Outcome of Hospitalized Myocardial Infarction
Véronique L. Roger, Susan A. Weston, Yariv Gerber, Jill M. Killian, Shannon M. Dunlay, Allan S. Jaffe, Malcolm R. Bell, Jan Kors, Barbara P. Yawn and Steven J. Jacobsen

Circulation. 2010;121:863-869; originally published online February 8, 2010;
doi: 10.1161/CIRCULATIONAHA.109.897249
Circulation is published by the American Heart Association, 7272 Greenville Avenue, Dallas, TX 75231
Copyright © 2010 American Heart Association, Inc. All rights reserved.
Print ISSN: 0009-7322. Online ISSN: 1524-4539

The online version of this article, along with updated information and services, is located on the
World Wide Web at:
http://circ.ahajournals.org/content/121/7/863

Permissions: Requests for permissions to reproduce figures, tables, or portions of articles originally published in Circulation can be obtained via RightsLink, a service of the Copyright Clearance Center, not the Editorial Office. Once the online version of the published article for which permission is being requested is located, click Request Permissions in the middle column of the Web page under Services. Further information about this process is available in the Permissions and Rights Question and Answer document.

Reprints: Information about reprints can be found online at:
http://www.lww.com/reprints

Subscriptions: Information about subscribing to Circulation is online at:
http://circ.ahajournals.org/subscriptions/