Association of Troponin Status With Guideline-Based Management of Acute Myocardial Infarction in Older Persons

Rahman Shah, MD; Jared Selter, MD; Yun Wang, PhD; Michael Greenspan, MD; JoAnne M. Foody, MD

Background: Over the past decade, a large body of evidence has emerged demonstrating the prognostic significance of troponin as well as its use in tailoring therapeutic interventions. Little is known, however, regarding the association of troponin status with guideline-based therapies in older patients with acute myocardial infarction (AMI).

Methods: A nationwide sample of eligible Medicare beneficiaries 65 years or older, who were hospitalized with a primary discharge diagnosis of AMI from April 1998 to March 1999 or from July 2000 to June 2001, was evaluated. The analysis was restricted to patients with clinically confirmed AMI who underwent testing for both creatine kinase–myocardial band (CK-MB) and troponin. Results were assessed in 3 groups of patients based on biomarker status: those whose findings were positive for troponin only (hereinafter, troponin-only patients), those whose findings were positive for CK-MB only (hereinafter, CK-MB–only patients), and those whose findings were positive for both troponin and CK-MB (hereinafter, troponin/CK-MB patients). Then, the use of guideline-recommended care was compared for patients without contraindications to treatment across the 3 groups.

Results: The final study sample included 33,096 patients (mean age, 77.6 years [range, 65-105 years]). The crude in-hospital mortality rate was highest for troponin-only patients (14%) and lowest for CK-MB–only patients (10%, P<.001). After adjusting for demographics, physician specialty, and hospital characteristics, CK-MB–only patients were more likely to receive aspirin (odds ratio [OR], 1.46; 95% confidence interval [CI], 1.28-1.65) and β-blocker (OR, 1.21; 95% CI, 1.08-1.34) within 24 hours of hospital arrival and aspirin on discharge (OR, 1.27; 95% CI, 1.08-1.49) compared with troponin-only patients. In addition, troponin/CK-MB patients were more likely to receive aspirin (OR, 1.55; 95% CI, 1.42-1.69) and β-blocker (OR, 1.22; 95% CI, 1.12-1.31) within 24 hours of arrival and on discharge compared with troponin-only patients (ORs, 1.31 [95% CI, 1.17-1.46] and 1.33 [95% CI, 1.15-1.52] for aspirin and β-blocker, respectively).

Conclusions: Despite the known poor prognosis associated with troponin elevations in AMI, we demonstrate that guideline-based therapies are underused in older patients with AMI. Therefore, national efforts should focus on the unique characteristics of this high-risk patient population to improve the quality of care for older patients with AMI.

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Historically, the diagnosis of an acute myocardial infarction (AMI) was generally made using the revised World Health Organization criteria. These criteria were based, in part, on creatine kinase–myocardial band (CK-MB) measurements. A large body of evidence emerged in the 1990s demonstrating that elevated levels of troponin add substantial diagnostic and prognostic value to clinical variables and conventional markers in the identification of patients with acute coronary syndromes who are at risk for cardiac events. Further studies established that troponin levels were more sensitive and specific than CK-MB for myocardial necrosis, and thus troponin was incorporated into the diagnosis of myocardial infarction (MI) in the past decade. Ultimately, troponin was identified as the gold standard biomarker in both national and international criteria for the diagnosis of MI. Several studies have posited that use of the troponin diagnostic criteria increased the reported incidence of AMI by 20% to 30%, with most of this increase occurring in older patients. At present, however, no data exist regarding the impact of troponin status on guideline-based treatment of older patients with AMI.

National studies of AMI supported by the Centers for Medicare and Medicaid Services (CMS) provide a unique opportu-
nity to evaluate the contemporary use and impact of troponin in older patients with AMI. Therefore, we sought to determine whether older patients who underwent testing for both CK-MB and troponin and whose findings were positive for troponin only (hereinafter, troponin-only patients) would be more or less likely to receive guideline-based care compared with older patients with "traditional" AMIs (diagnosed according to World Health Organization criteria).

METHODS

DATA SOURCE AND SAMPLING

We analyzed data collected for the Medicare Health Care Quality Improvement Program for April 1998 to March 1999 and for July 2000 to June 2001. These data were collected as part of the National Acute Myocardial Infarction Project, a quality improvement project of the CMS for AMI, and have been described previously.24 The AMI discharges were identified from the National Claims History File as those Part A Medicare claims cal data abstracted from hospital medical records and have been described previously.24 The AMI discharges were identified from the National Claims History File as those Part A Medicare claims with a principal discharge diagnosis of International Classification of Diseases, Ninth Revision, Clinical Modification code 410.xx, excluding 410.x2.25,26 The latter code was excluded because it represents an admission for a subsequent episode of AMI care following an AMI within the previous 8 weeks.

The administrative data were supplemented by in-depth clinical data abstracted from hospital medical records and have been described previously.27 Briefly, trained abstractors at CMS-contracted clinical data abstraction centers performed medical record abstraction. Intrater reliability of medical record abstraction was monitored using random reabstraction of samples of records. Discrepancies among abstractors were identified and examined, and retraining of staff was performed as needed, based on the results. Extensive written abstraction guidelines provided instruction for standardization of data collection. Purposeful sampling was used to select AMI discharges from each state after sorting by age, sex, race, and hospital provider number to provide a representative sample. If the number of medical records for a state was less than the number targeted for the sample, all AMI discharges in the relevant period were included. The sample totaled 71 120 records.

STUDY COHORT

For the purposes of this analysis, we identified a cohort of patients with clinically confirmed AMI, defined as a discharge diagnosis of an AMI and any 1 of the following criteria: a CK-MB level higher than 3%, a troponin (I or T) level greater than the upper limit of the reference range (of each institution), or testing for both CK-MB and troponin. A total of 71 120 patients were included in the raw database, in which 33 713 cases (30.2%) were abstracted during the baseline and 35 407 (49.8%) during remeasurement periods. After excluding patients younger than 65 years (4.5%) (because these patients are not generally representative of the Medicare cohort), those with recurrent AMI (0.1%), those without troponin measurements (28.9%) or CK-MB measurements (25.9%), those without clinically confirmed AMI (12.8%), and those without verified mortality data (2.3%), the final study sample included 33 096 patients. A total of 5897 (17.8%) were troponin-only patients; the findings of 3689 (11.1%) were positive for CK-MB only (hereinafter, CK-MB–only patients), and the findings of 23 510 (71.0%) were positive for both troponin and CK-MB (hereinafter, troponin/CK-MB patients).

QUALITY MEASURES

We evaluated patients’ quality of care using CMS quality-of-care measures: aspirin and β-blocker use within 24 hours of hospital arrival, thrombolysis within 30 minutes of hospital arrival, percutaneous transluminal coronary angioplasty (PTCA) performed within 90 minutes of hospital arrival, discharge prescription of aspirin, β-blockers, and angiotensin-converting enzyme (ACE) inhibitors.28 All measure rates were assessed only in those candidates considered ideal for treatment paralleling approaches of previously published studies (Table 1).24,27,28 First, those patients meeting minimal treatment requirements (hereinafter, eligible candidates) were identified. For the early administration of aspirin and β-blocker therapies (within 24 hours), patients who were transferred from another acute care facility were not considered eligible. For the discharge treatment measures, those patients who died during hospitalization, who were transferred to another acute care facility, or whose discharge status was unknown were not considered eligible. Among the cohorts of eligible candidates, ideal candidates were identified by excluding any patients with a documented contraindication to treatment. In general, the allowed contraindications were permissive, creating cohorts with a low likelihood of meaningful contraindications to treatment.

The timely use of PTCA or thrombolysis was assessed according to medical chart–abstracted data per the National Heart Care protocol.28,29 In brief, patients eligible for the “time to receipt of acute reperfusion therapy” quality indicator were those patients receiving either PTCA or thrombolytic drugs who had clinical and electrocardiographic features at the time of presentation, making them appropriate for consideration for acute reperfusion: they presented directly to the index hospital within 12 hours of symptom onset with ST-segment elevation of at least 1 mm in at least 2 contiguous leads or left bundle branch block. For the purpose of this analysis, receipt of thrombolytic drugs within 30 minutes and PTCA within 90 minutes were considered quality benchmarks. This method has been previously validated and forms the basis for the CMS and Joint Commission on Accreditation of Healthcare Organization performance measures for AMI.30 Finally, we calculated an opportunity-based composite quality score combining all 7 process-of-care indicators for each patient. The denominator of the score is composed of the number of those treatments for which a patient is eligible (or opportunities to treat), and the numerator is composed of the number of those treatments that the patient received.

PHYSICIAN AND HOSPITAL CHARACTERISTICS

We classified the physicians’ specialties on the basis of the attending physician listed in Medicare Part A claims. Each physician’s specialty was identified by linking his or her unique physician identification number with a directory of physician-reported specialties identified by the American Medical Association Physician Masterfile.31(pp1481-1482) The attending physician is regarded as “the clinician who is primarily and largely responsible for the care of the patients from the beginning of the hospital episode.” In preliminary work, we were able to merge 99% of the physicians with the American Medical Association Physician Masterfile.31 The hospital-level characteristics, including size, capability of providing invasive cardiac services, teaching status, and ownership, were obtained from the American Hospital Association annual hospital survey database.32

STATISTICAL ANALYSIS

Descriptive statistics were performed for baseline demographic and clinical characteristics, treatments, procedures, and hospital characteristics. Comparison of the characteristics and differ-
coronary angioplasty.

We then evaluated use of aspirin and β-blockers within 24 hours of hospital arrival; thrombolysis within 30 minutes of hospital arrival; PTCA within 90 minutes of hospital arrival; and β-blockers, aspirin, and ACE inhibitors on discharge among the cohort of ideal patients for whom it was appropriate to prescribe these medications and excluding patients with substantial contraindications to these therapies across the 3 diagnostic groups.

A sequence of multiple logistic regression models was developed to determine the adjusted likelihood of early medication use (aspirin, β-blockers, thrombolysis), hospital discharge medication (aspirin, β-blockers, ACE inhibitors), and early reperfusion or thrombolysis in the CK-MB–only patients or troponin/CK-MB patients, compared with troponin–only patients. Independent variables included in the models were demographics (age, race, and sex), attending physician characteristics, and hospital characteristics. In each model, standard errors were adjusted for patients clustering within hospitals by using the Huber-White sandwich estimator of variance method. Because the rates for most quality performances were high in our study, the odds ratio estimated by logistic regression models could have overestimated the effect size; therefore, we converted the odds ratio to relative risk using the method described by Zhang and Yu.

All statistical analyses were performed using Stata statistical software (version 8.0; StataCorp LP, College Station, Texas).

**BASELINE CHARACTERISTICS AND IN-HOSPITAL MORTALITY**

There were considerable differences in patient demographics between the groups not tested for troponin vs those tested, and those tested for CK-MB vs those not tested. However, the differences were not consistently significant. The most important differences were that rates of receipt of all reperfusion therapies were highest in troponin–only patients and lowest in CK-MB patients. The rate of receipt of aspirin was highest in troponin–only patients and lowest in CK-MB patients. The rate of receipt of β-blockers was highest in troponin–only patients and lowest in CK-MB patients. The rate of receipt of triple therapy was highest in troponin–only patients and lowest in CK-MB patients.

**RESULTS**

### BASELINE CHARACTERISTICS AND IN-HOSPITAL MORTALITY

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tested. In the group not tested for troponin vs those tested, the mean ages were 74.9 and 77.6 years, respectively (P < .001). For groups not tested for CK-MB vs those tested, the mean ages were 74.7 and 77.3 years (P < .001), respectively. The proportion of women was slightly higher in the group not tested for troponin vs the tested group (49.1% vs 47.8%, P = .12) but was statistically significantly lower in the group not tested for CK-MB vs the tested group (46.1% vs 48.9%, P = .01).

In the study cohort of interest, composed of 33,096 patients tested for both CK-MB and troponin, the mean age was 77.6 years (Table 2). Most of the patients were
white, and men and women were equally represented. Comorbid conditions were quite common, as shown in Table 2. Troponin-only patients were slightly older and had higher rates of comorbidities than the other 2 groups (Table 2). Furthermore, they were less likely to receive care from an attending cardiologist but more likely to be admitted to a teaching hospital compared with troponin/CK-MB patients or CK-MB–only patients. The crude inhospital mortality rate was highest for troponin-only patients, followed by troponin/CK-MB patients, and lowest for CK-MB–only patients (14%, 12%, and 10%, respectively; \( P < .001 \)).

### QUALITY OF CARE

Among ideal candidates, guideline-based therapy use was suboptimal across all patients irrespective of biomarker status; however, older troponin-only patients were less likely to receive standard guideline-based therapies compared with CK-MB–only patients or troponin/CK-MB patients (Table 3). Troponin-only patients were substantially less likely to receive aspirin and \( \beta \)-blockers during the first 24 hours after presentation compared with the other 2 groups. Similarly, troponin-only patients were less likely to undergo PTCA within 90 minutes of hospital arrival compared with the other 2 groups, although there were no differences in receipt of thrombolytic therapy within 30 minutes of hospital arrival among the 3 groups.

Among patients considered ideal to receive therapy on discharge, substantial differences were found in the use of guideline-based discharge therapies, according to biomarker status. Older troponin-only patients were consistently less likely to receive discharge aspirin and \( \beta \)-blockers compared with the other 2 groups, although there was no difference with respect to prescribing of ACE inhibitors.

In the multiple logistic regression model, after adjusting for patient characteristics, physician specialty, and hospital characteristics, CK-MB–only patients were more likely to receive aspirin and \( \beta \)-blockers within 24 hours of hospital arrival and aspirin on discharge than troponin-only patients (Table 4). Similarly, troponin/CK-MB patients were more likely to receive aspirin and \( \beta \)-blockers within 24 hours of hospital arrival and on discharge compared with troponin-only patients (Table 3). The results did not substantially differ after stratification by age.

The opportunity-based composite score demonstrated that compared with the troponin-only group, troponin/CK-MB patients had a higher likelihood of receiving treatment (Table 3).

### COMMENT

To our knowledge, this is the first study to assess the impact of troponin status on guideline-based management of older patients with AMI in a nationwide sample. We have found that overall adherence to guidelines was suboptimal for older patients with AMI irrespective of biomarker status, but older troponin-only patients were less likely to receive standard post-AMI therapies compared with the other 2 groups. Whether during hospital arrival or on discharge, older troponin-only patients were less likely to receive aspirin or \( \beta \)-blockers compared with CK-MB–only patients or troponin/CK-MB patients. These differences in quality of care persisted, even after adjusting for demographics, physician specialties, and hospital characteristics. Our findings demonstrate a considerable treatment gap in the care of this high-risk group.

Our study has important clinical as well as public health implications. Growing evidence demonstrates that elevations of troponin are associated with worse clinical outcomes across the spectrum of acute coronary syn-

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**Table 3. Quality Performance Rates by AMI Confirmation for All Ideal Patients**

<table>
<thead>
<tr>
<th>Quality Measure</th>
<th>Ideal Cohort, No.</th>
<th>Overall Quality Performance Rate</th>
<th>Rate for Troponin-Only Group</th>
<th>Rate for CK-MB–Only Group</th>
<th>Rate for Troponin/CK-MB Group</th>
<th>( P ) Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Admission therapy</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Aspirin within 24 h of arrival</td>
<td>16,219</td>
<td>84.5</td>
<td>77.8</td>
<td>85.5</td>
<td>86.0</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>( \beta )-Blocker within 24 h of arrival</td>
<td>8175</td>
<td>65.9</td>
<td>59.4</td>
<td>67.4</td>
<td>67.1</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>PTCA performed within 90 min of arrival</td>
<td>1136</td>
<td>12.0</td>
<td>4.0</td>
<td>16.6</td>
<td>10.8</td>
<td>&lt;.01</td>
</tr>
<tr>
<td>Thrombolysis within 30 min of arrival</td>
<td>1136</td>
<td>19.2</td>
<td>14.0</td>
<td>16.6</td>
<td>20.4</td>
<td>.24</td>
</tr>
<tr>
<td>Discharge therapy</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Aspirin</td>
<td>11,075</td>
<td>85.1</td>
<td>81.0</td>
<td>85.4</td>
<td>86.0</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>( \beta )-Blocker</td>
<td>3483</td>
<td>75.1</td>
<td>69.2</td>
<td>74.3</td>
<td>76.8</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>ACE inhibitor</td>
<td>4183</td>
<td>72.8</td>
<td>72.5</td>
<td>73.9</td>
<td>72.7</td>
<td>.86</td>
</tr>
<tr>
<td>Aggregated therapy</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Composite score</td>
<td>45,407</td>
<td>76.3</td>
<td>73.3</td>
<td>74.3</td>
<td>77.3</td>
<td>&lt;.001</td>
</tr>
</tbody>
</table>

Abbreviations: ACE, angiotensin-converting enzyme; AMI, acute myocardial infarction; CK-MB, creatine kinase–myocardial band; PTCA, percutaneous transluminal coronary angioplasty.

a Ideal patients are those with no contraindications to treatment. Data are given as percentages except where indicated.

b Those whose findings were positive for troponin only.

c Those whose findings were positive for CK-MB only.

d Those whose findings were positive for troponin and CK-MB.

e For description of the composite score, see the “Quality Measures” subsection in the “Methods” section.

f Total number of opportunities for the composite score.
were highest among troponin/CK-MB patients (12.7%). In multivariate models, 6-month case fatality rates for troponin levels, even without elevation of CK or CK-MB levels, were slightly higher in patients with negative findings for troponin and CK and CK-MB–only patients. In the large, multinational prospective Global Registry of Acute Coronary Events, hospital case fatality rates were lowest among patients with negative findings for troponin and CK and slightly higher in patients with negative findings for troponin and CK-MB. In contrast, case fatality rates were at least 2-fold among patients with elevated cardiac troponin levels, even without elevation of CK or CK-MB levels. In multivariate models, 6-month case fatality rates were highest among troponin/CK-MB patients (12.7%), followed by troponin-only patients (8.4%, P = .001). Patients with findings that were negative for troponin but positive for CK-MB (5.8%) and those with findings that were negative for both troponin and CK-MB (5.3%) had similar 6-month mortality rates.22

Furthermore, the CRUSADE (Can Rapid Risk Stratification of Unstable Angina Patients Suppress Adverse Outcomes) investigators have shown that any degree of troponin elevation, regardless of CK-MB levels, is associated with a higher risk of mortality for patients with MI, but guideline-recommended medical therapies are used more commonly only in patients with intermediate and major troponin elevations.43 Interestingly, patients with minor troponin elevations were treated no more aggressively than patients with troponin levels below the reference limit.

Consistent with these results and extending them to a nationally representative sample of older patients with MI, we demonstrate that older troponin-only patients were less likely to receive standard post-AMI therapies compared with the other 2 groups. This may be due, in part, to the perception that these “infarctlets” or enzyme “leaks” were of less clinical importance than transmural infarction.44 In addition, most of these high-risk patients in US hospitals are cared for by noncardiologists,45 who may apply guideline-recommended therapies and interventions less frequently than cardiologists.46 Although differences in the use of evidence-based therapies persisted after adjusting for physician specialty, there is a continued need to promote practice guideline recommendations among all specialties that may care for troponin-only patients.

This study has several limitations that warrant discussion. First, the data used in this study were obtained using retrospective medical record review and thus reflect only health care that was documented. Furthermore, although we have paid considerable attention to assessing and improving the reliability of the medical chart abstraction, this process is not as reliable as prospective data collection in the context of a clinical trial. Although the data collected for each patient are extensive, unmeasured differences among patients may have caused confounding of the results. Second, we measured only a subset of AMI care and excluded the substantial number of patients transferred to or from the hospital of interest. In addition, we excluded large numbers of troponin-only patients for whom CK-MB had not been obtained, which might have introduced substantial selection bias. Third, serial troponin results were not recorded, so we could not ascertain how the exact timing of troponin elevation affected care delivery. However, evidence-based therapies were suboptimal even on discharge. Fourth, patients with a primary discharge diagnosis of AMI were included in the study sample, but those patients with a secondary discharge diagnosis of AMI were not. In addition, findings from electrocardiograms were not used to confirm the diagnosis of AMI, which may have led to some misclassification of the study sample and possible differences in treatment practices either in conjunction with, or separate from, the cardiac enzyme findings. Finally, consensus guidelines from the American College of Cardiology and the American Heart Association47 were

Table 4. Logistic Regression Models Evaluating the Quality of Care

<table>
<thead>
<tr>
<th>Model</th>
<th>CK-MB-Only Group</th>
<th>Troponin/CK-MB Group</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unadjusted</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Aspirin within 24 h of arrival</td>
<td>1.53 (1.35-1.72)</td>
<td>1.58 (1.45-1.72)</td>
</tr>
<tr>
<td>Aspirin on discharge</td>
<td>1.31 (1.11-1.53)</td>
<td>1.36 (1.22-1.52)</td>
</tr>
<tr>
<td>β-Blocker within 24 h of arrival</td>
<td>1.24 (1.11-1.37)</td>
<td>1.23 (1.14-1.33)</td>
</tr>
<tr>
<td>β-Blocker on discharge</td>
<td>1.20 (0.97-1.45)</td>
<td>1.33 (1.15-1.52)</td>
</tr>
<tr>
<td>ACE inhibitor on discharge</td>
<td>1.05 (0.86-1.27)</td>
<td>1.01 (0.86-1.15)</td>
</tr>
<tr>
<td>Thrombolysis within 30 min of arrival</td>
<td>1.03 (0.87-1.22)</td>
<td>1.08 (0.92-1.17)</td>
</tr>
<tr>
<td>PTCA performed within 90 min of arrival</td>
<td>1.15 (1.02-1.19)</td>
<td>1.08 (0.97-1.11)</td>
</tr>
<tr>
<td>Composite score</td>
<td>1.04 (0.97-1.11)</td>
<td>1.18 (1.12-1.24)</td>
</tr>
<tr>
<td>Adjusted for demographics</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Aspirin within 24 h of arrival</td>
<td>1.50 (1.32-1.69)</td>
<td>1.58 (1.45-1.72)</td>
</tr>
<tr>
<td>Aspirin on discharge</td>
<td>1.28 (1.08-1.51)</td>
<td>1.36 (1.21-1.52)</td>
</tr>
<tr>
<td>β-Blocker within 24 h of arrival</td>
<td>1.23 (1.10-1.36)</td>
<td>1.22 (1.13-1.32)</td>
</tr>
<tr>
<td>β-Blocker on discharge</td>
<td>1.20 (0.97-1.46)</td>
<td>1.33 (1.15-1.52)</td>
</tr>
<tr>
<td>ACE inhibitor on discharge</td>
<td>1.07 (0.89-1.29)</td>
<td>1.02 (0.89-1.16)</td>
</tr>
<tr>
<td>Thrombolysis within 30 min of arrival</td>
<td>1.03 (0.87-1.12)</td>
<td>1.08 (0.92-1.18)</td>
</tr>
<tr>
<td>PTCA performed within 90 min of arrival</td>
<td>1.15 (1.03-1.19)</td>
<td>1.08 (0.98-1.11)</td>
</tr>
<tr>
<td>Composite score</td>
<td>1.04 (0.97-1.10)</td>
<td>1.18 (1.12-1.24)</td>
</tr>
<tr>
<td>Adjusted for demographic, hospital characteristics, and physician specialty</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Aspirin within 24 h of arrival</td>
<td>1.46 (1.28-1.65)</td>
<td>1.55 (1.42-1.69)</td>
</tr>
<tr>
<td>Aspirin on discharge</td>
<td>1.27 (1.08-1.49)</td>
<td>1.31 (1.17-1.46)</td>
</tr>
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<td>1.07 (0.96-1.11)</td>
</tr>
<tr>
<td>Composite score</td>
<td>1.02 (0.96-1.09)</td>
<td>1.17 (1.11-1.23)</td>
</tr>
</tbody>
</table>

Abbreviations: ACE, angiotensin-converting enzyme; CI, confidence interval; CK-MB, creatine-kinase myocardial band; PTCA, percutaneous transluminal coronary angioplasty; RR, risk ratio.

aThe group whose findings were positive for troponin only was the reference group. The RR was converted from the odds ratio using the approximation method described by Zhang and Yu.46

bStandard errors adjusted for clustering on hospitals. For a description of the composite score, see the “Quality Measures” subsection in the “Methods” section.

cThose whose findings were positive for CK-MB only.

dThose whose findings were positive for troponin and CK-MB.

d7,35-41 Similarly, several studies have shown that the prognosis of troponin-only patients is worse than that of CK-MB–only patients.22,39,42 In the large, multinational prospective Global Registry of Acute Coronary Events, hospital case fatality rates were lowest among patients with negative findings for troponin and CK and slightly higher in patients with negative findings for troponin and CK-MB. In contrast, case fatality rates were at least 2-fold among patients with elevated cardiac troponin levels, even without elevation of CK or CK-MB levels. In multivariate models, 6-month case fatality rates were highest among troponin/CK-MB patients (12.7%), followed by troponin-only patients (8.4%, P = .001). Patients with findings that were negative for troponin but positive for CK-MB (5.8%) and those with findings that were negative for both troponin and CK-MB (5.3%) had similar 6-month mortality rates.22

Furthermore, the CRUSADE (Can Rapid Risk Stratification of Unstable Angina Patients Suppress Adverse Outcomes) investigators have shown that any degree of troponin elevation, regardless of CK-MB levels, is associated with a higher risk of mortality for patients with MI, but guideline-recommended medical therapies are used more commonly only in patients with intermediate and major troponin elevations.43 Interestingly, patients with minor troponin elevations were treated no more aggressively than patients with troponin levels below the reference limit.

Consistent with these results and extending them to a nationally representative sample of older patients with MI, we demonstrate that older troponin-only patients were less likely to receive standard post-AMI therapies compared with the other 2 groups. This may be due, in part, to the perception that these “infarctlets” or enzyme “leaks” were of less clinical importance than transmural infarction.44 In addition, most of these high-risk patients in US hospitals are cared for by noncardiologists,45 who may apply guideline-recommended therapies and interventions less frequently than cardiologists.46 Although differences in the use of evidence-based therapies persisted after adjusting for physician specialty, there is a continued need to promote practice guideline recommendations among all specialties that may care for troponin-only patients.

This study has several limitations that warrant discussion. First, the data used in this study were obtained using retrospective medical record review and thus reflect only health care that was documented. Furthermore, although we have paid considerable attention to assessing and improving the reliability of the medical chart abstraction, this process is not as reliable as prospective data collection in the context of a clinical trial. Although the data collected for each patient are extensive, unmeasured differences among patients may have caused confounding of the results. Second, we measured only a subset of AMI care and excluded the substantial number of patients transferred to or from the hospital of interest. In addition, we excluded large numbers of troponin-only patients for whom CK-MB had not been obtained, which might have introduced substantial selection bias. Third, serial troponin results were not recorded, so we could not ascertain how the exact timing of troponin elevation affected care delivery. However, evidence-based therapies were suboptimal even on discharge. Fourth, patients with a primary discharge diagnosis of AMI were included in the study sample, but those patients with a secondary discharge diagnosis of AMI were not. In addition, findings from electrocardiograms were not used to confirm the diagnosis of AMI, which may have led to some misclassification of the study sample and possible differences in treatment practices either in conjunction with, or separate from, the cardiac enzyme findings. Finally, consensus guidelines from the American College of Cardiology and the American Heart Association47 were
published after the collection of our initial cohort sample, so it is likely that care of troponin-only patients has improved and our results may not reflect current practice. Despite this, given the considerable differences in care, these results warrant further investigation.

Despite these limitations, this study has substantial strengths. To our knowledge, no other national sample available to date has this level of detail with respect to troponin testing and guideline-based therapy in older persons with AMI. This national cohort is unique in that it reflects an older group of patients not typically included in randomized clinical trials and, as such, has the power to provide insights into care and outcomes for this large population of patients seen in daily clinical practice. Furthermore, our data suggest an area of potential public concern and the need for further educational interventions.

In conclusion, in this national sample of older patients hospitalized with AMI, we demonstrate that in a cohort of patients in which both CK-MB and troponin were tested, the diagnoses of 17.8% of patients with AMI were confirmed based solely on a positive finding for troponin. Unfortunately, these troponin-only patients are less likely to receive proven, effective therapies for the treatment of AMI, including aspirin and β-blockers, both in the hospital and on discharge, even when considered ideal to receive these therapies. Therefore, national efforts should focus on improving the quality of health care to this high-risk cohort of patients with AMI.

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