ORIGINAL ARTICLE

Cardiac Troponin and Outcome in Acute Heart Failure

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ABSTRACT

BACKGROUND

Cardiac troponin provides diagnostic and prognostic information in acute coronary syndromes, but its role in acute decompensated heart failure is unclear. The purpose of our study was to describe the association between elevated cardiac troponin levels and adverse events in hospitalized patients with acute decompensated heart failure.

METHODS

We analyzed hospitalizations for acute decompensated heart failure between October 2001 and January 2004 that were recorded in the Acute Decompensated Heart Failure National Registry (ADHERE). Entry criteria included a troponin level that was obtained at the time of hospitalization in patients with a serum creatinine level of less than 2.0 mg per deciliter (177 μmol per liter). A positive troponin test was defined as a cardiac troponin I level of 1.0 μg per liter or higher or a cardiac troponin T level of 0.1 μg per liter or higher.

RESULTS

Troponin was measured at the time of admission in 84,872 of 105,388 patients (80.5%) who were hospitalized for acute decompensated heart failure. Of these patients, 67,924 had a creatinine level of less than 2.0 mg per deciliter. Cardiac troponin I was measured in 61,379 patients, and cardiac troponin T in 7880 patients (both proteins were measured in 1335 patients). Overall, 4240 patients (6.2%) were positive for troponin. Patients who were positive for troponin had lower systolic blood pressure on admission, a lower ejection fraction, and higher in-hospital mortality (8.0% vs. 2.7%, P<0.001) than those who were negative for troponin. The adjusted odds ratio for death in the group of patients with a positive troponin test was 2.55 (95% confidence interval, 2.24 to 2.89; P<0.001 by the Wald test).

CONCLUSIONS

In patients with acute decompensated heart failure, a positive cardiac troponin test is associated with higher in-hospital mortality, independently of other predictive variables. (ClinicalTrials.gov number, NCT00366639.)

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The United States is in the midst of a heart failure epidemic. More than 1 million hospitalizations in 2007 were for heart failure, and the Centers for Medicaid and Medicare Services currently spends more on the diagnosis and treatment of this condition than on any other medical condition.[1] Most patients with heart failure are admitted to the hospital from the emergency department, where a comprehensive evaluation is required to determine the precipitating cause of the condition. Unfortunately, the definition of a comprehensive evaluation has not been established. Since coronary artery disease is the most common cause of heart failure in the United States, it is appropriate to evaluate patients with heart failure for myocardial ischemia. Initial evaluation of patients who present with heart failure often includes a focused history, physical examination, electrocardiogram, and measurement of biomarkers. Although this approach is well validated for the evaluation of acute coronary syndromes, except for specific laboratory-based investigations, an objective risk-stratification process for the evaluation of acute decompensated heart failure is lacking.

The value of measuring serum cardiac troponin when a patient presents with acute decompensated heart failure remains uncertain. Although several limited analyses suggest that an increase in serum cardiac troponin levels is associated with adverse long-term outcomes,[2-5] the short-term implications are less clearly defined. Some small trials involving patients with heart failure have shown that increases in troponin levels, even in the absence of chest pain or an acute coronary syndrome, correlate with a poor prognosis[5-7] and that detectable troponin, at any level, is associated with impaired hemodynamics, a progressive decline in left ventricular systolic function, and shortened survival.[5-8] We conducted a large study to describe short-term outcomes associated with elevated troponin levels on admission in hospitalized patients with acute decompensated heart failure.

Methods

Registry Data

With the use of data from the Acute Decompensated Heart Failure National Registry (ADHERE), we analyzed outcomes associated with elevated troponin levels in patients with acute decompensated heart failure. The methods and design of ADHERE have been published previously.[9] Briefly, ADHERE is an observational registry of individual hospital episodes, from initial presentation through discharge, involving patients with an ultimate discharge diagnosis of acute decompensated heart failure. We examined records from 274 hospitals, from October 2001 through January 2004. Inclusion criteria were hospitalization and documentation of the measurement of cardiac troponin I or cardiac troponin T at the initial evaluation (defined as within 24 hours after admission). Because renal dysfunction may influence cardiac troponin concentrations, patients with a serum creatinine level higher than 2.0 mg per deciliter (176.8 μmol per liter) were excluded from the study. Ischemic heart failure was defined as the cause of the acute decompensated heart failure if the patient reported a history of coronary artery disease or myocardial infarction. Race or ethnic group was self-reported.

Troponin Measurements

We chose to pool cardiac troponin I and cardiac troponin T measurements, first, because an elevated value for either one is consistent with an acute coronary syndrome, and second, because they are used interchangeably in clinical practice and often in a qualitative fashion (as positive or negative for troponin), especially during the initial evaluation (the period examined in this analysis). Since these molecules are treated identically for all other conditions in the clinical setting, we chose to treat them identically in this investigation of acute decompensated heart failure.

ADHERE collected assay data but did not control for the assay platform. Measurement of cardiac troponin T is performed on a uniform platform in the United States, and the cutoff point of 0.1 μg per liter or higher for detection of a myocardial infarction has been defined by the manufacturer and derived from a receiver-operating-characteristic (ROC) curve. Because troponin I has different cutoff points that are dependent on the platform used (more than a dozen different assays), a predefined cutoff point was set at 1.0 μg per liter or higher. This cutoff point was based on expert consensus, approximating values defined from a ROC curve that was optimized for the detection of myocardial infarction. Qualitative tests were considered to be positive if they were recorded as such.

STATISTICAL ANALYSIS

The primary outcome was in-hospital mortality from all causes, and the secondary outcomes included differences in medical management, procedures, and length of stay between the troponin-positive and troponin-negative cohorts. All outcomes were specified before the data were examined. We also examined associations between therapy and mortality, controlling for troponin in patients who received inotropes or vasodilators, but not both.

Analysis of variance, Wilcoxon rank-sum tests, or chi-square tests were used for univariate analyses. All reported P values are two-sided. Because of anticipated differences between troponin-positive and troponin-negative groups with respect to medical history and clinical characteristics at presentation, mortality was adjusted for relevant prognostic factors. Of 80 variables collected in ADHERE, the most important predictors of in-hospital mortality have been previously identified by classification-and-regression-tree (CART) analysis and logistic-regression models.[10] For this analysis, mortality according to troponin group was compared by logistic regression adjusted for age, blood urea nitrogen, systolic blood pressure, diastolic blood pressure, serum creatinine, serum sodium, heart rate, and dyspnea at rest. Overall, 1.2% of the records were excluded because of missing values. Since there was little variation in the rate of measurement of troponin by center, hospital type, or region, hierarchical analysis was not performed. Analyses were performed with the use of SAS software, version 8.2 (SAS Institute).

The study was designed by all the authors; the data were gathered by the 274 hospitals that participated in ADHERE, and the statistical analysis was performed by ADHERE statisticians.

RESULTS

TROPONIN LEVELS AND CHARACTERISTICS OF THE PATIENTS

Troponin levels were measured at the time of admission in 84,872 of 105,388 hospitalized patients (80.5%), with 67,924 patients meeting all inclusion and exclusion criteria. Overall, 4240 patients (6.2%) were positive for troponin on admission. Characteristics of the patients according to whether they were positive or negative for troponin are summarized in Table 1. There were small but significant differences between the two troponin cohorts. On admission, troponin-positive patients had lower systolic blood pressure and lower ejection fractions but were less likely to have atrial fibrillation.

Cardiac troponin I was measured in 61,379 patients (90.4%), and cardiac troponin T in 7880 patients (11.6%). The values were positive in 3253 patients (5.3%) and 1035 patients (13.1%), respectively. Both markers were measured in 1335 patients (2.0%); of these, 48 patients were positive for both, 1059 were negative for both, 71 were positive for cardiac troponin I only, and 157 were positive for cardiac troponin T only. For this analysis, if either marker was above the defined cutoff point, the patient was considered to be troponin-positive. Since both cardiac troponin I and cardiac troponin T were measured in only 2% of patients, no comparison between these proteins was made.

IN-HOSPITAL MORTALITY

Overall, troponin-positive patients had a higher rate of in-hospital mortality than troponin-negative patients (8.0% vs. 2.7%, P<0.001). Actuarial analysis showed that within 1 day after admission, in-hospital mortality was higher for troponin-positive than for troponin-negative patients (Fig. 1). When the troponin level was examined as a continuous variable, higher values were also associated with higher mortality. The adjusted odds ratio for death among patients with a positive troponin test was 2.55 (95% confidence interval [CI], 2.24 to 2.89; P<0.001). Increased mortality was observed with elevations in either cardiac troponin T or cardiac troponin I.

Mortality according to quartiles of cardiac troponin T and cardiac troponin I levels is shown in Figure 2. For cardiac troponin I, the adjusted odds ratio for death in a comparison of quartile 4 with quartile 1 was 2.33 (95% CI, 1.98 to 2.75; P<0.001). The first two troponin T quartiles were unequal in size because 37% of the records had a value of 0.01 μg per liter. In addition, because qualitative troponin results were not included in the quartile analysis, this cohort was smaller than the total in the study.

Ischemic heart failure, which was reported as the cause of the acute decompensated heart failure in 53% and 52% of troponin-positive and troponin-negative patients, respectively, was not a useful discriminator of troponin status, nor was it predictive of mortality. Among troponin-posi-

tive patients, mortality was 8.4% for those with ischemic heart failure and 7.4% for those without ischemic heart failure; among troponin-negative patients, mortality was 2.8% and 2.6%, respectively, for these groups.

TREATMENT, TROPONIN STATUS, AND MORTALITY

Although the rate of use of diuretics was similar in the troponin-positive and troponin-negative cohorts (Table 1), troponin-positive patients were more likely to be receiving nitroglycerin, inotropic

Table 1. Patient Characteristics and Treatment According to Troponin Status.*

Characteristic	Positive for Troponin (N=4240)	Negative for Troponin (N=63,684)	P Value
Age (yr)	73.3±14.0	72.9±14.0	0.05
Male sex (% of patients)	48	45	<0.001
Race (% of patients)†			
White	73	70	0.27
Black	19	20	
Other	4	4	
Heart failure due to ischemia (% of patients)	53	52	<0.001
Hospitalization for heart failure within the past 6 mo (% of patients)	31	36	<0.001
Medical conditions (% of patients)			
Atrial fibrillation	23	31	<0.001
Coronary artery disease	58	56	0.002
Prior myocardial infarction	37	30	<0.001
Prior coronary artery disease or myocardial infarction	61	58	<0.001
Chronic obstructive pulmonary disease or asthma	29	32	<0.001
Ventricular tachycardia or ventricular fibrillation	7	8	0.03
Diabetes	42	41	0.19
Hypertension	72	73	0.54
Hyperlipidemia	36	34	0.02
Current smoker	16	14	0.001
Peripheral vascular disease	18	16	<0.001
Condition requiring placement of a pacemaker	12	16	<0.001
Initial clinical findings			
Systolic pressure (mm Hg)	141±32	147±32	<0.001
Left ventricular ejection fraction			
Mean (%)	35±16	39±17	<0.001
<40% or moderate or severe (% of patients)	61	51	<0.001
Initial electrocardiogram			
QRS (msec)	111.4±37.4	113.8±41.0	<0.001
QRS >120 msec (% of patients)	29	33	<0.001
Symptoms on presentation (% of patients)			
Dyspnea	87	91	<0.001
Edema	60	66	<0.001
Fatigue	30	30	0.76
Pulmonary edema	88	88	0.30
Rales	72	70	0.03

Table 1. (Continued.)

Characteristic	Positive for Troponin (N=4240)	Negative for Troponin (N=63,684)	P Value
In-hospital treatment			
Interval to first diuretic (hr)			
Median	2.4	2.2	<0.001
Interquartile range	1.0–6.8	1.0–5.1	
Diuretics (% of patients)			
Any	91	93	<0.001
Furosemide	88	89	<0.001
Bumetanide	8	7	0.004
Other	3	3	0.12
Interval to first vasoactive agent (hr)			
Median	4.1	4.3	0.746
Interquartile range	1.1–21.3	1.0–19.8	
Inotropes (% of patients)			
Any	18	9	<0.001
Dobutamine	9	5	<0.001
Dopamine	11	5	<0.001
Milrinone	4	2	<0.001
Vasodilators (% of patients)			
Any	28	18	<0.001
Nesiritide	11	9	<0.001
Nitroglycerin	20	10	<0.001
Nitroprusside	2	1	<0.001

* Plus–minus values are means ±SD.
† Race was ascertained from hospital records.

agents, and vasodilators than were troponin-negative patients. There were also differences in resource utilization and mortality according to treatment (Tables 2 and 3 and Fig. 3). However, among troponin-positive patients, mortality, as indicated by the adjusted odds ratio, was independent of treatment. The adjusted odds ratio for the troponin-positive group as compared with the troponin-negative group was 1.84 (95% CI, 1.43 to 2.36) in the subgroup of patients who were treated with inotropic agents and 1.96 (95% CI, 1.37 to 2.81) in the subgroup treated with vasodilators (P<0.001 for both comparisons by the Wald test). Finally, there was no interaction between treatment and troponin status with respect to mortality. The adjusted odds ratio for death among patients receiving inotropic agents as compared with those receiving vasodilators was 4.44 (95% CI, 2.90 to 6.81) for the troponin-positive group and 4.54 (95% CI, 3.75 to 5.49) for the troponin-negative group (P<0.001 for both comparisons by the Wald test).

DISCUSSION

In our data set, which included data from 105,388 patients, troponin was measured in 80.5% of the hospitalized patients with acute decompensated heart failure as a part of their routine care. Of these patients, 6.2% were found to be positive for troponin, including those with and those without a history of coronary artery disease or myocardial infarction. Like patients presenting with an acute coronary syndrome, patients presenting with acute decompensated heart failure and a positive troponin status were found to be a high-risk cohort. Patients in this cohort, as compared with those who were negative for troponin, required more cardiac procedures and longer hospitalization and had a higher risk of in-hospital death, even after adjustment for other risk factors. These results suggest that measurement of troponin adds important prognostic information to the initial evaluation of patients with acute decompen-

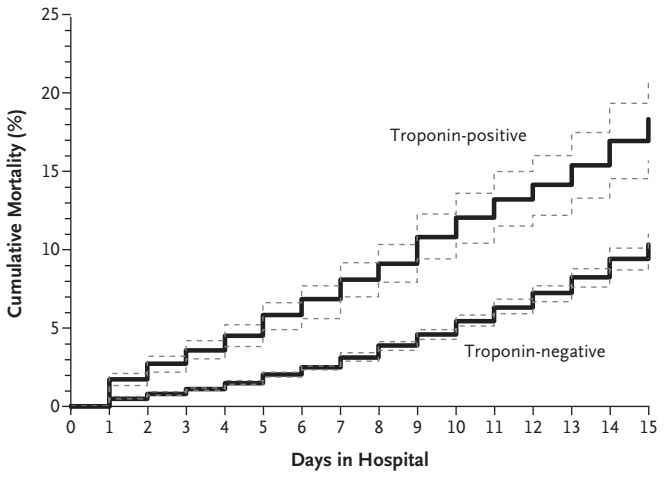

Figure 1. Mortality According to Number of Days in the Hospital and Troponin Status at Presentation.

P<0.001 by the log-rank test. Dashed lines show 95% confidence intervals.

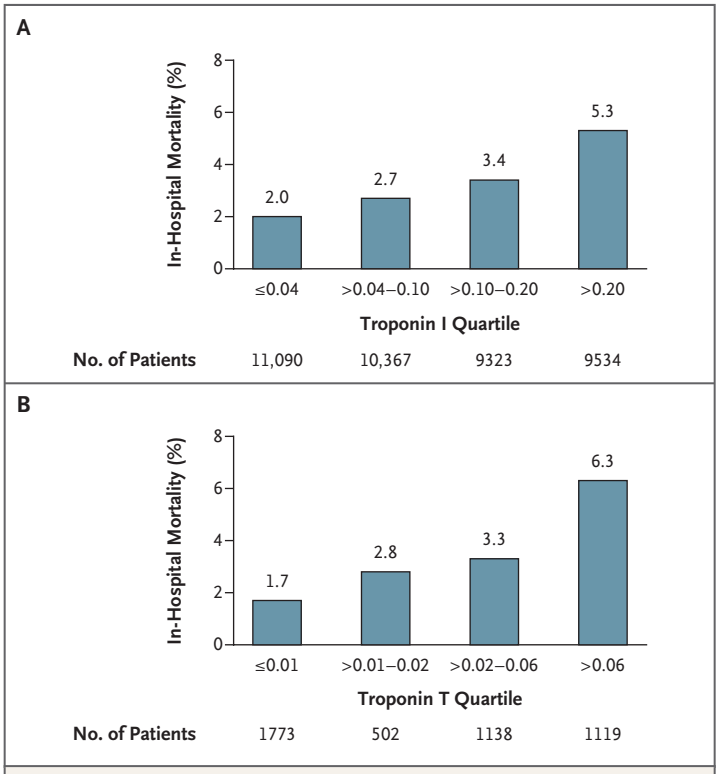

Figure 2. In-Hospital Mortality According to Troponin I or Troponin T Quartile.

P<0.001 by the chi-square test for all comparisons.

sated heart failure and should be considered as part of an early assessment of risk.

Since patients who are positive for troponin have a disproportionately high mortality, an association that is independent of other well-validated risk factors for acute decompensated heart failure, the results of troponin tests should be factored into decisions that are made with respect to triage and management. Although we did not study differential management, in our opinion, patients with an increased risk of death should undergo more intensive cardiovascular monitoring; they may require admission to a critical care unit or cardiac telemetry. Our findings add to the existing risk-stratification data for predicting the short-term risk of death among patients with acute decompensated heart failure. Patients with an initial blood urea nitrogen level of more than 43 mg per deciliter (15.4 mmol per liter), systolic blood pressure of less than 115 mm Hg, or a creatinine level of more than 2.75 mg per deciliter (243.1 μmol per liter) have high short-term mortality, exceeding 22% if all three factors are present.[10] Since these mortality rates are higher than those that are associated with most episodes of acute myocardial infarction, a more aggressive therapeutic approach is justified. A positive troponin status adds incremental prognostic information to that obtained from vital signs and other laboratory data.

Conversely, we found that a negative troponin status was associated with a short-term mortality rate that was nearly two thirds lower than the rate with a positive troponin level. Although the absence of high-risk predictors does not equate with low risk, the absence of detectable troponin may be helpful in planning treatment. When considered in the context of other predictors of low risk, a negative troponin test may aid in the identification of patients for whom less intense monitoring and therapy are appropriate. Few studies have examined predictors of low risk in patients with acute decompensated heart failure. In a study of patients with acute decompensated heart failure who were in an emergency department observation unit,[11] a blood urea nitrogen level of less than 30 mg per deciliter (10.7 mmol per liter) was associated with successful treatment in a short-stay unit. Another analysis showed that an elevated blood pressure (>160 mm Hg) or a nega-

Table 2. Resource Utilization According to Troponin Status.*

Resource	Positive for Troponin (N=4240)	Negative for Troponin (N=63,684)	P Value	Odds Ratio (95% CI)
Intensive care unit				
Any time — no. (%)	1565 (37)	10,493 (16)	<0.001	
Median days (IQR)	2.9 (1.6–5.0)	2.3 (1.2–4.1)	<0.001	
Adjusted mean days	4.1	3.7	0.007	
Hospital — days				
Median stay (IQR)	5.1 (3.2–8.3)	4.1 (2.8–6.7)	<0.001	
Adjusted mean stay	6.6	5.5	<0.001	
Procedures — no. (%)				
CABG	164 (4)	478 (1)	<0.001	5.46 (4.54–6.57)
IABP	113 (3)	192 (<1)	<0.001	8.03 (6.30–10.2)
Cardiac catheterization	1002 (24)	6383 (10)	<0.001	3.04 (2.81–3.28)
Mechanical ventilation	479 (11)	641 (1)	<0.001	2.68 (2.41–2.99)

* Means were adjusted for age, blood urea nitrogen level, systolic and diastolic blood pressure, creatinine level, sodium level, heart rate, and presence or absence of dyspnea at rest. Odds ratios are for the troponin-positive group as compared with the troponin-negative group and were adjusted for age, blood urea nitrogen level, systolic and diastolic blood pressure, creatinine level, sodium level, heart rate, and presence or absence of dyspnea at rest. CABG denotes coronary-artery bypass graft, IABP intraaortic balloon pump, and IQR interquartile range.

Table 3. In-Hospital Mortality According to Treatment.

Treatment	Positive for Troponin (N=4240)	Negative for Troponin (N=63,684)	P Value	Odds Ratio (95% CI)*
	no./total no. (%)			
Inotropes only				
Any	104/461 (23)	460/3676 (13)	<0.001	1.84 (1.43–2.36)
Dobutamine	39/209 (19)	180/1847 (10)	<0.001	1.96 (1.32–2.91)
Dopamine	85/293 (29)	366/1797 (20)	<0.001	1.49 (1.12–1.99)
Milrinone	24/85 (28)	58/738 (8)	<0.001	4.65 (2.58–8.38)
Vasodilators only				
Any	42/882 (5)	203/9308 (2)	<0.001	1.96 (1.37–2.81)
Nesiritide	14/324 (4)	125/4335 (3)	0.14	1.44 (0.80–2.59)
Nitroglycerin	32/630 (5)	93/5397 (2)	<0.001	2.55 (1.65–3.95)
Nitroprusside	0/28	7/227 (3)	0.35	NA

* Odds ratios are for the troponin-positive group as compared with the troponin-negative group and were adjusted for age, blood urea nitrogen level, systolic and diastolic blood pressure, creatinine level, sodium level, heart rate, and presence or absence of dyspnea at rest. NA denotes not applicable.

tive troponin test was associated with discharge from the hospital within 24 hours and an absence of adverse outcomes within 30 days.[12] These analyses suggest that initial blood pressure, renal function, and troponin status are the most useful risk-stratification data in patients presenting with acute decompensated heart failure.

In the current study, patients who were positive for troponin required longer hospitalization and greater use of resources. Since hospitaliza-

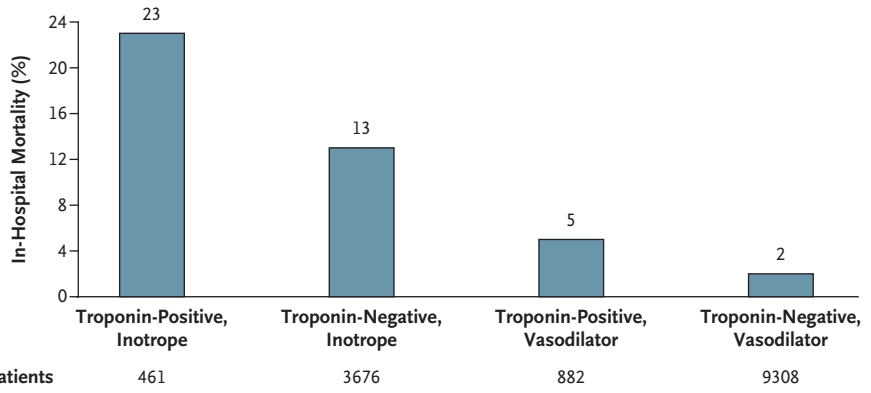

Figure 3. Mortality According to Type of Treatment and Troponin Status.

P<0.001 by the chi-square test for the association between troponin status and mortality within the vasodilator and inotrope groups.

tion and length of stay in an intensive care unit are important determinants of cost, early identification of patients who will require greater resources could allow early implementation of aggressive therapy. The impact of early risk stratification has been supported in other studies of acute decompensated heart failure. In the B-Type Natriuretic Peptide for Acute Shortness of Breath Evaluation (BASEL) trial,[13] simply establishing an early, accurate diagnosis of heart failure decreased both length of stay and costs. Early risk stratification may help identify patients who are likely to receive the greatest benefit from early intensive therapy.

In an analysis of subjects in the Enhanced Feedback for Effective Cardiac Treatment (EFFECT) study, You et al. evaluated cardiac troponin I and mortality in 2025 patients who were hospitalized with heart failure.[14] They reported that levels of cardiac troponin I higher than 0.5 μg per liter, which were present in 34.5% of the patients, were an independent predictor of short-term death, with a dose–response relationship. However, applying these findings to those from centers that used a different assay platform from that used by EFFECT may be problematic. Furthermore, the rate of elevated troponin levels in the EFFECT study is markedly higher than the rate in the current study and in earlier analyses.[15]

Smaller studies of patients with heart failure have shown similar implications of elevated troponin levels with respect to short-term morbidity and mortality. In 98 consecutive patients admitted for worsening heart failure, in-hospital death from cardiac causes occurred in 10 of 45 patients (22%) who had cardiac troponin T levels higher than 0.033 μg per liter, as compared with 4 of 53 (8%) who had lower cardiac troponin T levels (P=0.04).[3] Cardiac troponin T and brain natriuretic peptide, when considered together, identified patients at low risk (3%), intermediate risk (11%), and high risk (31%) for in-hospital death (P=0.006). A study of 159 patients with acute decompensated heart failure showed that 24 patients (15%) had high levels of troponin.[16] Of these patients, 20.8% died during hospitalization or had refractory heart failure, as compared with 3.7% of those with low troponin levels (odds ratio, 6.8; 95% CI, 1.5 to 31.2). Finally, in a subgroup analysis of 133 patients in the Randomized Intravenous TeZosentan 4 (RITZ-4) study, which involved patients with acute decompensated heart failure or an acute coronary syndrome, an elevated cardiac troponin I level before randomization was associated with an increased rate of the composite end point of death, worsening heart failure, recurrent ischemia, or new myocardial infarction within 72 hours (odds ratio, 1.15; 95% CI, 1.01 to 1.32).[17]

In hospitalized patients with acute decompensated heart failure, but without classic signs of acute myocardial infarction, troponin is correlated with several physiological variables.[4,18] In 26 hospitalized patients with heart failure, a significant correlation was found between cardiac troponin T status and the left-ventricular-mass in-

dex.[4] In a study involving 40 hospitalized patients with heart failure,[18] troponin status was correlated with blood pressure and the presence or absence of left ventricular hypertrophy as assessed by electrocardiography. Several hypotheses, including subendocardial ischemia due to a mismatch between myocardial oxygen supply and demand, have been proposed as explanations for these associations, but the mechanisms by which these features cause increases in troponin levels in the absence of an acute coronary syndrome remain uncertain.

An elevation in cardiac troponin can indicate the presence of myocyte injury or death.[19] This model recognizes progressive myocyte loss as a prominent pathophysiological mechanism in the evolution of cardiac dysfunction and acute decompensated heart failure.[20] The pathophysiological factors that that are thought to be responsible for ongoing myocyte injury or cell death include excessive adrenergic stimulation through renin, angiotensin, aldosterone, or endothelin signaling pathways, abnormalities in calcium handling, inflammatory cytokines, nitric oxide, and oxidative and mechanical stress.[6]

National guidelines for the evaluation of an acute coronary syndrome recommend that levels of cardiac troponin and brain natriuretic peptide or N-terminal pro–brain natriuretic peptide be used for prognosis and risk stratification. Current guidelines for the evaluation of heart failure do not mention troponin and recommend the measurement of brain natriuretic peptide only in cases in which the diagnosis is uncertain. Our data suggest that the measurement of troponin levels in patients who present with heart failure provides independent prognostic information regarding in-hospital death and other clinical outcomes and can be useful for risk stratification of such patients.

Our study has several limitations. Since we performed a retrospective analysis of registry data, we cannot establish cause and effect. However, the associations are strong and are consistent with prior analyses of troponin in patients with acute decompensated heart failure. Furthermore, the ADHERE registry is a large data set based on a broad sample of patients with heart failure; thus, the data are not confounded as a result of being based on a prespecified subgroup of patients receiving predefined treatments.

A number of factors could have affected the results of the troponin tests. First, we used the results of various cardiac troponin I assays for which we defined cutoff points, rather than core laboratory results. Since many cardiac troponin I platforms are used in clinical practice, each with a unique cutoff point, our prespecified cutoff point may have introduced variability in assay performance.[21] However, although a single assay platform could increase the strength of the causality association, the generalizability of our data allows the findings to be considered in actual patient-care scenarios. Second, bias may have been introduced because we were unable to analyze those patients with heart failure in whom troponin was not assessed and are unable to determine why physicians obtained, or did not obtain, troponin measurements. Because troponin was measured only at the time of admission to the hospital, we cannot comment on the number of patients with an acute myocardial infarction, since a typical rise and fall of cardiac biomarkers was not recorded. Finally, the prognostic information that can be gained from an analysis of the interaction of troponin with other biomarkers, such as brain natriuretic peptide, was not explored in this study.

Several limitations of the study are a function of the registry itself. Inclusion in ADHERE required a discharge diagnosis of heart failure, with the determination of a nonischemic cause made at the discretion of the investigator. Because the diagnosis was not objectively ascertained, some patients with both heart failure and an acute coronary syndrome may have been included in our analysis. However, when only data from patients who were categorized as having nonischemic heart failure were analyzed, troponin levels retained their prognostic significance. In addition, ADHERE did not consistently report the cause of death, and noncardiac events may have contributed to the mortality rate. However, we expect that the incidence of noncardiac events would be equally distributed between the troponin-positive and troponin-negative groups. Finally, ADHERE recorded only in-hospital outcomes, not deaths after discharge. Consequently, our findings may underrepresent adverse outcomes, with possible prognostic implications, since others have found that mortality at 30 days may exceed in-hospital mortality.[14]

In hospitalized patients with acute decompensated heart failure, a positive troponin test

is associated with more frequent adverse events, including increased in-hospital mortality, independently of treatment and other prognostic variables. Patients with heart failure who were positive for troponin required greater use of hospital resources, including longer stays in the hospital and in the intensive care unit. We have identified a cohort of patients who have an elevated risk of adverse outcomes. Future research that examines therapies to mitigate these outcomes is needed.

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