

Myocardial Infarction

Predicting One-Year Mortality Among Elderly Survivors of Hospitalization for an Acute Myocardial Infarction: Results From the Cooperative Cardiovascular Project

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OBJECTIVES	We sought to develop a model based on information available from the medical record that would accurately stratify elderly patients who survive hospitalization with an acute myocardial infarction (AMI) according to their risk of one-year mortality.
BACKGROUND	Prediction of the risk of mortality among older survivors of an AMI has many uses, yet few studies have determined the prognostic importance of demographic, clinical and functional data that are available on discharge in a population-based sample.
METHODS	In a cohort of patients aged ≥ 65 years who survived hospitalization for a confirmed AMI from 1994 to 1995 at acute care, nongovernmental hospitals in the U.S., we developed a parsimonious model to stratify patients by their risk of one-year mortality.
RESULTS	The study sample of 103,164 patients, with a mean age of 76.8 years, had a one-year mortality of 22%. The factors with the strongest association with mortality were older age, urinary incontinence, assisted mobility, presence of heart failure or cardiomegaly any time before discharge, presence of peripheral vascular disease, body mass index < 20 kg/m ² , renal dysfunction (defined as creatinine > 2.5 mg/dl or blood urea nitrogen > 40 mg/dl) and left ventricular dysfunction (left ventricular ejection fraction $< 40\%$). On the basis of the coefficients in the model, patients were stratified into risk groups ranging from 7% to 49%.
CONCLUSIONS	We demonstrate that a simple risk model can stratify older patients well by their risk of death one year after discharge for AMI. (J Am Coll Cardiol 2001;38:453-9) © 2001 by the American College of Cardiology

Previous studies of prognosis among survivors of acute myocardial infarction (AMI) have not always been relevant

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to older patients, a group that represents the majority of those seen in practice (1). Some studies have focused on

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invasive or noninvasive test results that are not available or appropriate for all patients (2-7). Others have used populations from referral centers or patients who were part of clinical trials or epidemiologic studies from specific geographic regions (8,9). None of the studies have focused specifically on older patients. As a result, little information is available about the prognostic importance of comorbidity in addition to measures of disease severity for elderly patients after AMI.

Accordingly, we sought to study the one-year prognosis of a national sample of older patients who survived hospitalization for an AMI. The objective of this study was to develop a parsimonious model to predict mortality based on information that is available in the medical record. We particularly sought to identify the strongest factors that were independently associated with one-year survival. This study was conducted as part of the Cooperative Cardiovascular Project (CCP), a Health Care Financing Administration initiative to improve the quality of care for Medicare beneficiaries with an AMI.

METHODS

Data sources. The CCP database has been described previously (10). In brief, it includes more than 200,000

Abbreviations and Acronyms

AMI	= acute myocardial infarction
AROC	= area under the receiver operating characteristic
CCP	= Cooperative Cardiovascular Project
GUSTO	= Global Utilization of Streptokinase and tPA for Occluded Coronary Arteries
ICD-9-CM	= International Classification of Diseases, Ninth Revision, Clinical Modification
LVEF	= left ventricular ejection fraction
PREDICT	= Predicting Risk of Death in Cardiac Disease Tool
ROC	= receiver operating characteristic

patients hospitalized across the country with a principal discharge diagnosis of AMI (International Classification of Diseases, Ninth Revision, Clinical Modification [ICD-9-CM] 410) from 1994 to 1995. The Medicare Enrollment Database was the source for the vital status of the Medicare beneficiaries in this study (11).

Study sample. The overall study sample was restricted to patients who were aged ≥ 65 years, who had a confirmed AMI as previously reported (10), who were not received in transfer from another institution or not transferred out to another acute-care hospital and who survived the index hospitalization. To avoid counting patients more than once, we included only a patient's first confirmed AMI hospitalization.

Candidate predictor variables. On the basis of medical literature review and clinical experience, we selected candidate predictor variables that described demographic and clinical characteristics of the patients. These variables are shown in Table 1.

Left ventricular ejection fraction (LVEF) levels were measured using one of the following three methods: radio-nuclide ventriculography, echocardiogram or cardiac catheterization. For patients in whom LVEF was measured using more than one method, we selected one measurement, prioritized in descending order as listed in the preceding text. The LVEF levels were grouped into four categories: $< 20\%$, 20% to 39% , 40% to 54% , and $\geq 55\%$. Qualitative measures of left ventricular function were translated into quantitative measures as follows: normal left ventricular function was assigned a value of $\geq 55\%$, mild or mild-moderate depression 40% to 54% , moderate or moderate-severe depression 20% to 39% and severe depression $< 20\%$.

Missing data and extreme values. In general, missing data were considered characteristics not present for dichotomous or categorical variables. For continuous variables, a dummy variable was created to indicate missing values and was forced in the model when the corresponding variable was being analyzed. To guard against influential observations, we treated implausible recorded values for continuous variables as missing. If the recorded values were outside of the following ranges, we recorded the values as missing: respiratory rate 0 to 80 breaths/min, systolic blood pressure 0 to

300 mm Hg, diastolic blood pressure 0 to 150 mm Hg, serum urea nitrogen 5 to 150 mg/dl, creatinine and highest creatinine 0.1 to 15 mg/dl, albumin 2 to 20 mg/dl, hematocrit 10% to 65%, white blood cell count 3,000 to 50,000 and body mass index 0 to 50 kg/m^2 .

Few missing values ($< 2\%$) occurred in the majority of the candidate predictors. Missing observations exceeded 5% for only the following candidate predictor variables: AMI symptoms within 48 h before admission (15%), time since chest pain started (9%), body mass index (15%), albumin (27%) and LVEF (30%).

Model development. We defined a derivation sample for model development that randomly included half the patients in the study sample. In this derivation set, we evaluated by visual inspection the association of the continuous variables with the outcome to check for assumptions of linearity. We identified cutpoints using clinical judgment and knowledge of these relationships.

We performed iterations of Cox regression models with survival days from discharge as the dependent variable and censored by one-year mortality from discharge, gradually reducing the number of independent predictors. We began with all candidate predictors (except procedures and medications because these factors might be susceptible to intentional manipulation) with their associated dummy variables and a stepwise method with an entry level of $p < 0.0005$ and an exit level of $p > 0.0001$. When variables with missing observations were included in or removed from multivariate models, dummy variables indicating the presence of missing values (yes/no) were also added or removed. In order to identify the most influential variables, the model was further restricted to variables with a Wald chi-square value of > 50 . We created composite variables where related variables with similar odds ratios and clinical information (e.g., blood urea nitrogen > 40 mg/dl and highest creatinine > 2.5 mg/dl) were combined. We then repeated the Cox regression model to select variables with a Wald chi-square value of > 100 . Although this threshold is arbitrary, it allowed for the selection of variables with strong clinical associations to one-year mortality. Finally, we added cardiac procedures/treatments during hospitalization and discharge prescription of aspirin and beta-blockers to the final model to examine the stability of the selected risk predictors.

Model evaluation and validation. To identify potential problematic areas of model fit, we constructed and examined partial residual plots (12) using the derivation sample. We then did the logistic regression analysis (with one-year mortality as the dependent variable and the variables in the derived Cox model as independent variables) to construct the receiver operating characteristic (ROC) curves (13) and to calculate the area under them. In general, an area under the ROC curves (AROC) > 0.75 is considered to have good discriminant ability. We also evaluated the calibration of the model, or the extent to which the predicted probabilities are similar to what is observed, using the Hosmer-Lemeshow chi-square statistic. We repeated this evaluation in the

validation set. Lastly, we stratified patients into 10 groups based on ranking of their predicted mortality, then compared the observed mortality rate and predicted mortality rate among these groups in the validation cohort.

Risk score and risk category. On the basis of the final risk prediction model, we assigned a weight to each risk factor by dividing its coefficient estimate by the smallest coefficient among all of the variables that were estimated in the model. A risk score was then calculated for each patient by multiplying the weight to the presence or absence of the corresponding risk factor. A patient's risk of dying within one year postdischarge was further categorized as low, medium or high according to his/her risk score. The association between risk categories and one-year mortality was assessed with the use of the Cochran-Armitage test for trend in the validation cohort. To determine the generalizability of the identified predictors, we also examined the association of this risk prediction rule with all-cause readmission or death combined and AMI-specific readmission or death combined.

RESULTS

Study sample. Table 2 presents the inclusion and exclusion criteria of the study sample. The final study sample included 103,164 patients and was randomly split to include 51,851 patients in the derivation cohort and 51,313 patients in the validation cohort.

Predictors of one-year mortality. Table 1 presents the bivariate analysis between selected candidate predictors and one-year mortality in the derivation cohort. Among all candidate predictors examined, eight were identified, based on Cox proportional hazard regression models, to be associated with significantly increased risk of one-year mortality and, thus, were included in the final model as shown (Table 3). These factors were older age, urinary incontinence, assisted mobility, presence of heart failure or cardiomegaly any time before discharge, presence of peripheral vascular disease, body mass index <20 kg/m², renal dysfunction (defined as creatinine >2.5 mg/dl or blood urea nitrogen >40 mg/dl) and left ventricular dysfunction (LVEF $<40\%$). Adding aspirin and beta-blocker prescription at discharge and cardiac procedures during hospitalization did not change the predictive significance of these clinical characteristics.

Model performance and model validation. In a logistic regression model with all of the candidate predictors (except the medications and procedures), the AROC was 0.80; in the logistic regression model with selected predictors for the final model, the AROC was 0.77, indicating good model discrimination. Beyond the eight variables that were selected for the model, the next three strongest measures were hypertension (systolic blood pressure >180 mm Hg or diastolic blood pressure >110 mm Hg), dementia and diabetes, with Wald chi-square values of 94, 73 and 63, respectively. If these variables were added to the model, the

AROC increased by 0.004. In the analysis of subgroups without LVEF missing values or without body mass index missing values, the corresponding logistic regression models with the selected predictors in the final model did not change appreciably and still had an AROC of 0.77, indicating good model discrimination.

There was no evidence of a lack of fit of the model. Similar performance of the model was found in the validation cohort. When we stratified patients into 10 groups according to their ranks of predicted mortality rate, the correlation coefficient between the predicted mortality rate and the observed mortality rate among these groups was 0.997, and the test for equality of the predicted mortality rate and the observed mortality rate indicated good correlation ($p = 0.553$).

Risk score and risk category. Based on estimates in the final prediction Cox regression model shown in Table 3, the following weight was assigned to each risk factor: 1—presence of peripheral vascular disease, age 75 to 84 years, body mass index <20 kg/m², urinary incontinence or no urinary output, and walks with assistance; 2—age ≥ 85 years, LVEF 20% to 40%, presence of heart failure or cardiomegaly any time before discharge, renal dysfunction, and inability to walk; 3—LVEF $<20\%$.

A risk score was calculated for each patient. The risk scores ranged from 0 to 13. We further grouped the risk scores into three categories: 0 to 2 (low risk), 3 to 5 (medium risk) and ≥ 6 (high risk). Distribution of the number of patients and percent mortality in each risk category is shown in Table 4 for both the derivation and validation cohorts. About 40% of the cohort was assigned to the low-risk group and 18% to the high-risk group. As expected, there was a strong correlation between a higher risk score and a greater risk of mortality (Cochran-Armitage trend test $p < 0.001$). The distributions and the trends were similar in the derivation and validation cohorts. Patients in the low-risk category had a 7% one-year mortality rate, whereas patients in the high-risk category had a 49% one-year mortality rate. These risk predictors also provide a stratification of risk for mortality and readmission combined, and readmission and mortality from AMI (Table 4).

DISCUSSION

In this study we developed and validated a simple risk model for one-year mortality for older individuals who survived hospitalization for an AMI. The variables are based on clinical information and the results of an assessment of left ventricular systolic function available at discharge. Using this approach, we identified three risk groups with one-year mortality rates ranging from 7% to 49%.

Previous studies. This study has some important contrasts with the recently published study of one-year mortality among the subjects in the Global Utilization of Streptokinase and tPA for Occluded Coronary Arteries (GUSTO) trial who survived 30 days (14). The GUSTO trial, by

Table 1. Bivariate Analysis: Characteristics and One-Year Mortality

Characteristics	Survived (40,624)		Died (11,227)		Chi-Square	p Value
	N	%	N	%		
Demographics						
Age, yrs						
75-84	15,861	39%	4,924	44%	84.9	0.001
≥85	5,495	14%	3,388	30%	1,717.8	0.001
Female	19,874	49%	6,000	53%	71.9	0.001
Non-white	4,195	10%	1,218	11%	2.6	0.109
Medical history						
Angina	18,550	46%	5,099	45%	0.2	0.644
Hypertension	25,449	63%	7,098	63%	1.3	0.263
Diabetes (any type)	11,657	29%	4,167	37%	294.2	0.001
Active ulcer disease	5,463	13%	1,484	13%	0.4	0.527
Bleeding disorder	205	1%	67	1%	1.4	0.232
Internal bleeding	3,226	8%	1,130	10%	51.6	0.001
Bypass surgery	5,248	13%	1,435	13%	0.1	0.702
Heart failure or pulmonary edema	6,844	17%	4,583	41%	2,942.5	0.001
Chronic obstructive pulmonary disease	7,816	19%	2,911	26%	239.8	0.001
Cigarette smoker	6,239	15%	1,352	12%	77.4	0.001
Stroke	5,121	13%	2,321	21%	465.7	0.001
Acute myocardial infarction	12,561	31%	4,448	40%	301.9	0.001
Angioplasty	3,049	8%	551	5%	91.9	0.001
Trauma in last month	1,255	3%	545	5%	81.6	0.001
Functional status at discharge						
Urinary continence						
Incontinent	6,403	8%	5,387	24%	2,352.4	0.001
No urinary output	234	0%	257	1%	110.9	0.001
Mobility						
Walks with assistance	18,569	23%	8,937	40%	1,287.4	0.001
Unable to walk	2,507	3%	2,747	12%	1,515.9	0.001
Dementia/Alzheimer's disease	1,854	5%	1,523	14%	1,170.6	0.001
Clinical presentation and severity variables						
Admission blood pressure (mm Hg)						
SBP <160 and DBP <100	1,859	5%	764	7%	90.1	0.001
(SBP ≥140 or DBP ≥90) and SBP <160 and DBP <100	2	0%		0%	0.6	0.457
(SBP ≥160 or DBP ≥100) and SBP <180 and DBP <110	30,839	76%	8,662	77%	7.5	0.006
SBP ≥180 or DBP ≥110	7,831	19%	1,774	16%	70.4	0.001
Admission heart rate						
<60 beats/min	3,864	10%	526	5%	264.4	0.001
>100 beats/min	8,991	22%	4,273	38%	1,172.2	0.001
Admission respiratory rate >22 breaths/minute	11,990	30%	5,414	48%	1,380.6	0.001
Admission temperature >100.4°	673	2%	333	3%	79.3	0.001
AMI symptoms						
Chest pain before admission	35,414	99%	8,246	99%	60.9	0.001
Chest pain prolonged >6 h	14,260	39%	5,151	52%	555.7	0.001
Angina ≥60 min after arrival	15,412	38%	3,057	27%	439.9	0.001
Hemorrhage (any type)	1,010	2%	473	4%	94.4	0.001
Cardiac arrest	735	2%	232	2%	3.2	0.075
Shock	396	1%	170	2%	23.7	0.001
Gallop rhythm or S3	1,376	3%	741	7%	231.9	0.001
Rales	12,386	30%	5,920	53%	1,904.9	0.001
Heart failure/pulmonary edema	18,432	45%	8,014	71%	2,381.1	0.001
Peripheral vascular disease	3,709	9%	1,734	15%	373.3	0.001
Body mass index						
Missing	5,378	13%	2,465	22%	520.7	0.001
>20 kg/m ²	32,774	81%	7,459	66%	1,025.7	0.001
Initial laboratory results						
Albumin						
Missing	11,115	27%	3,008	27%	1.4	0.231
>3 mg/dl	1,153	3%	680	6%	267.2	0.001
BUN >40 mg/dl or creatinine >2.5 mg/dl	2,323	6%	2,269	20%	1,489.8	0.001
Hematocrit <36%	6,831	17%	3,345	30%	939.4	0.001
Sodium <130 mmol/l	882	2%	413	4%	82.1	0.001
WBC >12,000/cu mm	9,803	24%	4,093	36%	681.2	0.001

Table 1. Continued

Characteristics	Survived (40,624)		Died (11,227)		Chi-Square	p Value
	N	%	N	%		
First electrocardiogram						
LBBB	2,213	5%	1,198	11%	390.5	0.001
Pacemaker rhythm	567	1%	281	3%	67.0	0.001
RBBB	2,758	7%	1,009	9%	63.1	0.001
ST-segment elevation	11,588	29%	2,717	24%	82.3	0.001
Ventricular tachycardia	240	1%	115	1%	24.3	0.001
Atrial fibrillation/flutter	3,312	8%	1,561	14%	341.7	0.001
2nd/3rd degree heart block	464	1%	138	1%	0.6	0.446
Evidence of old myocardial infarction	2,224	5%	780	7%	35.0	0.001
Documented location(s) of myocardial infarction						
Antero/septal	17,870	44%	5,377	48%	54.2	0.001
Subendocardial (non-Q-wave)	16,820	41%	5,197	46%	86.0	0.001
Other	24,495	60%	5,802	52%	269.0	0.001
Hospital events						
Highest creatinine >2.5 mg/dl	2,201	5%	1,848	16%	1,489.8	0.001
Pneumonia	2,876	7%	1,694	15%	702.0	0.001
Decubitus ulcers	677	2%	739	7%	800.2	0.001
Deep vein thrombosis	175	0%	76	1%	11.1	0.001
Cerebrovascular accident	793	2%	472	4%	187.4	0.001
Hypotension	7,157	18%	2,115	19%	8.9	0.003
Bradycardia	14,925	37%	2,816	25%	531.0	0.001
Shock	942	2%	366	3%	31.7	0.001
Re-infarction	1,046	3%	316	3%	2.0	0.160
CHF/pulmonary edema	14,674	36%	7,229	64%	2,880.8	0.001
Re-angina	23,465	58%	5,452	49%	301.8	0.001
Hemorrhage/bleeding (any type)	6,621	16%	2,029	18%	19.9	0.001
Hospital medications						
ACE inhibitor	16,100	40%	5,914	53%	612.7	0.001
Warfarin	7,215	18%	2,198	20%	19.6	0.001
Heparin >4,000 U	28,699	71%	6,300	56%	846.6	0.001
Thrombolytics	7,005	17%	744	7%	780.0	0.001
Aspirin	34,747	86%	8,104	72%	1,092.9	0.001
Beta-blocker	21,421	53%	3,730	33%	1,340.0	0.001
Hospital procedures and tests						
Intubation	1,984	5%	917	8%	179.6	0.001
Cardiac catheterization	17,058	42%	1,634	15%	2,872.0	0.001
PTCA during stay	7,046	17%	490	4%	1,193.0	0.001
CABG during stay	3,663	9%	220	2%	632.4	0.001
LVEF, %						
Missing	11,194	28%	4,293	38%	479.2	0.001
<20	421	1%	370	3%	298.9	0.001
20-39	7,227	18%	3,047	27%	484.0	0.001
40-54	15,006	37%	2,709	24%	641.7	0.001
≥55	6,776	17%	808	7%	633.4	0.001
Medications prescribed at discharge						
ACE inhibitor	13,331	33%	4,664	42%	295.6	0.001
Warfarin	6,533	16%	1,852	16%	1.1	0.291
Aspirin	28,225	69%	6,007	54%	1,000.5	0.001
Insulin	3,766	9%	1,559	14%	203.4	0.001
Oral hypoglycemic	4,766	12%	1,369	12%	1.8	0.180
Bronchodilator	3,992	10%	1,518	14%	126.4	0.001
Beta-blocker	16,640	41%	2,534	23%	1,276.5	0.001
Calcium channel blocker	14,784	36%	3,813	34%	22.6	0.001
Antidepressant medication	2,094	5%	887	8%	122.4	0.001

ACE = angiotensin-converting enzyme; BUN = blood urea nitrogen; CABG = coronary artery bypass graft surgery; CHF = congestive heart failure; DBP = diastolic blood pressure; LBBB = left bundle branch block; LVEF = left ventricular ejection fraction; PTCA = percutaneous transluminal coronary angioplasty; RBBB = right bundle branch block; SBP = systolic blood pressure; WBC = white blood cell.

definition, focused only on persons who were eligible for and received thrombolytic therapy, whereas our study included all older patients hospitalized during the study

period. The marked difference in the population was reflected in the outcomes. The one-year mortality rate among 30-day survivors in the GUSTO trial was 2.9% compared

Table 2. Study Logic (Inclusions and Exclusions)

Total sample	234,769
Exclusions*	
Age <65 years	17,593 (7.5%)
AMI not confirmed	31,186 (13.3%)
Transferred	75,981 (32.7%)
Repeat hospitalization†	23,773 (10.6%)
Hospital death	33,508 (14.3%)
Terminal illness	4,617 (2.0%)
Unverified death	204 (0.1%)
Study sample	103,164
Derivation sample	51,851 (50.3%)
Validation sample	51,313 (49.7%)

*Not mutually exclusive; †repeat hospitalization occurred in 22,187 patients.
AMI = acute myocardial infarction.

with 22% among hospital survivors in our study. Both studies identified age, ejection fraction and heart failure as important predictors of mortality. Our study further identified the prognostic importance of comorbidity in these patients, factors that may be less important in a younger randomized trial population. The GUSTO investigators were able to define a group with 1% mortality at one year, but we could not identify a group with a risk of death that was <7%.

This study is also distinct from the recently published Predicting Risk of Death in Cardiac Disease Tool (PREDICT) risk score in several ways (9). The PREDICT score estimated the six-year death rate from information on admission and discharge diagnoses of 6,134 patients aged 30 to 74 years at the time of their hospitalization. The predictors included electrocardiographic variables, measures of shock, age, and clinical history of angina, AMI or stroke. Our study focused on one-year outcomes, which occurred at a substantial rate in this national cohort of older Americans. In addition, we used demographic and clinical information from the hospitalization that was derived from chart review, not billing codes. We also considered information about functional status. In our score, several of these noncardiac variables had substantial prognostic importance.

Model variables. The challenge for the clinician discharging a patient after an AMI is to distinguish the patients who

remain at higher risk from the many relatively low-risk patients. Numerous tests have been developed to aid in this process, but the assessment should start with clinical data and an assessment of the ejection fraction. The clinical data available for all patients and ejection fraction should be obtained, aside from its prognostic value, because of its importance in determining the use of angiotensin-converting enzyme inhibitors. A highly predictive model based on this information can guide the use of further testing or interventions. Additional tests must be highly sensitive and specific if they are to have incremental clinical value beyond what is already available.

This study revealed some prognostic factors that are not commonly included in studies of patients with an AMI. Frailty, as indicated by decreased functional status (urinary incontinence, inability to walk) and low body mass index was also an important predictor of mortality. These characteristics may indicate the absence of functional reserve and a susceptibility to a large number of mortality risks. The geriatrics literature is replete with information about the relationship of functional status with outcomes, but this information is rarely collected and reported in cardiology studies despite the high prevalence of cardiovascular disease in the elderly.

Several variables are conspicuous by their absence. Although we do include variables that indicate a higher risk for sudden arrhythmic events (e.g., LVEF, heart failure), there are others that have been reported that we do not include (e.g., size of infarction, anterior or Q-wave infarction, ventricular ectopy). We also did not include any electrocardiographic characteristics in the final model. All of these factors may have prognostic value, but we particularly sought to identify a small number of highly influential variables that would have the best predictive value. We purposely did not include all of the variables that were statistically significant.

Our risk index also does not include an assessment of the extent of coronary disease or myocardium at risk. Our findings do not undermine the conventional wisdom that the severity of coronary disease and the amount of myocar-

Table 3. Derived Model by Cox Regression Analysis (in Derivation Set)

Characteristics	Parameter Estimate	Standard Error	Wald Chi-Square	P > Chi-Square	Risk Ratio	Lower Limit	Upper Limit
Age 75-84 years	0.4023	0.0238	286.06	0.0001	1.495	1.427	1.567
Age ≥85 years	0.6716	0.0271	612.72	0.0001	1.957	1.856	2.064
BMI missing	0.2190	0.0240	83.20	0.0001	1.245	1.188	1.305
BMI <20 kg/m ²	0.3609	0.0306	139.33	0.0001	1.435	1.351	1.523
BUN >40 mg/dl or highest creatinine >2.5 mg/dl	0.6658	0.0226	866.47	0.0001	1.946	1.862	2.034
Urinary incontinence or no urinary output	0.4683	0.0250	349.74	0.0001	1.597	1.521	1.678
Walks with assistance	0.3708	0.0220	285.18	0.0001	1.449	1.388	1.513
Unable to walk	0.7716	0.0350	486.30	0.0001	2.163	2.020	2.317
Peripheral vascular disease	0.3226	0.0264	148.92	0.0001	1.381	1.311	1.454
CHF/pulmonary edema or cardiomegaly	0.8040	0.0262	944.39	0.0001	2.234	2.123	2.352
LVEF missing	0.4962	0.0232	459.55	0.0001	1.642	1.570	1.719
LVEF <20%	1.0592	0.0550	370.29	0.0001	2.884	2.589	3.213
LVEF 20%-39%	0.5595	0.0251	495.75	0.0001	1.750	1.666	1.838

BMI = body mass index; BUN = blood urea nitrogen; CHF = congestive heart failure; LVEF = left ventricular ejection fraction.

Table 4. Mortality by Risk Groups: Comparison of the Derivation and the Validation Samples

Risk Groups*	Derivation Sample		Validation Sample		Total	
	# of Patients	% of Events	# of Patients	% of Events	# of Patients	% of Events
Distribution						
Low	20,032	40.13	19,648	39.76	39,680	39.90
Medium	20,987	42.04	20,694	41.87	41,681	42.00
High	8,903	17.83	9,080	18.37	17,983	18.10
Mortality						
Low	1,459	7.28	1,433	7.29	2,892	7.29
Medium	4,982	23.74	4,926	23.80	9,908	23.77
High	4,407	49.50	4,436	48.85	8,843	49.17
Mortality or readmission						
Low	9,425	47.05	9,402	47.85	18,827	47.45
Medium	13,372	63.72	13,312	64.33	26,684	64.02
High	6,997	78.59	7,081	77.98	14,078	78.29
Mortality or readmission for AMI						
Low	2,783	13.89	2,821	14.36	5,604	14.12
Medium	6,603	31.46	6,631	32.04	13,234	31.75
High	4,878	54.79	4,931	54.31	9,809	54.55

*Risk groups were determined by the risk score: low risk (0-2), medium risk (3-5), high risk (≥6).
AMI = acute myocardial infarction.

dial tissue at risk for recurrent ischemia have a major influence on long-term prognosis. We demonstrate that before employing either of the two major testing strategies (noninvasive stress testing and cardiac catheterization), physicians can estimate the risk of dying within one year after discharge with reasonable accuracy.

Study limitations. In this study, we had an extensive list of candidate variables for the models. Unfortunately, despite information in the first electrocardiogram, we did not have information about the presence of ST-segment depression, though it is interesting that none of our electrocardiographic variables strongly predicted one-year outcomes among patients who survived the hospitalization. Also, some of our variables had missing values. We did not attempt to impute values but did indicate that they were missing. Our secondary analyses did not suggest that our results were substantially affected by the missing data.

Conclusions. We demonstrate that a simple risk model can effectively stratify older patients by their risk of death one year after discharge for AMI. The model has good discriminant value and can be used to stratify patients into three risk groups with mortality ranging from 7% to 49%. Knowledge of risk in this contemporary cohort should enhance clinical decision making with respect to further diagnostic testing and intervention.

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