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Mortality in Medicare Patients Undergoing Elective Percutaneous Coronary Intervention With or Without Antecedent Stress Testing

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Abstract

Background—Guidelines advise testing for ischemia – such as with stress testing – prior to elective percutaneous coronary intervention (PCI). However, pre-PCI stress testing is not always done; the implications of this practice are not known. Our objective was to evaluate whether receipt of stress testing prior to elective PCI predicts mortality.

Methods and Results—Using claims data from a 20% random sample of Medicare beneficiaries, we identified patients who had elective PCI in 2004 and followed them for a median of 3.4 years (N=23,887). Cox proportional hazards models were used to test the relationship of pre-PCI stress testing to survival. Population-based rates of elective PCI and stress testing were calculated for 306 hospital referral regions (HRR) and categorized into four groups: high stress test rate/high PCI rate, low stress test/low PCI, low stress test/high PCI, and high stress/low PCI regions. Cox modeling was used to test if category of HRR related to survival. Patients who underwent pre-PCI stress testing had a 13% lower risk of mortality than those who did not (adjusted hazard ratio (HR) 0.87, 95% CI 0.81–0.92) after median follow-up of 3.4 years. Patients in low stress test/high PCI regions had a 14% higher risk of mortality than those in high stress test/high PCI regions (adjusted HR 1.14, 95% CI 1.03, 1.26).

Conclusions—Pre-PCI stress testing is associated with lower mortality in patients undergoing elective PCI. Greater adherence to guidelines with respect to documenting ischemia prior to elective PCI may result in improved outcomes for patients.

Keywords

angioplasty; coronary disease; ischemia; revascularization

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Disclosures: None

Current evidence suggests that, in many patients with stable coronary artery disease (CAD), the main benefit of elective percutaneous coronary intervention (PCI) is improvement in anginal symptoms.[1] No survival benefit has been demonstrated for elective PCI for most patients, and there are potential harms from the procedure, including risk of bleeding, acute myocardial infarction (MI), emergency coronary artery bypass graft (CABG) surgery, and death. Professional society guidelines, therefore, recommend limiting elective PCI procedures to those patients whose symptoms are not controlled with goal-directed medical therapy and have evidence of significant ischemia on non-invasive testing.[2]

Prior work has demonstrated that routine testing for ischemia with stress testing prior to elective PCI is not taking place in many parts of the United States.[3, 4] This raises the question of whether patients who are not undergoing stress testing are potentially being exposed to the risk of harm from PCI without expectation of benefit and/or not receiving the same high quality care as patients in regions that are guideline adherent. Therefore, we sought to understand whether patients whose physicians ordered a stress test prior to the decision to proceed to elective PCI had differential survival than patients who did not undergo stress testing. We hypothesized that pre-PCI documentation of ischemia via stress testing could help select patients for whom the benefits of elective PCI were great enough to outweigh the harms, and could be a key indicator of high quality care for elective PCI. We examined this hypothesis using the same observational cohort of Medicare patients undergoing elective PCI that we analyzed in a prior study,[5] following the patients for an additional three years.

Methods

Institutional review boards at the University of California, San Francisco and Maine Medical Center reviewed and approved the study protocol.

Data sources

To identify patients undergoing elective PCI, their characteristics, and pre-PCI use of noninvasive testing, we obtained data for a 20% random sample of Medicare beneficiaries from the Medicare Provider Analysis and Review (MEDPAR), Physician and Supplier Files, and Denominator files between January 1, 2003 and December 31, 2004 from the Center for Medicare and Medicaid Services. The MEDPAR files (Part A) and Physician and Supplier files (Part B) contain data on services provided to Medicare fee-for-service beneficiaries, including hospitalizations, physician claims, and outpatient services. The files contain unique identifiers for individual patients, physicians, and hospitals; date and place of service; and diagnoses and procedures as defined by the International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM) codes and Physicians' Current Procedural Terminology (CPT) codes. Additionally, we obtained the Denominator files only for those same patients for the 3 years of follow up from 2005–2007. The Denominator files have enrollment and demographic data, including date of death, for every Medicare beneficiary for the year.

Cohort

Using Part B claims from 2004, we used CPT codes for PCI (92980–92982, 92984, 92995–92996) to identify patients undergoing PCI. We then limited the population to patients who had a Denominator record, were eligible because of age, were eligible for both Part A and Part B, had at least 12 months of eligibility prior to the index PCI, and were enrolled in the Medicare fee-for-service program. We selected the first PCI per patient. We then linked MEDPAR and Part B data to create a file containing patients who had had PCI in 2004 and had a complete year of claims prior to the index PCI available. To identify a cohort of

patients with stable angina who would be candidates for elective PCI, we excluded patients who had a primary diagnosis of acute myocardial infarction (ICD-9-CM codes 410.XX) or unstable angina (411.1, 411.81, 411.89), and patients who had PCI, coronary artery bypass grafting (CABG) surgery, valve surgery, acute myocardial infarction, or unstable angina within one year prior to the index PCI. We further excluded patients admitted from an emergency room, transferred from another institution, or who had emergency procedures.

Definition of Stress Test

We used CPT codes for stress echocardiography (93350), exercise treadmill or pharmacologic stress test (93015, 93016–93018), and myocardial nuclear imaging (78460–78461, 78464–78466, 78468–78469, 78472–78473, 78478, 78480–78481, 78483, 78491–78492, 78494, 78496) to identify stress tests for each patient. For imaging stress tests, patients must have had both a stress component and an associated imaging component within a 1-day window.

Outcomes

Our primary outcome of interest was survival. Death was obtained from the Medicare Denominator File. Each patient was followed up from date of PCI through December 31, 2007, for a minimum of 3 years of follow-up data for each surviving patient.

Comorbid Conditions

We used ICD-9-CM codes to identify diagnoses typically included in the Charlson comorbidity score, including prior myocardial infarction (MI), peripheral vascular disease, chronic obstructive pulmonary disease (COPD), renal disease, severe diabetes mellitus, severe liver disease, congestive heart failure, rheumatic disease, cerebrovascular disease, peptic ulcer disease, metastatic cancer, dementia, and AIDS. We also used ICD-9-CM codes to identify diagnoses of CAD, hyperlipidemia, hypertension, and prior cardiac catheterization for each patient in the year prior to the index PCI. Because we did not have access to clinical information, we also searched for the ICD-9-CM diagnosis codes for angina and chest pain in the year prior to the index PCI to try to assess if patients had been symptomatic. These variables were included in our model, as they represent conditions that are likely to be clinically relevant to the likelihood of stress testing.

Analyses

Statistical analyses were done using SAS version 9 (SAS Institute, Cary, NC). Patients were divided into 2 cohorts according to whether or not they had a stress test within the 90 days prior to the index PCI. Differences in baseline patient characteristics were assessed using a chi-squared test for categorical variables and a Student’s t-test for continuous variables. We used Cox proportional hazards models to estimate survival in the two groups. Surviving patients were censored as of December 31, 2007. Models were then adjusted for baseline characteristics to control for differences between the stress tested and non-stress tested patients. Results are reported as an adjusted hazard ratio (HR) with 95% confidence intervals (95% CI).

To address the concern that sicker patients may be less likely to receive a stress test, we included patients who received pharmacological stress testing in addition to exercise testing. In addition, to account for the fact that receipt of a stress test may be affected by individual patient characteristics we also assessed outcomes for patients based on their geographic regions of residence. Each patient’s ZIP code of residence was used to assign him/her to one of 306 Hospital Referral Regions (HRR), based on referral patterns for tertiary care and as defined in The Dartmouth Atlas of Healthcare.[6] We then calculated age-adjusted population-

based rates per 100,000 Medicare beneficiaries of stress tests and elective PCI for each HRR, and divided the cohort into four groups of HRRs based on median rates of stress test and elective PCI: high stress test/high PCI rate (reference category), high stress test/low PCI rate, low stress test/low PCI rate, and low stress test/high PCI rate regions. For this analysis, we excluded patients from HRRs where fewer than 50 PCIs were performed in order to ensure stable rate estimates. Cox modeling was used to test if category of HRR related to survival, controlling for patient characteristics. To assess geographic variability in underlying disease and its impact on performance of PCI, AMI and CABG rates were used as proxies for the prevalence and severity of coronary disease within a geographic region; association of these rates with PCI rates was evaluated using correlation techniques.

Results

We identified a total of 87,343 patients undergoing PCI in 2004 from 107,162 Medicare line-item claims. We excluded patients if they had a non-elective PCI or prior cardiac procedure within 1 year of the index PCI (N=46,872), or for administrative reasons (N= 16,584). The remaining 23,887 patients met eligibility criteria for an elective PCI and became the study cohort (Figure 1). We found that 44.5% of patients (N=10,629) underwent stress testing in the 90 days prior to their elective PCI. Patients who underwent stress testing were more likely to be less than 80 years old, male, and have cancer (Table 1). Patients who did not undergo stress testing had higher rates of angina, and were more likely to have a history of CAD, congestive heart failure, COPD, mild diabetes mellitus, and renal disease. They were also more likely to have had a previous cardiac catheterization and have been admitted urgently for their PCI.

Patients were followed for a median of 3.4 years (interquartile range, 3.1, 3.7 years). Patients who underwent pre-PCI stress testing were 21% less likely to die compared with patients who did not undergo stress testing (crude HR 0.79, 95% CI 0.74–0.84). Even after adjusting for differences in baseline characteristics, patients undergoing pre-PCI stress testing were 13% less likely to die than those who did not undergo stress testing (adjusted HR 0.87, 95% CI 0.81, 0.92).

We then assessed whether residing in an area with higher or lower rates of stress testing and elective PCI affected survival. We calculated HRR-level stress test and elective PCI rates for HRRs where more than 50 PCIs were performed (N=19,631), and assessed survival based on area rates, separating regions according to whether their rates of stress testing or PCI were above or below the median rate for all regions. After adjusting for differences in baseline characteristics, patients treated in low stress test/high PCI regions had a 14% greater cumulative mortality compared with patients treated in regions with high stress test/ high PCI rates (adjusted HR 1.14, 95% CI 1.03, 1.26, Figure 2). There was no difference in cumulative mortality in patients in low PCI areas compared with high stress test/high PCI areas, regardless of stress test status (Table 2).

Since rates of PCI may also vary based on regional disease prevalence and severity, we also calculated acute MI and CABG rates for each HRR, and correlated them with elective PCI rates. We found that HRR rates for acute MI were not correlated with rates of elective PCI (rho = 0.05), but did weakly correlate with rates of CABG surgery (rho = 0.15). Rates of CABG surgery were negatively correlated with PCI rates, (rho = −0.28).

Discussion

This is the first national, population-based study to assess the effect of risk stratification with stress testing on mortality for patients undergoing elective PCI. We found that patients who

underwent stress testing in the 90 days prior to elective PCI had better survival than those who did not. Furthermore, we found that patients treated in regions with low rates of stress testing but high rates of PCI fared worst. These results suggest that receipt of stress testing – independent of stress test results – may be a critical indicator of the quality of care being provided to patients with stable CAD

There are several possible explanations for our findings. First, use of stress testing might have identified patients with a higher burden of ischemia. In two observational studies by Hachamovitch et al., patients who had moderate to severe ischemia on single-photon emission computed tomography (SPECT) testing had a survival advantage with PCI, whereas patients who had no or mild ischemia fared better with medical therapy.[7, 8] In a posthoc subanalysis of the COURAGE trial, Shaw et al. studied 300 randomized patients with stable CAD and found that PCI in addition to optimal medical therapy reduced inducible ischemia, as measured by stress testing with nuclear imaging, to a greater extent than with medical therapy alone.[9] In that study, after risk adjustment, there was a non-significant trend towards event-free survival in the patients who had ≥ 5% reduction in ischemic myocardium. Other techniques for determining the hemodynamic significance prior to PCI, such as use of fractional flow reserve (a technique used to measure the impedence of flow across an area of stenosis), have also yielded better outcomes compared with angiography alone.[10] Our study lends further support that patients may have better outcomes with ischemia-guided PCI. The importance of the extent of reduction of ischemic burden is being tested in the NIH funded ISCHEMIA trial.

Furthermore, the results of stress testing can strongly influence clinical decision making. Sharples et al. found that 20–25% of patients who underwent stress testing prior to angiography ended up not being referred for angiography based upon the test results and without affecting outcomes.[11] Since the benefits of PCI in a patient with stable angina are primarily symptom relief and reduction of ischemic burden, reliance on angiography data alone for clinical decision-making may lead to overtreatment of lesions or patients with an unfavorable risk/benefit ratio receiving invasive treatment instead of optimization of medical therapy. In our analysis, patients in low stress test/high PCI areas did worse than patients in high stress test/high PCI areas, suggesting that receipt of stress testing – and hence assessment of ischemia – may help avoid unnecessary PCIs that do not lead to any patient benefit and expose patients to harm.

Alternatively, stress testing may be a marker for higher quality care. Patients in the high stress test/high PCI regions had lower mortality than patients in the low stress test/high PCI regions. This survival difference was apparent even in the absence of differences in prevalence and severity of disease (as demonstrated by the lack of correlation between regional acute MI and elective PCI rates and a persistent survival difference after accounting for comorbidities). While the high rates of PCI may reflect a variety of factors, for example, local style of practice, favorable reimbursement policies, as well as physician and patient belief in the benefits of PCI[12–14], those factors do not explain why antecedent stress testing did not take place, as recommended by clinical guidelines. In addition, high stress test/high PCI regions had similar mortality to low PCI regions (regardless of whether stress testing was done). This is an expected finding given that undergoing elective PCI does not appear to improve mortality for patients with stable CAD, and may indicate that stress testing is particularly important for predicting for which patients the benefits of PCI outweigh potential harms, particularly in light of the efficacy of optimal medical therapy. Alternatively, it may be that in regions where fewer patients undergo PCI, there is greater focus on optimizing medical therapy and therefore, regardless of whether or not stress testing is done, outcomes are similar. Regardless of reason, our results suggest that stress testing could be used to indicate better overall quality of care for patients undergoing

elective PCI, and evaluation for ischemia prior to cardiac intervention should be encouraged as part of quality improvement efforts.

There are limitations to our study. The data were derived from Medicare claims and are thus observational in nature; there may be differences in the population or other unmeasured confounders presenting bias in the results. We attempted to address potential selection bias and unmeasured confounders by assessing care at the HRR level. Furthermore, one may also interpret these results as "reduced-form instrumental variable" estimates, where the instruments are geographic location. In this interpretation, the estimated impact of pre-PCI stress testing (equal to the overall mortality rate divided by the difference in stress-testing rates between the high and low stress-test regions) would be considerably larger. Our ability to account for clinical characteristics such as chest pain and angina was limited to what was present in the claims file. We did not have access to clinical data, in particular data on symptoms or medication use, and coding of symptoms such as chest pain and angina may be incomplete. Therefore we cannot assess whether patients underwent PCI for unremitting symptoms or whether they received symptomatic benefit from their procedure. We also did not have data on the results of the stress test; however, it is reasonable to assume that physicians made appropriate decisions in regards to referral for PCI on the basis of the stress test results. In addition, it is not necessary to know the outcome of the stress test to assess treatment effects. We also attempted to characterize the underlying prevalence of coronary disease in our population using rates of AMI. Such rates may not accurately reflect the actual disease burden, as coronary lesions may or may not cause ischemia prior to AMI. Further study is needed to determine which clinical and procedural characteristics may be key components to predicting patients' risk of mortality for elective PCI. Intermediate outcomes such as repeat revascularization, hospitalizations, or major adverse cardiovascular events were not contained in our dataset and therefore not able to be ascertained, as we did not have Medicare Part A and B data for our cohort for the follow-up years of 2005–2007. However, our finding of differential mortality between groups suggests that there might be differences in those outcomes as well. Our population is limited to Medicare patients 65 years and older, so we cannot comment on whether the mortality difference is present in younger populations, or in persons who are not covered by Medicare. Finally, all patients in the cohort received a procedure, so we cannot compare outcomes with similar patients who were treated with medical therapy or CABG surgery.

As with most technology, the dissemination of PCI has led to its use beyond recommended indications, leading to patterns of utilization that do not necessarily follow guidelines. Our study raises the possibility that utilization of PCI without prior stress testing may not only be unnecessary but also harmful; this possibility requires further investigation in future studies. Given that a significant number of patients undergo elective PCI without prior stress testing, greater focus on selecting appropriate patients for elective PCI, in part by promoting high quality care though adherence to clinical practice guidelines, could improve patient outcomes.

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What is known

Documenting cardiac ischemia prior to elective percutaneous coronary intervention (PCI) is recommended by clinical practice guidelines.

A prior study suggested that documenting ischemia with stress testing prior to elective PCI occurred in less than half of Medicare patients.

What this article adds

Medicare patients who had ischemia documented by stress testing prior to the elective PCI had a 13% lower risk of mortality after 3 years than those who did not.

Patients who lived in regions with relatively low rates of stress testing and high rates of elective PCI had a 14% higher risk of mortality compared with patients who lived in regions where there were high rates of both stress testing and elective PCI.

Though the mechanism is not entirely clear, greater use of stress testing prior to elective PCI may result in improved outcomes.

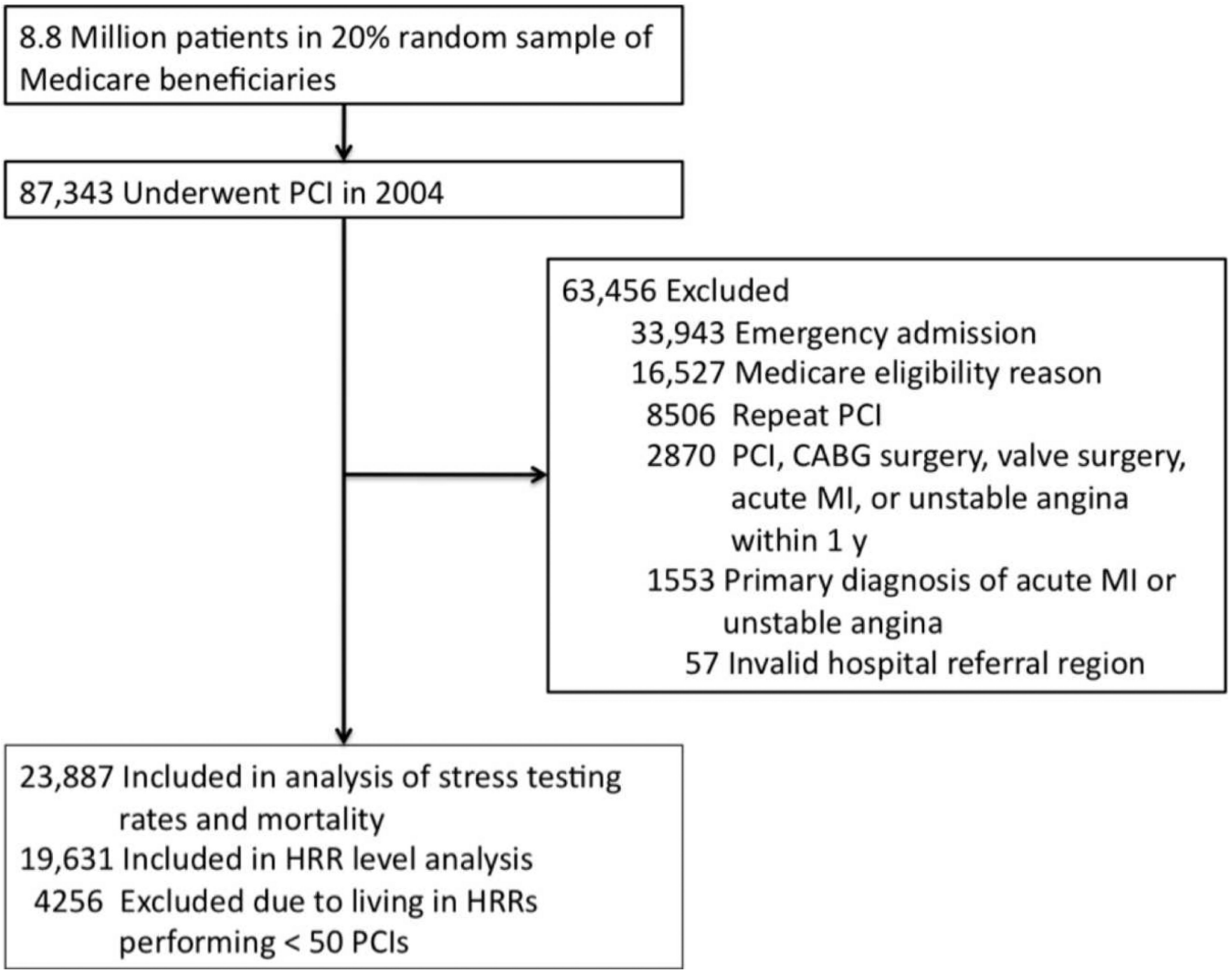

Figure 1. Study Cohort

The cohort includes all Medicare patients determined to have undergone an elective percutaneous coronary intervention (PCI) in 2004. CABG = coronary artery bypass graft; MI = myocardial infarction; HRR = hospital referral region

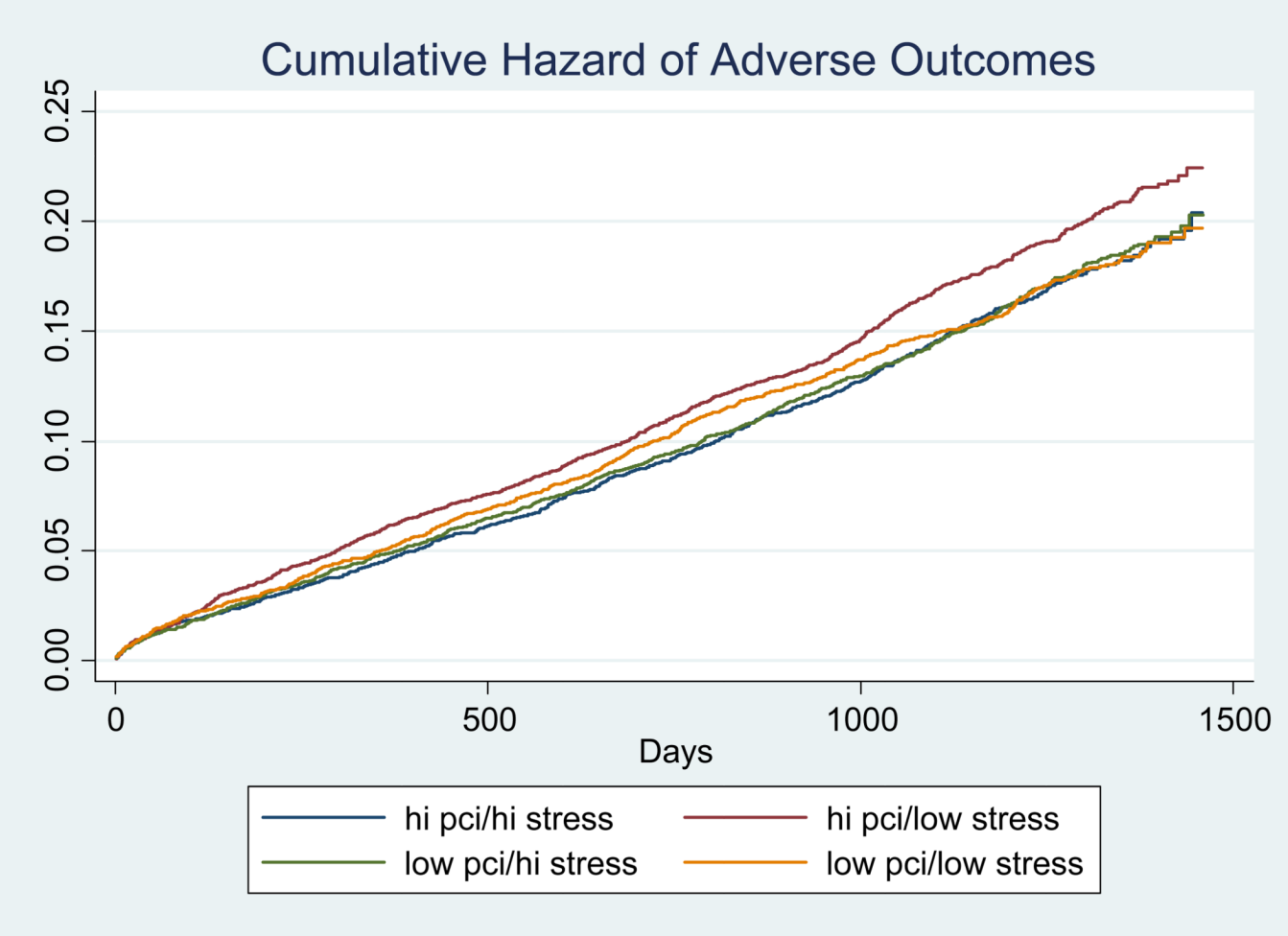

Figure 2. Cumulative Mortality of Patients Undergoing Elective PCI by Hospital Referral Region

We calculated population-based rates of stress tests and elective PCI for each HRR, and divided the cohort into four groups of HRRs: high stress test/high PCI rate, high stress test/low PCI rate, low stress test/low PCI rate, and low stress test/high PCI rate regions. Cumulative mortality is shown, with patients in the low stress test/high PCI groups having significantly higher mortality than the other groups (adjusted hazard ratio 1.12, 95% CI 1.02, 1.24).

Table 1

Select baseline patient characteristics of patients who did and did not undergo stress testing prior to elective PCI.

Characteristic	Stress test (N=10,629)	No stress test (N=13,258)	P value
Age > 79	20.3%	22.5%	<0.001
Female	38.7%	40.6%	0.002
Non-white	7.7%	7.0%	0.10
Diagnoses within prior one year[a]			
Angina	1.7%	2.2%	0.01
Chest pain	2.6%	2.5%	0.62
CAD	11.8%	14.7%	<0.001
Co-morbidities[a]			
CHF	17.8%	21.8%	<0.001
Cancer	12.6%	11.4%	0.004
COPD	21.9%	25.7%	<0.001
CVD	11.7%	12.6%	0.02
PVD	20.9%	21.9%	0.05
Mild diabetes	27.4%	26.0%	0.01
Severe diabetes	8.8%	9.3%	0.15
Renal disease	3.9%	4.7%	0.003
Urgent admission	29.0%	36.9%	<0.001
Prior cardiac catheterization within previous 1 year[a]	1.9%	4.7%	<0.001

[a]Diagnoses identified using ICD-9-CM codes from Medicare claims in the one year prior to the index PCI procedure.

CAD = coronary artery disease; CHF = congestive heart failure; COPD = chronic obstructive pulmonary disease; CVD = cerebrovascular disease; PVD = peripheral vascular disease

Table 2

Comparison of patient mortality after elective percutaneous coronary intervention based on Hospital Referral Region rates of stress test and elective PCI

HRR stress test/PCI rate category	Crude mortality rate	Crude hazard ratio (95% CI)	Adjusted hazard ratio (95% CI)
High stress test/high PCI (reference group)	15.9%	-----	-----
Low stress test/low PCI	16.0%	1.01 (0.91, 1.12)	1.02 (0.92, 1.12)
High stress test/low PCI	16.0%	1.01 (0.91, 1.11)	1.04 (0.94, 1.15)
Low stress test/high PCI	17.9%	1.14 (1.04, 1.26)	1.14 (1.03, 1.26)

Adjusted for age, sex, race, comorbidities, and past cardiac history, and admission type
PCI = percutaneous coronary intervention; CI = confidence interval