BRIEF REPORT

Utilization of stress testing for low-risk patients with chest discomfort in the emergency department

Sheela Krishnan, MD,[a] Rachael Venn, MD,[b] Daniel M. Blumenthal, MD, MBA,[c]
Vijeta Bhambhani, MS, MPH,[c] Henry Gewirtz, MD,[c] Rory B. Weiner, MD,[c]
John T. Nagurney, MD, MPH,[d] and Jason H. Wasfy, MD, MPhil[c]

[a] Division of Cardiovascular Medicine, Department of Medicine, Hospital of the University of Pennsylvania, Philadelphia, PA
[b] Department of Medicine, Harvard Medical School, Massachusetts General Hospital, Boston, MA
[c] Cardiology Division, Department of Medicine, Harvard Medical School, Massachusetts General Hospital, Boston, MA
[d] Department of Emergency Medicine, Harvard Medical School, Massachusetts General Hospital, Boston, MA

Background. The management of patients presenting to an emergency department with chest discomfort at low-risk for acute coronary syndrome represents a common clinical challenge. Such patients are often triaged to chest pain units for monitoring and cardiac stress testing for further risk stratification.

Methods. We conducted a retrospective study of 292 low-risk patients who presented to an emergency department with chest discomfort. We performed physician-adjudicated chart reviews of all patients with positive stress tests to assess downstream testing, subsequent coronary revascularization, and outcomes.

Results. Of the 292 patients, 33 (11.3%) had stress tests positive for ischemia, and 12 (4.1%) underwent diagnostic cardiac catheterization. Of the 292 patients, 4 (1.4%) underwent coronary revascularization that may have resulted in a mortality benefit.

Conclusion. These data suggest a very low yield of detecting clinically significant coronary disease with stress testing low-risk patients with chest discomfort in emergency department chest pain units. (J Nucl Cardiol 2019;26:1642–6.)

Key Words: Ischemia • myocardial • exercise: stress testing • diagnostic and prognostic application • pharmacologic stress • myocardial perfusion imaging: SPECT

Abbreviations

ACS	Acute coronary syndrome
CAD	Coronary artery disease
EDOU	Emergency Department Observation Unit
ECG	Electrocardiogram
MPI	Myocardial perfusion imaging
MI	Myocardial infarction
PCI	Percutaneous coronary intervention
CABG	Coronary artery bypass graft
EF	Ejection fraction
RCA	Right coronary artery

See related editorial, pp. 1647–1649

INTRODUCTION

Cardiac testing for patients with chest discomfort who are at low risk for acute coronary syndrome (ACS) presents a challenge that integrates safety, resource utilization, and value.[1] ''Low-risk patients'' are defined as those who are hemodynamically stable, free of arrhythmias or ischemic electrocardiographic changes, and have negative initial cardiac biomarkers.[2] In many hospitals, low-risk patients who present to an emergency room with chest discomfort are triaged to chest pain units for monitoring and testing. An important goal of this approach is to detect patients with ACS or high-risk coronary artery disease (CAD). The most commonly utilized strategy to achieve this includes cardiac stress testing with or without imaging, which has implications for both cost and patient safety due to radiation exposure.[2,3] Understanding the utilization and effectiveness of cardiac stress testing in this setting could suggest tactics to improve the quality and value of care provided to these patients.

METHODS

We examined a prospectively collected database of patients at a large, tertiary academic center who underwent imaging or non-imaging stress tests in the Emergency Department Observation Unit (EDOU) from January 1, 2014 to April 1, 2014. In general during this time period, patients who presented to the emergency department for chest discomfort or potential anginal equivalents were triaged based on ACS risk, which was determined via non-algorithmic clinical assessment. Triage destinations, depending on pre-test probability of ACS, included discharge home, temporary stay in the EDOU, or admission to a general medicine floor, a cardiology-specific step down unit, or an ICU-level cardiac care unit. Per emergency department triage policy, patients triaged to the EDOU for further risk stratification with stress testing must be deemed low-risk for ACS, defined as above (hemodynamically stable with a non-ischemic electrocardiogram (ECG) and negative cardiac biomarkers). An internist (S. K.) performed the initial chart reviews on all patients with positive stress tests to determine the method of stress testing, how each test was deemed positive, downstream clinical testing, subsequent coronary revascularization, and outcomes. A cardiologist (J. H. W.) performed a second chart review, including review of cardiac imaging, for all patients who underwent coronary revascularization during index admissions. These cases were categorized according to the ACC/AHA guidelines on stable ischemic heart disease. In those guidelines, specific categories are delineated for which it is reasonable to perform revascularization for the indication of mortality reduction. Cases for which these specific categories applied were deemed cases for which the assumption of mortality benefit was reasonable.[4] The Partners Healthcare Institutional Review Board approved this study.

RESULTS

From January to April 2014, 292 low-risk patients who presented to the emergency department with chest discomfort or other symptoms underwent a total of 316 stress tests. Baseline demographics and primary and secondary presenting symptoms appear in Table 1. Of these stress tests, 98/316 (31.0%) were exercise treadmill tests without imaging and 218/316 (69.0%) were pharmacologic or exercise stress tests with myocardial perfusion imaging (MPI). Thirty-three of 292 patients (11.3%) had stress tests positive for ischemia. The stress tests with MPI that were positive were deemed so by imaging criteria. Approximately 50% of patients with a positive stress test had a prior history of myocardial infarction (MI), percutaneous coronary intervention (PCI), and/or coronary artery bypass graft (CABG). Of the remaining 259 patients with negative stress tests, a subset ($n = 32$) had a non-diagnostic or uninterpretable ECG with a corresponding MPI that was negative for ischemia. Thirteen patients had ECGs that were positive for ischemia but with corresponding MPIs that were negative. Eleven patients had MPIs that were negative for ischemia but that did demonstrate fixed perfusion deficits consistent with prior infarction. Of the 33 patients with positive stress tests, 11 underwent exercise treadmill tests with MPI, 17 underwent pharmacologic stress tests with MPI, four had exercise treadmill tests without imaging, and one patient who developed chest pain while undergoing an exercise treadmill test without imaging subsequently underwent a pharmacologic stress test with imaging that was positive for ischemia. Of the four patients who underwent exercise treadmill testing without imaging, two were positive by electrocardiographic findings, one developed recurrent chest pain with equivocal ECG findings, and

1644   Krishnan et al.
Utilization of stress testing for low-risk patients

Journal of Nuclear Cardiology®
September/October 2019

Table 1. Baseline characteristics of patients who underwent stress testing from the emergency department observation unit from January to April, 2014

	Total N = 292
Demographics	
Mean age, years (SD)	61.4 (13.1)
Women n (%)	126 (43)
Race	
White n (%)	208 (71)
Black n (%)	21 (7)
Asian n (%)	14 (5)
American Indian n (%)	1 (0.3)
Hispanic n (%)	23 (8)
Other n (%)	25 (9)
Clinical covariates	
Presenting symptoms (primary and secondary)	
Chest pain n (%)	223 (76)
Dyspnea n (%)	10 (3)
Syncope n (%)	9 (3)
Pre-syncope n (%)	5 (2)
Palpitations n (%)	3 (1)
Hypertension n (%)	2 (1)
Other n (%)	43 (15)
Documented cardiac risk factors	
Diabetes n (%)	58 (20)
Hypertension n (%)	183 (63)
Dyslipidemia n (%)	176 (60)
Prior MI n (%)	43 (15)
Family history of early MI n (%)	115 (39)
Smoking history (or current smoker) n (%)	146 (50)
Prior CABG n (%)	29 (10)
Stents (prior PCI) n (%)	48 (16)

MI, myocardial infarction; *CABG*, coronary artery bypass graft; *PCI*, percutaneous coronary intervention

one developed non-sustained ventricular tachycardia at peak exercise.

Of the 292 patients, 12 (4.1%) underwent diagnostic cardiac catheterization, and 6 (2.1%) subsequently underwent coronary revascularization (PCI or CABG). The remaining 21 patients with positive stress tests did not undergo coronary angiography. Of these, 13 were discharged directly from the EDOU with plan for outpatient cardiology follow up. All 13 patients had negative serial troponins and nearly all had stress MPIs that reported mild ischemia or a small territory of involvement. Eight of these 21 patients were admitted from the EDOU to a cardiology or general medicine

floor with cardiology consultants following. All but one had additional in-hospital testing that informed the decision not to proceed with angiography. One patient underwent transthoracic echocardiogram with preserved ejection fraction (EF) and no wall motion abnormalities, three patients underwent CT angiogram with insignificant CAD, and three patients who had undergone treadmill stress testing without imaging underwent subsequent inpatient stress MPIs that were negative for ischemia.

For the 12 patients who underwent diagnostic cardiac catheterization, the decision to proceed was made at the discretion of consultant cardiologists, without any standard decision rules. However, compared to the 21 patients with positive stress tests who did not undergo angiography, these patients tended to have larger areas of ischemia noted on MPI and/or additional clinical findings that raised their pre-test probably of significant disease. These findings included prior CABG or PCI (six patients), a newly depressed EF, a dilated/hypokinetic left ventricle noted on MPI (three patients), or highly concerning ECG changes that developed in association with stress (two patients).

Of the six patients who underwent diagnostic coronary angiography without revascularization, four patients were found to have mild, diffuse disease, one patient had no detectable epicardial coronary disease, and one patient had a totally occluded distal right coronary artery (RCA) but with moderate collateralization from the distal left anterior descending artery. Given that the inferior territory was well perfused, revascularization was deferred. Three of six of these patients were subsequently started on optimal medical therapy including aspirin, a statin, and a beta blocker. Two of six had known CAD and experienced subsequent minor medication adjustments (e.g. uptitration of anti-hypertensives, addition of a nitrate) and one without significant disease experienced no medication changes. While the study was not designed to assess clinical course longitudinally, re-review of these six patients who underwent angiography without intervention demonstrated further extensive cardiac testing between the years of 2014 and 2017, including six echocardiograms, eight repeat stress tests, and two repeat angiographies, none of which resulted in revascularization.

For the other six patients who underwent revascularization after diagnostic coronary angiography, three patients were found to have complex multivessel disease and subsequently underwent CABG, one patient underwent PCI to the RCA based on sequential high-grade stenoses corresponding to a moderate inferior reversible defect on stress MPI, and two patients who had undergone prior CABG had stents placed to high-grade
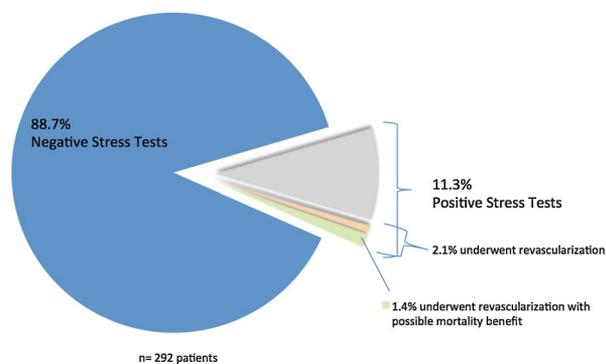
Figure 1. Stress test results and revascularization outcomes of patients who underwent stress testing from the emergency department observation unit from January to April, 2014.

stenoses of their native vessels (one with a drug-eluting stent extending from an area of 95% stenosis of the left main coronary artery to a 95% stenosis of an ostial circumflex lesion, and one with two stents placed to a 99% stenosed mid-RCA lesion).

Overall, four of the 33 patients (12.1%) with positive stress tests underwent revascularization with possible mortality benefit. Ultimately, of the 292 patients who underwent stress testing, only four (1.4%) underwent revascularization that may have resulted in a mortality benefit (Figure 1).

DISCUSSION

These data suggest a low yield of detecting clinically significant coronary disease with stress testing of low-risk patients in the setting of an emergency department chest pain unit, and are consistent with previous findings regarding stress testing in comparable cohorts.[5-7] Our specific finding that the subset of patients who underwent coronary angiography without intervention underwent significant additional testing between 2014 and 2017, none of which resulted in revascularization, is also supported by recent literature. In a recent large-scale study, patients who presented with chest pain and received upfront cardiac testing were more likely to undergo additional downstream testing without a corresponding decrease in number of admissions for chest pain.[5]

Similar to what has been done at other sites, future studies should seek to address how other methods of risk-stratification, including application of newer evidence-based triage algorithms, may reduce utilization of in-hospital stress testing resources in patients who present with low-risk chest pain.[8] While our results suggest the overall low yield of stress testing in low-risk patients, the fact that a disproportionate number of

patients with positive stress tests had a prior history of MI (15%), PCI (16%), and/or prior CABG (10%) (Table 1), suggests that triaging patients based on known history of CAD may have some role in increasing the yield of stress testing in patients at otherwise low-risk for ACS.

An important limitation of our work is that these data from this single-center, retrospective study cannot be generalized to other populations with certainty. However, they are likely generalizable to similar large, urban, general hospital settings. Second, given our methodology of comparing diagnostic angiography results to clinical consensus guidelines, we do not know how many of the 21 patients with positive stress tests who did not receive a cardiac catheterization during index admissions would have derived a mortality benefit from revascularization. A third limitation is our inability to further retrospectively risk-stratify patients based on their presenting signs and symptoms (e.g. retrospectively apply a Heart Score). While the emergency department triage protocol requires that all patients admitted to the EDOU be deemed low-risk for ACS, we are unable to further categorize this due to lack of standardization in documentation of the history of presenting illness.

NEW KNOWLEDGE GAINED

Our results both confirm previous findings of the low yield of stress testing in chest pain units,[5-7] and extend those results to highlight that a very low proportion of patients (1.4% in our study) could derive a potential mortality benefit from downstream testing and treatment. Even among the 33 patients with abnormal stress tests, only 4 (12.1%) appeared to have derived a potential mortality benefit from testing and revascularization during index admissions.

CONCLUSION

Our findings indicate that among low-risk patients who present to the emergency department with chest pain and undergo stress testing, the number of patients who achieve a mortality benefit from such testing is small. This suggests potential overutilization of stress testing in this setting. Better risk-stratification prior to stress testing may improve the value of care provided to this population in emergency departments and chest pain units nationwide.

Author Contributions

Dr. Krishnan and Dr. Wasfy had full access to all the data in the study and take responsibility for the integrity of the data and the accuracy of the data analysis.

1646   Krishnan et al.
Utilization of stress testing for low-risk patients

Journal of Nuclear Cardiology®
September/October 2019

Disclosure

References

1. Pope JH, Aufderheide TP, Ruthazer R, Woolard RH, Feldman JA, Beshanksy JR, et al. Missed diagnoses of acute cardiac ischemia in the emergency department. N Engl J Med 2000;342:1163-70.
2. Amsterdam EA, Kirk JD, Bluemke DA, Diercks D, Farkouh ME, Garvey JL, et al. Testing of low-risk patients presenting to the emergency department with chest pain: A scientific statement from the American Heart Association. Circulation 2010;122:1756-76.
3. Hendel RC, Berman DS, Di Carli MF, Heidenreich PA, Henkin RE, Pellikka PA, et al. ACCF/ASNC/ACR/AHA/ASE/SCCT/SCMR/SNM 2009 appropriate use criteria for cardiac radionuclide imaging. Circulation 2009;119:e561-87.
4. Fihn SD, Blankenship JC, Alexander KP, Bittl JA, Byrne JG, Fletcher BJ, et al. 2014 ACC/AHA/AATS/PCNA/SCAI/STS focused update of the guideline for the diagnosis and management of patients with stable ischemic heart disease. Circulation 2014;130:1749-67.
5. Sandhu AT, Heindenreich PA, Bhattacharya J, Bundorf MK. Cardiovascular testing and clinical outcomes in emergency department patients with chest pain. JAMA Intern Med 2017;177:1175-82.
6. Hermann LK, Newman DH, Pleasant WA, Rojanasarntikul D, Lakoff D, Goldberg SA, et al. Yield of routine provocative cardiac testing among patients in an emergency department-based chest pain unit. JAMA Intern Med 2013;173:1128-33.
7. Sun BC, Redberg RF. Cardiac testing after emergency department evaluation for chest pain: Time for a paradigm shift. JAMA Intern Med 2017;177:1183-84.
8. Poldervaart JM, Reitsma JB, Backus BE, Koffiiberg H, Veldkamp RF, Ten Haaf ME, et al. Effect of using the heart score in patients with chest pain in the emergency department: A stepped-wedge, cluster randomized trial. Ann Intern Med 2017;166:689-97.