MAYO CLINIC

# Use of Echocardiography in Olmsted County Outpatients With Chest Pain and Normal Resting Electrocardiograms Seen at Mayo Clinic Rochester

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## Abstract

**Objective:** To determine how often unnecessary resting echocardiograms that are "not recommended" by clinical practice guidelines are performed in patients with stable chest pain and normal resting electrocardiograms (ECGs).

**Patients and Methods:** We performed a retrospective search of electronic medical records of all outpatients seen at Mayo Clinic Rochester from January 1, 2010, through December 31, 2013, to identify residents of Olmsted County, Minnesota, with stable chest pain and known or suspected coronary artery disease who underwent resting echocardiography and had normal resting ECGs and no other indication for echocardiography.

**Results:** Of the 8280 outpatients from Olmsted County who were evaluated at Mayo Clinic Rochester with chest pain, 590 (7.1%) had resting echocardiograms. Ninety-two of these 590 patients (15.6%) had normal resting ECGs. Thirty-three of these 92 patients (35.9%) had other indications for echocardiography. The remaining 59 patients (10.0% of all echocardiograms and 0.7% of all patients) had normal resting ECGs and no other indication for echocardiography. Fifty-seven of these 59 patients (96.6%) had normal echocardiograms. Thirteen of these 59 echocardiograms (22.0%) were "preordered" before the provider (physicians, nurses, physician assistants) visit.

**Conclusion:** The overall rate of echocardiography in Olmsted County outpatients with chest pain seen at Mayo Clinic Rochester is low. Only 1 in 10 of these echocardiograms was performed in violation of the class III recommendation in the American College of Cardiology Foundation/American Heart Association guidelines for the management of stable angina. These unnecessary echocardiograms were almost always normal. The rate of unnecessary echocardiograms could be decreased by eliminating preordering.

 ■ Mayo Clin Proc. 2015;90(11):1492-1498

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Health care resources devoted to imaging services, and in particular cardiac imaging services, have been of increasing concern to third-party payers. One of the goals of clinical practice guidelines is to identify procedures and treatments that are ineffective or harmful. The American College of Cardiology Foundation (ACCF) and the American Heart Association (AHA) have collaborated on clinical practice guidelines for almost 30 years. Class III recommendations in these guidelines are assigned to procedures and treatments that are not recommended in specific situations. The ACCF/AHA guidelines for the management of stable angina, first published in 1999,[1,p2835] had a class III recommendation on the use of echocardiography in patients with stable symptoms and known or suspected coronary artery disease: "Echocardiography is not recommended in patients with a normal ECG, no history of MI, and no signs or symptoms suggestive of heart failure, valvular heart disease, or hypertrophic cardiomyopathy". The most recent revision of these guidelines in 2012[2] maintained this class III recommendation.



Mayo Clin Proc. ■ November 2015;90(11):1492-1498 ■ http://dx.doi.org/10.1016/j.mayocp.2015.07.025
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A single-center study in 2000[3] suggested that as many as 39% of echocardiograms ordered to check left ventricular systolic function were in patients with normal resting ECGs. However, this study required referral to echocardiography for entry and was not designed to determine how often echocardiography was performed in patients with chest pain and known or suspected coronary artery disease. The study relied on physician contact, rather than the medical record, for the primary indication and did not identify other indications. To our knowledge, no published data exist to indicate how often this class III recommendation is not followed in community practice. The purpose of this study was therefore to assess the rate of echocardiography performed in patients of Olmsted County, Minnesota, with known or suspected coronary artery disease seen at Mayo Clinic Rochester, to determine how often these patients had normal resting ECGs and no other indication for echocardiography, and to assess the clinical impact of the echocardiograms performed in violation of this class III recommendation. Our hypothesis was that echocardiography was often performed in patients with chest pain and known or suspected coronary artery disease who had normal ECGs and no other recognized indication for echocardiography and that these tests would be of limited clinical value.

## PATIENTS AND METHODS

### Study Group

We searched the electronic medical records of all outpatients seen at Mayo Clinic Rochester from January 1, 2010, through December 31, 2013, to identify residents of Olmsted County with stable chest pain that was possibly due to coronary artery disease. We specifically excluded the following:

1. patients seen in the emergency department;
2. patients seen in the hospital;
3. patients admitted within 24 hours of an outpatient visit;
4. patients who had exertional dyspnea without chest pain (we did include patients who had both exertional dyspnea and chest pain); and
5. patients who did not provide research authorization in accordance with Minnesota law.

We adapted a natural language processing algorithm used previously to identify heart failure[4] to identify outpatient encounters with chest pain. The natural language processing algorithm was implemented in a pattern-based concept extraction engine, in which a rule-based context annotator is included to assign each concept a status modifier, that is, confirmed, negative, or probable.[5] We performed several pilot studies to test our algorithm. The first study considered patients seen during January 2010 (without restriction to Olmsted County residents). We excluded individuals for whom chest pain was *not* a confirmed symptom (eg, "There is no evidence of chest pain" or "Chest pain negative"). We also ignored clinical notes in which chest pain was listed in the review of systems but not in the subsequent diagnoses or clinical impression. After these refinements, we performed a second pilot study of patients seen from January 1, 2010, through March 31, 2010 (without restriction to Olmsted County), and further refined the algorithm to more completely exclude patients seen in the emergency department and in the hospital.

### Echocardiograms

We used the echocardiographic laboratory database from Mayo Clinic Rochester to identify all patients from the study population who underwent a resting echocardiogram within 3 days before or 7 days after the clinical note reporting chest pain. We restricted our search to resting transthoracic echocardiograms performed at Mayo Clinic Rochester. We excluded echocardiograms performed at remote sites on one of our mobile vans, stress echocardiograms, and transesophageal echocardiograms.

### Electrocardiograms

We used the database of the Mayo ECG laboratory to identify patients with echocardiograms who had normal resting ECGs. We considered sinus bradycardia and varying P-wave morphology to be normal; any other abnormal ECG finding was grounds for exclusion. We performed a pilot search to identify all normal ECGs in patients from Olmsted County in 2011. We identified 6628 such patients and manually reviewed every 50th patient for a sample of 131. This manual review identified 3 patients from a sample of 131 who had an abnormal ECG: 1 patient

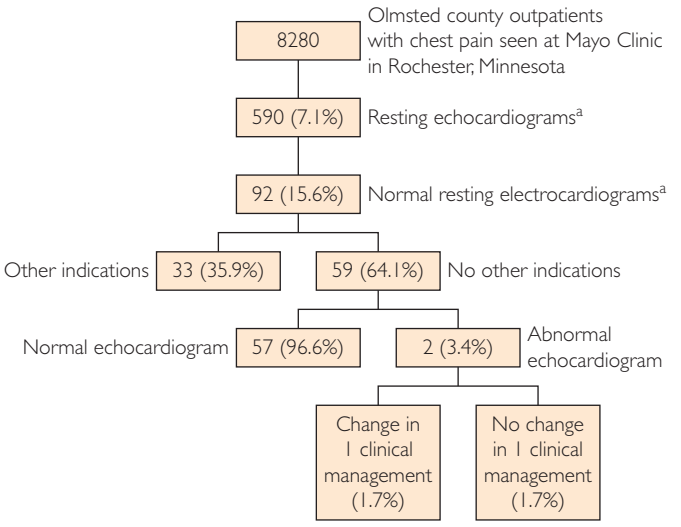


**FIGURE.** Results of the study. [a]Within 3 days before or 7 days after the clinical note reporting chest pain.

had first-degree atrioventricular block, 1 patient had right atrial enlargement, and 1 patient had left atrial enlargement. We refined our search to exclude such minor abnormalities. Using this refined search algorithm, we identified all patients from the study population who had normal resting ECGs within 3 days before or 7 days after the clinical note reporting chest pain. When there were multiple ECGs in this time frame, we examined the one closest in time to the clinical note.

### Registered Nurse Review of the Medical Records

An experienced registered nurse (RN) abstractor (D.C.) then reviewed the medical records of all the patients with normal ECGs and resting echocardiograms to identify other indications for echocardiography, including a history of myocardial infarction, hypertension, signs or symptoms of heart failure, signs or symptoms of valvular heart disease, hypertrophic cardiomyopathy, known or suspected arrhythmias, or other known cardiac or vascular disease (eg, ascending aortic aneurysm, percutaneous intervention, or coronary artery bypass grafting). Five questionable cases were reviewed with the supervising cardiologist (R.J.G.) before the final assignment.

The RN review also identified the ordering RN, physician assistant, or physician as well as the specialty of the ordering physician. The review identified echocardiograms that had been "preordered" before the provider visit associated with the clinical note reporting chest pain.

This review also identified a few patients for whom stress echocardiograms had been ordered but then canceled because the resting echocardiogram was abnormal. These patients with abnormal resting echocardiograms were excluded.

The RN review examined the results of the echocardiograms. Trivial or mild abnormalities in wall thickness, valvular regurgitation, pulmonary hypertension, or diastolic filling were ignored. All other abnormalities were recorded as "abnormal." In patients with abnormal echocardiograms, the impact of these studies was examined in subsequent clinical notes, and referrals to cardiology or other testing, as well as additional follow-up visits, were recorded.

### Human Studies Approval

This study was approved by the Mayo Clinic Institutional Review Board.

### Statistical Analyses

General descriptive statistics were used to present the results. Differences in preordering by physician specialty were examined using the Fisher exact test because of the presence of small cells.

## RESULTS

The results of our study are shown in the Figure. We identified 8280 unique outpatients from Olmsted County who were evaluated at Mayo Clinic Rochester with chest pain from January 1, 2010, and December 31, 2013. Of these 8280 patients, 590 (7.1%) had resting echocardiograms ordered within 3 days before or 7 days after their encounter. Of these 590 patients who underwent resting echocardiography, 92 (15.6%) had normal resting ECGs performed within 3 days before or 7 days after their clinical encounter.

### Other Indications for Echocardiography

The RN review of the electronic medical record for these 92 patients identified other indications for echocardiography in 33 (35.9%). As presented in Table 1, the most common indications were heart murmur or valvular heart disease, known or suspected cardiac arrhythmias, or known cardiac or vascular disease. The remaining 59 patients (64.1%) who underwent


Mayo Clin Proc. ■ November 2015;90(11):1492-1498 ■ http://dx.doi.org/10.1016/j.mayocp.2015.07.025
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**TABLE 1. Other Indications for Echocardiography in Patients With Normal Electrocardiograms**

| Characteristic | N | % |
|---|---|---|
| Known or suspected arrhythmias | 11 | 34 |
| Heart murmur or known valvular disease | 9 | 27 |
| Other known cardiac or vascular disease | 4 | 12 |
| Other | 9 | 27 |
| Total | 32 | 100 |

resting echocardiography and had normal resting ECGs had no other indication other than chest pain listed in their medical record for echocardiography.

### Results of Resting Echocardiography

Of the 59 patients who underwent resting echocardiography and had normal resting ECGs and no other indication for echocardiography, 57 (96.6%) had normal echocardiograms. Only 2 patients (3.4%) had abnormal echocardiograms. One of these exhibited modest diastolic impairment, which led to no additional clinical action. The other abnormal echocardiogram exhibited a pericardial effusion, which prompted a referral to cardiology. By the time this occurred, the patient's symptoms had resolved and no additional medication was prescribed.

### Ordering Provider

The ordering providers for the 59 patients who had resting echocardiograms, normal ECGs, and no other indication for echocardiography are listed in Table 2. The largest number of these echocardiograms (20 [34%]) were ordered by cardiologists. General internists and family medicine physicians accounted for 22% and 20% of these echocardiograms, respectively. Physician assistants and RNs accounted for only 5 of these echocardiograms (8%).

Of these 59 echocardiograms, 13 were preordered before the clinical visit. The largest number of these (7) were preordered by cardiologists. Cardiologists, general internists, and other doctors of internal medicine preordered 31% of their echocardiograms. In contrast, family medicine physicians, physician assistants, and RNs did not preorder any of their echocardiograms. Whether an echocardiogram was preordered or not did vary by physician specialty (Fisher exact, $P$=.04) (see Table 2).

## DISCUSSION

Our study finds that the rate of echocardiography in the management of Olmsted County patients with chest pain is low. Only 7.1% (or ~1 in 14 patients) had an echocardiogram ordered as part of their initial evaluation, either within 3 days before or 7 days after their clinical evaluation. To our knowledge, there are no previous data on nonreferral patients regarding this issue.

In those patients who do have echocardiograms ordered, most have abnormal ECGs. Only 15.6% (or ~1 in 6) have normal ECGs. On the basis of multiple previous studies on this subject, it can be concluded that patients with stable chest pain and normal ECGs have normal left ventricular function more than 95% of the time.[3,6-8] Thus, the use of echocardiography to assess ventricular function in such patients is not an efficient use of resources. However, echocardiograms may be ordered for other indications, as outlined in the class III recommendation in the guidelines for the management of stable angina. More than one-third of the patients who had echocardiograms ordered in our study despite normal ECGs had another indication for their echocardiogram. The most common indications were valvular heart disease, known or suspected cardiac arrhythmias, or other known cardiac or vascular disease. The correct categorization of these echocardiograms required detailed chart review. Further studies of this issue using administrative databases might therefore misclassify these patients.

Some of these unnecessary echocardiograms may have been ordered by clinicians who chose to follow the ACCF Appropriate Use Criteria for Echocardiography. The Appropriate Use Criteria describe echocardiography as "appropriate" in a broad range of patients with suspected ischemic heart disease and do not make any distinction between patients with normal ECGs and patients with abnormal ECGs. This discrepancy between the Appropriate Use Criteria and the guidelines may have caused confusion in the minds of practicing clinicians, leading them to order echocardiograms in patients with normal ECGs.

A total of 59 patients had resting echocardiograms, normal ECGs, and no other indication for echocardiograms. These 59 echocardiograms

**TABLE 2. Ordering Professionals for the Patients Who Had Resting Echocardiograms Without Other Indications and Number Preordered[a]**

| Professional | No. of resting TTEs | % of resting TTEs | Preordered resting TTEs | % of total preordered TEEs |
|---|---|---|---|---|
| Cardiologist | 20 | 34 | 7 | 53.9 |
| General internist | 13 | 22 | 2 | 15.4 |
| Family medicine physician | 12 | 20 | 0 | 0 |
| Other MD | 9 | 15 | 4 | 30.8 |
| PA/RN | 5 | 8 | 0 | 0 |
| Total | 59[b] | 100 | 13 | 100 |

[a]MD = doctor of medicine; PA = physician assistant; RN = registered nurse; TTE = transthoracic echocardiogram.
[b]Of the 59 resting TTEs, 22% were preordered.

met the class III recommendation in the guidelines and were therefore unnecessary. They represented 10% (or ~1 in 10) of all the echocardiograms performed. However, because this study was performed over a total of 48 months, our results suggest that there was an average of only 1.2 unnecessary echocardiograms performed each month for this reason. The 59 patients represented only 0.7% of all the included patients.

We examined the clinical impact of these "unnecessary" echocardiograms. Fifty-seven of the 59 echocardiograms (96.6%) were normal. They therefore had no meaningful clinical impact other than providing some additional reassurance to the patient and their health care provider. However, in this situation, the presence of a normal ECG should itself provide reassurance. Only 2 of the 59 unnecessary echocardiograms (3.4%) were abnormal. Only 1 of the 59 unnecessary echocardiograms (1.7%) led to a modest change in clinical management. These findings support the class III recommendations in the guidelines and suggest that these unnecessary echocardiograms could be eliminated with minimal clinical impact.

The previous literature relevant to our study is scant. Talreja et al[3] reported their findings on a prospective series of 300 patients who were referred to their echocardiography laboratory to assess left ventricular systolic function. They used physician contact to determine the primary indication for the echocardiogram, but did not identify other indications. However, their study did require referral to the echocardiography laboratory and offered no insight into the rate of use of echocardiograms in patients with chest pain. They reported that the prevalence of abnormal left ventricular function in these patients was only 1.7%, but they did not examine other findings on the echocardiograms or their clinical impact.

Sirovich et al[9] used a mail survey of primary care physicians in 20 hospital referral regions in the United States to determine how often physicians would order an echocardiogram "always or almost always" or "most of the time" for a 75-year-old man with chest pain on heavy exertion. The surveys indicated that the rate of echocardiography varied from 15% in hospital referral regions that were selected to have low spending to 40% in the 4 hospital referral regions that were selected to have high overall spending. Rochester was not included in this survey.

The use of echocardiography in patients with Medicare fee-for-service insurance in 2010 and 2011 was detailed in an Agency for Healthcare Research and Quality report as part of the Effective Health Care Program.[10] Although indications and patient symptoms were not available, approximately 20% of patients with Medicare fee-for-service insurance had at least 1 echocardiogram annually in 2010 and 2011, but the rate of echocardiography varied widely, from 12.7% in Idaho to 27.3% in New York. The rate of echocardiography reported in patients with Medicare fee-for-service insurance from Minnesota was 14.7% in 2010 and 14.4% in 2011, both well below the national average (~20%) and only modestly higher than the lowest state rate reported in Idaho. Although we report a lower rate of echocardiography use in this study, our study population included a much broader population and focused on patients with chest pain, which may account for these differences. Patients with known or suspected valvular heart disease, or known or suspected arrhythmias, might well justify a higher rate of use of echocardiography.

Our results set a "reasonable community standard" for the rate of echocardiography use in patients with symptoms of chest pain. Although the number of patients who met the class III recommendation, and therefore had unnecessary echocardiograms, was quite low, it could still be reduced. The most obvious step to reduce the rate of unnecessary echocardiograms would be to eliminate preordering, which


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accounted for more than 1 in 5 of the unnecessary echocardiograms. In contrast to previous studies, which have suggested an increased rate of unnecessary tests ordered by noncardiologists or nonphysicians,[11,12] our study did not suggest that any one group was responsible for a high percentage of the unnecessary echocardiograms. However, given the limited number of unnecessary echocardiograms in this study, our power to detect a difference among providers was limited. Application of our results to community practice will require education of ordering physicians about this issue.

The most obvious limitation of our study was that it was based on local, nonreferral patients. The expectations of both patients and physicians might well lead to a different rate of echocardiography in referral patients. We did not test this hypothesis. Our results are unique to Olmsted County and may not therefore apply to other states or other regions, in which Medicare data suggest a higher overall rate of echocardiograms. We did not collect information on insurance coverage or racial or socioeconomic status for these patients and cannot therefore comment on any differences in the rate of utilization of echocardiograms by insurance coverage, racial status, or socioeconomic status. We did not specifically search the medical history for a family history of cardiomyopathy, congenital heart disease, or sudden death, which may have been a factor in the decision to order an echocardiogram in these patients with normal resting ECGs and no other indication. In the Mayo Clinic practice, physicians are salaried. Therefore, our findings may not apply to providers in fee-for-service practices.

## CONCLUSION

Despite these limitations, we believe that these data indicate an overall low rate of echocardiography in Olmsted County patients with chest pain seen at Mayo Clinic Rochester. Only 10% of all the echocardiograms performed met the class III recommendation in the guidelines for the management of stable angina, and the remaining were therefore unnecessary. These unnecessary echocardiograms were almost always normal. The small percentage of echocardiograms that were abnormal had relatively little impact on patient outcomes. Our data suggest that the rate of unnecessary echocardiograms could be reduced further by eliminating preordering, so that the health care provider is aware of the electrocardiogram before the echocardiogram is ordered.

**Abbreviations and Acronyms:** **ACCF** = American College of Cardiology Foundation; **AHA** = American Heart Association; **ECG** = electrocardiogram; **RN** = registered nurse

**Potential Competing Interests:** Dr Gibbons has consulting agreements with Lantheus Medical Imaging, Astellas Pharmaceuticals, and Stealth Peptides. Dr Ebbert has research grants from Pfizer, Takeda, and JHP Pharmaceuticals.

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## REFERENCES

1. Gibbons RJ, Chatterjee K, Daley J, et al. ACC/AHA/ACP-ASIM guidelines for the management of patients with chronic stable angina: executive summary and recommendations: a report of the American College of Cardiology/American Heart Association Task Force on Practice Guidelines (Committee on Management of Patients with Chronic Stable Angina). *Circulation*. 1999; 99(21):2835.
2. Fihn SD, Gardin JM, Abrams J, et al. American College of Cardiology Foundation/American Heart Association Task Force. 2012 ACCF/AHA/ACP/AATS/PCNA/SCAI/STS guideline for the diagnosis and management of patients with stable ischemic heart disease: a report of the American College of Cardiology Foundation/American Heart Association task force on practice guidelines, and the American College of Physicians, American Association for Thoracic Surgery, Preventive Cardiovascular Nurses Association, Society for Cardiovascular Angiography and Interventions, and Society of Thoracic Surgeons. *Circulation*. 2012;126(25):e354-e471.
3. Talreja D, Gruver C, Sklenar J, Dent J, Kaul S. Efficient utilization of echocardiography for the assessment of left ventricular systolic function. *Am Heart J*. 2000;139(3):394-398.
4. Pakhomov S, Weston SA, Jacobsen SJ, Chute CG, Meverden R, Roger VL. Electronic medical records for clinical research: application to the identification of heart failure. *Am J Manag Care*. 2007;13(6 Pt 1):281-288.
5. Liu H, Bielinski SJ, Sohn S, et al. An information extraction framework for cohort identification using electronic health records. *AMIA Jt Summits Transl Sci Proc*. 2013;2013:149-153.
6. O'Keefe JH Jr, Zinsmeister AR, Gibbons RJ. Value of normal electrocardiographic findings in predicting resting left ventricular function in patients with chest pain and suspected coronary artery disease. *Am J Med*. 1989;86(6 Pt 1):658-662.
7. Christian TF, Miller TD, Chareonthaitawee P, Hodge DO, O'Connor MK, Gibbons RJ. Prevalence of normal resting left ventricular function with normal rest electrocardiograms. *Am J Cardiol*. 1997;79(9):1295-1298.
8. Nielsen OW, Hansen JF, Hilden J, Larsen CT, Svanegaard J. Risk assessment of left ventricular systolic dysfunction in primary care: cross sectional study evaluating a range of diagnostic tests. *BMJ*. 2000;320(7229):220-224.
9. Sirovich B, Gallagher PM, Wennberg DE, Fisher ES. Discretionary decision making by primary care physicians and the

cost of U.S. Health care. *Health Aff (Millwood)*. 2008;27(3):813-823.

10. Virnig BA, Shippee ND, O'Donnell B, Zeglin J, Parashuram S. *Trends in the Use of Echocardiography, 2007 to 2011*:Data Points #20 (prepared by the University of Minnesota DEcIDE Center, under Contract No. HHSA290201000131). Rockville, MD: Agency for Healthcare Research and Quality; May 2014: AHRQ Publication No. 14-EHC034-EF. Available at:. http://www.ncbi.nlm.nih.gov/books/NBK208663/. Accessed July 1, 2015.
11. Hendel RC, Cerqueira M, Douglas PS, et al. A multicenter assessment of the use of single-photon emission computed tomography myocardial perfusion imaging with appropriateness criteria. *J Am Coll Cardiol*. 2010;55(2):156-162.
12. Willens HJ, Gómez-Marín O, Heldman A, et al. Adherence to appropriateness criteria for transthoracic echocardiography: comparisons between a regional department of Veterans Affairs health care system and academic practice and between physicians and mid-level providers. *J Am Soc Echocardiogr*. 2009;22(7):793-799.