Variation in Routine Electrocardiogram Use in Academic Primary Care Practice

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Background: Lack of practical consensus regarding routine electrocardiogram (ECG) ordering in primary care led us to hypothesize that nonclinical variations in ordering would exist among primary care providers.

Methods: We used 2 computerized billing systems to measure ECG ordering at visits to providers in 10 internal medicine group practices affiliated with a large, urban teaching hospital from October 1, 1996, to September 30, 1997. To focus on screening or routine ECGs, patients with known cardiac disease or suggestive symptoms were excluded, as were providers with fewer than 200 annual patient visits. Included were 69,921 patients making 190,238 visits to 125 primary care providers. Adjusted rates of ECG ordering accounted for patient age, sex, and 5 key diagnoses. Logistic regression evaluated additional predictors of ECG ordering.

Results: Electrocardiograms were ordered in 4.4% of visits to patients without reported cardiac disease. Among the 10 group practices, ECG ordering varied from 0.5% to 9.6% of visits (adjusted rates, 0.8%-8.6%). Variations between individual providers were even more dramatic: adjusted rates ranged from 0.0% to 24% of visits, with an interquartile range of 1.4% to 4.7% and a coefficient of variation of 88%. Significant predictors of ECG use were older patient age, male sex, and the presence of clinical comorbidities. Additional nonclinical predictors included Medicare as a payment source, older male providers, and providers who billed for ECG interpretation.

Conclusions: Variations in ECG ordering are not explained by patient characteristics. The tremendous nonclinical variations in ECG test ordering suggest a need for greater consensus about use of screening ECGs in primary care.

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NONINVASIVE diagnostic testing for cardiac disease has great potential to evaluate conditions that are prevalent and for which specific therapy alters outcomes. Electrocardiograms (ECGs) are the oldest, most widely available, and most frequently used cardiac test.1 Annually, ECGs are ordered in 20 million US physician office visits (2.6% of all visits) and, as a diagnostic test, are exceeded in frequency only by urinalysis, complete blood cell counts, cholesterol tests, and Papanicolaou tests.2

Despite the usefulness of ECGs in evaluating sentinel symptoms of cardiac disease, such as chest pain and palpitations, their role in routine screening for asymptomatic cardiac disease remains controversial. There is no practical consensus on the use of ECGs in primary care, particularly for patients without known or suspected cardiac disease. Current guidelines, however, suggest a limited role for routine ECG testing. Recommendations against screening ECGs have been issued by the US Preventive Services Task Force3 and the Canadian Task Force on the Periodic Health Examination.4 Guidelines of the American College of Cardiology/American Heart Association5 and the American College of Physicians 6 suggest a potential but limited role for baseline testing and for testing in the elderly. When specific documented cardiac risk factors or cardiac disease are present, current guidelines offer greater support for the use of routine ECGs although, even in these situations, the benefit of screening has not been rigorously established.7 Often cited in recommendations against routine use of ECGs are their low sensitivity, only modest specificity, and contribution to health care costs. The cost of ECG testing includes not only its direct costs but also the costs attributable to subsequent diagnostic and therapeutic activities resulting from false-positive or equivocal findings.
In several studies, phy- sician ordering of electrocardiograms (ECGs) has been found to vary widely among primary care physicians. This variability may influence both patient care and physician autonomy. Despite the cautions raised by guidelines, physicians may nonetheless perceive that routine screening ECGs are valuable clinically across a broad range of patients, including those at low risk of cardiac disease. Arguments given in favor of screening ECGs include the value of a baseline ECG before the potential occurrence of cardiac symptoms, the ability of ECG testing to fulfill patients’ expectations regarding diagnosis and monitoring, and a belief that more complete diagnostic testing necessarily improves clinical decision making. It also may be that expectations of peers or patients may lead physicians to order some ECGs in physician settings that were not intended for screening or routine purposes rather than for diagnosis or clinical monitoring. We excluded an additional 22205 patient visits (11% of visits to the included PCPs) with a principal or secondary diagnosis of cardiac disease (codes 391-429, except for 401, 403, and 405 [hypertension and hypertensive renal disease]) or with reported symptoms of chest pain (codes 786.50-786.59) or palpitations (codes 789.0-789.3). Our final database was composed of 125 providers, 69921 patients, and 190238 patient visits.

**STATISTICAL METHODS**

Our analysis had 2 goals: (1) to quantify variation in ECG testing among primary care group practices and providers and (2) to identify patient, provider, and group practice characteristics associated with ECG ordering. Our principal outcome measure was the likelihood of an ECG being ordered at a given patient visit.

We calculated unadjusted rates of ECG ordering for group practices or individual providers as the ratio of ECGs ordered to the total number of visits. We also calculated variation tends to be greatest for those activities where there is the most uncertainty. To evaluate and describe current practices regarding routine ECG use in primary care, we examined the practices of 125 primary care providers (PCPs) in 10 internal medicine group practices at an urban academic medical center. Given the lack of definitive guidelines regarding ECG use and the competing pressures faced by PCPs, we hypothesized that sizable variations in ECG ordering rates would exist and that nonclinical factors would strongly predict ECG use.

For the 190238 visits by patients without reported cardiac disease included in our study, ECGs were ordered in 8357 or 4.4% of visits. There was tremendous variation in ECG ordering at the level of both primary care group practices and PCPs that was not altered substantially by adjustment for patient characteristics. The ECG ordering rates for the 10 group practices varied from 0.5% to 9.6% of visits by patients without cardiac disease. Only modest differences were observed in the expected rates of ECG ordering based on applying global age-, sex-, and diagnosis-specific rates to each
adjusted rates of ECG ordering using indirect standardization to account for the differing patient characteristics between providers. These adjusted rates of ECG use accounted for systematic variation in ECG use that we observed by age, sex, and clinical diagnosis. Following exploratory analysis of ECG rates by patient age, we defined age groups of 30 years or younger, 31 to 50, 51 to 65, and older than 65 years. Exploratory analysis of ECG rates by principal diagnosis identified 5 clinical conditions statistically associated with increased ECG use: hyperlipidemia (ICD-9 codes 272.0-272.7); hypertension (ICD-9 codes 401.0-401.9); dizziness, syncope, and giddiness (ICD-9 codes 780.2, 780.4, 781.2, and 781.3); malaise and fatigue (ICD-9 code 780.7); and general medical examination (ICD-9 codes V70.0-V76.9). A sixth diagnostic category included all other visits.

Using data from all providers, we developed standard rates of ECG ordering for all 48 combinations of age (4 categories), sex (2 categories), and diagnosis (6 categories). These standard rates were applied to the distribution of these characteristics for each provider’s visits to derive an expected number of ECG. The calculation of expected ECGs assumed that for each patient category the provider’s practices would follow the age-, sex-, and diagnosis-specific standard rates derived for all providers. Adjusted rates of ECG ordering were then calculated as the ratio of actual to expected ECGs multiplied by the mean rate of ECG ordering for all providers. This adjustment method allowed us to compare the practices of different providers while accounting for the demographic and clinical characteristics of their patients.

We described variations in ECG ordering behavior between providers using the coefficient of variation and interquartile range. Using provider-specific ECG ordering rates, we calculated the coefficient of variation as the SD divided by the overall mean ordering rate, both weighted by patient visits. The interquartile range represented the ordering rate of the 25th percentile provider compared with the 75th percentile provider.

To further explore potential explanations for variations in ECG ordering, a multiple logistic regression model was developed to predict the likelihood of ECG ordering at specific visits. In addition to the variables of patient age, sex, and diagnosis used to calculate adjusted rates of ECG ordering, this model included provider sex, provider years postgraduation, annual provider visit volume, expected source of payment for the visit, type of primary care practice, and whether the PCP billed separately for ECG interpretation. After 20 visits with incomplete information were excluded, the sample for this analysis included 190,218 office visits. Initial testing of this model indicated significant statistical interaction between 2 pairs of predictor variables. For this reason, we defined combinations of patient sex and age, as well as provider sex and years postgraduation, to capture these interactive effects. We interpreted the effect of predictor variables on ECG ordering by calculating adjusted odds ratios and their 95% confidence intervals.

Our methods using patient visit as the unit of analysis do not explicitly account for the clustered nature of our data, where multiple visits to hospital-affiliated physicians were made by individual patients. However, we also analyzed patterns of ECG use with patients as the unit of analysis, with the probability of 1 or more ECGs in a year as our outcome variable. This analysis indicated similar patterns and variations in ECG use compared with the findings presented here. We opted to use visits as the unit of analysis because diagnostic data and provider assignment were specific to visits.

![Screening electrocardiogram (EGC) use by primary care practice, Massachusetts General Hospital, October 1, 1996, to September 30, 1997. The actual ECG rate is the proportion of applicable visits where a screening ECG was ordered. The expected ECG rate is the rate expected if overall age-, sex-, and diagnosis-specific rates were applied to the characteristics of each group’s patient visits.](image)

This median accounted for 7301 (87.4%) of 8357 ECGs ordered.

We evaluated whether other factors beyond patient demographic and clinical factors explained the observed variations in ECG use. We used a logistic regres-
specific clinical conditions were independently associ-
dering rates were lowest, have traditionally had clinical missions emphasizing services to their communities rather than financial performance. Finally, providers who bill for interpretation of the ECGs had a slightly greater likelihood of ECG ordering than those who did not.

The large magnitude of unexplained variations between providers may result from the lack of a clear consensus on the use of screening ECGs and the potentially conflicting demands faced by providers in applying cardiac diagnostic technology. While evidence-based clinical guidelines generally discourage the use of screening ECGs, this diagnostic test is a traditional feature of office-based internal medicine practice. To the extent that the general public perceives ECGs to be integral to comprehensive ambulatory care, physicians may be compelled to negotiate specific demands from patients regarding ECG ordering.

Although the cost associated with a single ECG is relatively modest, the aggregate cost of ECG testing is substantial given the frequency of ECG ordering among primary care visits. Using an average Medicare-allowed charge of $30 for ECG performance and interpretation (Current Procedural Terminology code 93000), we conservatively estimate that $250,000 is expended in our setting annually for screening ECGs by PCPs. By extension, the annual national cost of all ECG ordering likely exceeds $600 million. In addition, the cost implications of ECG testing extend beyond the test itself. These costs include those associated with follow-up testing of suspicious or false-positive findings. Finally, false-positive findings may serve as an entry point into a diagnostic and therapeutic pathway eventually leading to costly revascularization.

Several limitations of our analysis should be kept in mind. We have used billing information on ECG ordering and patient diagnoses that has not been validated. Because of our data source, we had a limited range of variables available for use in our multivariate statistical model. Other information on providers and patients might have increased our ability to explain the variations we noted. Our results apply to academic internal medicine group practices and may not be generalizable to other settings. However, the observed 4.4% ECG use rate is not substantially different from the 2.6% rate reported for all visits to all US office-based physicians. Finally, while existing guidelines suggest that ECGs may be overused, this study has not attempted to evaluate whether the ordering of specific ECGs was appropriate clinically.

The tremendous variation in ECG ordering that we observed suggests that decision making about this diagnostic test is subject to considerable discretion and uncertainty. Although variation in clinical practice is not necessarily inappropriate, extreme variations suggest that providers are making decisions without a consistent relationship to patient outcomes. The existence of variations despite widely disseminated clinical guidelines suggests that these guidelines have not been particularly influential in guiding clinical practice. More aggressive efforts to fully implement these guidelines into clinical care may be appropriate. Beyond clinical uncertainty about ECG use, an additional contributor to variations may be the lack of feedback available to providers. The ability of providers to compare their practices with their peers also could help PCPs make appropriate decisions about screening ECG use.

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