Variation in Routine Electrocardiogram Use in Academic Primary Care Practice

Randall S. Stafford, MD, PhD; Bismruta Misra, MPH

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 Force[3] and the Canadian Task Force on the Periodic Health Examination.[4] Guidelines of the American College of Cardiology/American Heart Association[5] 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.[3] 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.

From the Primary Care Operations Improvement Team and Institute for Health Policy, Massachusetts General Hospital, Boston (Dr Stafford and Ms Misra); and Howard University College of Medicine, Washington, DC (Ms Misra). Dr Stafford is now with the Stanford Center for Research in Disease Prevention, Palo Alto, Calif.

METHODS

DATA SOURCES

We obtained data on ECG ordering from October 1, 1996, through September 30, 1997, for 10 primary care internal medicine group practices associated with the Massachusetts General Hospital, Boston. These practices included 4 private practices associated with the Massachusetts General Physicians Organization, 3 hospital-based practices, and 3 affiliated health center practices. These practices varied in size from 6 to 20 PCPs, nearly all of whom were internists. Two electronic billing systems, IDX Systems Corp (Burlington, Vt) (for the 4 private practices) and Transition Systems, Inc (Boston) (for the other 6 practices), were used to gather information on patient visits and ECG ordering. In both billing systems, ECG ordering during PCP visits was identified by the presence of at least 1 of the following *Current Procedural Terminology*[20] codes: 93000, 93005, 93010, 93012, 93014, 93224-93237, 93268, 93270, 93271, or 93272.

In addition, these 2 billing systems provided information on patient age, sex, payment source, site of care, and principal and secondary diagnoses. We also linked information about individual patient visits to provider characteristics that were available from the hospital's physicians organization. Provider characteristics included provider type, specialty, years since medical school graduation, and sex. From our billing information, we also determined each provider's annual visit volume and whether providers interpreted their own ECGs or billed for this service. Institutional review board approval was obtained for our data collection and analysis protocol.

Our database initially included information on 220 305 visits by 74 738 patients to more than 300 PCPs. To ensure sufficient sample sizes at the provider level, we excluded providers with fewer than 200 annual patient visits. The excluded providers were mostly internal medicine residents or part-time faculty who had limited clinical practices (total visits, 9882; 4% of total) and were not representative. Most of the 125 included providers were faculty-level internists (86%), with the remainder being nurse practitioners (8%), nurses (3%), and others (3%). Providers were nearly equally distributed between private practices (n=40), hospital-based practices (n=42), and affiliated community-based health centers (n=43).

We focused our analysis on ECGs ordered for screening or routine purposes rather than for diagnosis or clinical monitoring. We excluded an additional 22 205 patient visits (11% of visits to the included PCPs) with a principal or secondary *International Classification of Diseases, Ninth Revision* (*ICD-9*)[21] 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 785.0-785.3). Our final database was composed of 125 providers, 69 921 patients, and 190 238 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

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,[7] the ability of ECG testing to fulfill patients' expectations regarding evaluation,[8,9] and a belief that more complete diagnostic testing necessarily improves clinical decision making.[10] It also may be that expectations of peers or patients may lead physicians to order some ECGs. Although each of these arguments has substantial limitations,[7,11,12] they nonetheless appear to influence physician test-ordering behavior.[9]

Past analyses of ECG use in primary care are limited. National assessments of office-based physician practices indicate that ECG use has not changed between 1979 (2.7% of all US office visits)[13] and 1993 (2.6%).[2] As expected, ECG use increases with increasing patient age.[14] Greater ECG ordering also has been correlated with physician characteristics, including large group practice (compared with small group or solo practice),[15] fee-for-service practice (compared with prepaid practice),[16] more recent physician graduation, and physician specialty training.[17] Several studies suggest that a broad range of physician activities, including the use of diagnostic tests, vary considerably among physicians.[9,18,19] The magnitude of variation tends to be greatest for those activities where there is the most uncertainty.[9]

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.

RESULTS

For the 190 238 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[22] 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).[21] 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.

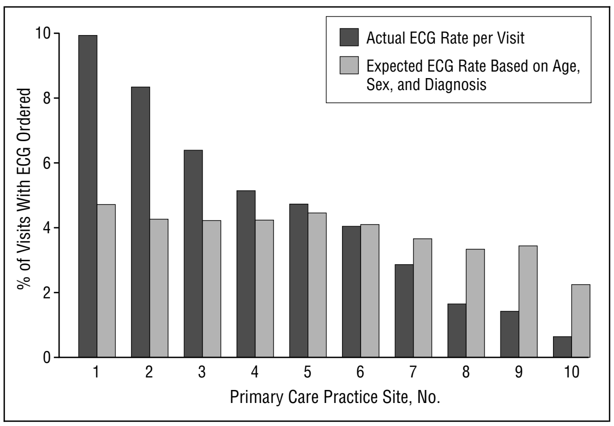
We described variations in ECG ordering behavior between providers using the coefficient of variation and interquartile range. Using provider-specific ECG ordering rates, we calculated the coefficient of variation as the SD divided by the overall mean ordering rate, both weighted by patient visits. The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

practice's visit characteristics (**Figure**). After adjustment for expected ECG ordering, the adjusted rates of the group practices varied from 0.8% to 8.6% of visits. Group practices at hospital-affiliated health centers had an adjusted ECG use rate of 2.0% of visits (range, 1.5%-2.6%), considerably lower than all but 1 of the other group practices. Hospital-based group practices (mean, 6.5%; range, 4.2%-9.6%) and 3 of 4 private practices affiliated with the hospital's physician organization (mean, 6.7%; range, 4.2%-9.6%) had higher rates. The 1 exception to this pattern was a private women's health practice (mean, 0.5%).

Differences between the 125 individual providers were of even greater magnitude, with ECG ordering rates varying from 0.0% to 32% of visits. The coefficient of variation at the provider level was 111% (SD of physician-specific rates [4.9%] divided by overall mean ECG rate [4.4%]). Adjusting for sex, age, and diagnosis narrowed this gap somewhat, although provider-specific adjusted rates still varied between 0.0% and 24% with a coefficient of variation of 88%. The median rate of screening ECG test ordering for all PCPs was 2.5% with an interquartile range from 1.3% (25th percentile) to 5.4% (75th percentile). After adjustment, the interquartile range for the likelihood of ECG testing during a visit was 1.4% to 4.7%. The 63 providers whose testing rates were above this median accounted for 7301 (87.4%) of 8357 ECGs ordered.



Screening electrocardiogram (ECG) 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.

We evaluated whether other factors beyond patient demographic and clinical factors explained the observed variations in ECG use. We used a logistic regres-

Independent Predictors of Electrocardiogram (ECG) Use at Primary Care Visits Based on Multiple Logistic Regression, Massachusetts General Hospital, October 1996 Through September 1997

Predictor	Visits, No. (%)	ECG Rate per Visit, %	Adjusted Odds Ratio (95% Confidence Interval)
Sex/age, y			
M/≤30	8778 (4.6)	1.4	1.00 (Reference)
M/31-50	24 432 (12.8)	4.8	3.43 (2.83-4.15)
M/51-65	16 731 (8.8)	9.0	5.93 (4.89-7.18)
M/>65	16 589 (8.7)	8.1	4.66 (3.82-5.69)
F/≤30	25 121 (13.2)	0.5	0.43 (0.33-0.56)
F/31-50	43 554 (22.9)	2.0	1.73 (1.42-2.10)
F/51-65	26 350 (13.9)	5.2	3.99 (3.29-4.83)
F/>65	28 663 (15.1)	6.5	4.16 (3.41-5.07)
Principal diagnosis			
Visits without listed comorbidities	141 354 (74.3)	3.3	1.00 (Reference)
Hypertension	24 014 (12.6)	7.8	1.75 (1.65-1.85)
General medical examination	11 917 (6.3)	4.7	2.35 (2.14-2.58)
Hyperlipidemia	7165 (3.8)	11.6	2.24 (2.07-2.43)
Dizziness, syncope, and giddiness	2067 (1.1)	12.0	4.19 (3.64-4.83)
Malaise and fatigue	3701 (1.9)	5.9	1.89 (1.64-2.18)
Payer classification			
Medicare	26 951 (14.2)	7.3	1.00 (Reference)
Commercial (age, <65 y)	28 789 (15.1)	5.8	0.80 (0.74-0.86)
Self-pay/ uncompensated care	36 664 (20.9)	3.1	0.59 (0.54-0.65)
Other payment sources	7704 (4.1)	3.3	0.54 (0.47-0.63)
Health maintenance organization (age, <65 y)	69 121 (36.3)	3.8	0.72 (0.66-0.78)
Medicaid	17 989 (9.5)	1.7	0.59 (0.52-0.67)
Total visits to provider per year			
≥2755	46 129 (24.3)	4.5	1.00 (Reference)
2055-2754	47 452 (24.9)	4.9	1.49 (1.40-1.59)
1446-2054	48 706 (25.6)	5.0	1.88 (1.76-2.01)
200-1445	47 931 (25.2)	3.2	0.92 (0.86-0.99)
Provider sex/ postgraduation year			
F/>15	28 942 (15.2)	2.3	1.00 (Reference)
M/>15	66 566 (35.0)	6.9	2.27 (2.06-2.49)
F/≤15	59 285 (31.2)	2.8	1.22 (1.11-1.35)
M/≤15	35 425 (18.6)	4.1	1.70 (1.54-1.89)
Type of primary care practice			
Hospital based	44 163 (23.2)	6.5	1.00 (Reference)
Private practice	75 183 (39.5)	5.4	0.97 (0.90-1.04)
Health center	70 872 (37.3)	2.0	0.35 (0.32-0.37)
Provider bills for ECG interpretation			
No	30 887 (16.2)	4.5	1.00 (Reference)
Yes	159 331 (83.8)	4.4	1.16 (1.07-1.26)
Total	**190 218 (100.0)**	4.4	

sion model that included additional predictors of ECG use, including provider characteristics. The **Table** presents the odds ratio from a logistic regression model developed to predict the likelihood of ECG use at specific visits. This model confirmed that older age, male sex, and specific clinical conditions were independently associated with an increased likelihood of ECG ordering. As expected, older patients were more likely to receive ECGs. Male patients had greater ECG use, but only at younger ages. For patients older than 65 years, adjusted male vs female differences were minimal. All 5 of the selected comorbidities independently increased the odds of ECG ordering.

In the logistic regression model, a range of nonclinical factors had an impact on ECG ordering. Payment source affected ECG ordering so that patients with Medicare as their primary source of payment were the most likely to receive ECGs, whereas patients with Medicaid coverage were the least likely. Providers with either high or low numbers of patient visits ordered ECGs less often than providers in the 2 middle quartiles of annual visits. Male providers were more likely to order ECGs than female providers. This difference was more extreme for providers who were more than 15 years postgraduation (male vs female odds ratio, 2.27) compared with younger providers (odds ratio, 1.39). The strongest predictor of ECG ordering was type of practice, with providers in the hospital-affiliated health centers ordering ECGs only a third as often as providers in hospital-based or private practices.

While not apparent in unadjusted comparisons, screening ECG ordering at primary care visits was 16% more likely for providers who billed for their ECG interpretations. Health center providers (with lower use rates) tend to interpret their own ECGs. Therefore, in the absence of an effect of billing status, on an unadjusted basis, one would have expected ECG use to be much lower in providers who billed for ECG interpretation.

Despite this broad range of clinical and nonclinical predictors, this logistic regression model explained the equivalent of only 5% of the total variation in ECG use at the level of individual visits.

COMMENT

For 10 primary care internal medicine practices affiliated with a large urban academic medical center, we found tremendous variations in the ordering of screening ECGs. These variations were evident both at the level of group practices and individual providers and were not explained by patient sex, age, and principal diagnosis.

A logistic regression model developed to evaluate other potential predictors revealed additional factors associated with variations in ECG use. A range of clinical and nonclinical factors were found to be associated with ECG use. However, most of the statistical variation in ECG use was not explained by these predictors. Contrary to past studies,[17] younger providers were not consistently more likely to order ECGs. Female providers were far less likely to order ECGs, particularly if they had been in practice more than 15 years.

For several of these nonclinical predictors, the results suggest that financial incentives may directly or indirectly influence ECG ordering, a finding consistent with past work.[16] Patients with private insurance or Medicare were more likely to have ECGs ordered compared with patients without health insurance or with Medicaid coverage. The hospital's health centers, where ordering 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),[23] 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.[2] 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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Corresponding author: Randall S. Stafford, MD, PhD, Stanford Center for Research in Disease Prevention, 1000 Welch Rd, Palo Alto, CA 94304 (e-mail: rstafford@stanford.edu).

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