Residency Education

Accuracy of Electrocardiogram Reading by Family Practice Residents

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Objectives: This study evaluated the electrocardiogram (EKG) reading skills of family practice residents. Methods: A multicenter study was carried out to evaluate the accuracy of EKG reading in the family practice setting. Based on the frequency and potential for clinical significance, we chose 18 common findings on 10 EKGs for evaluation. The EKGs were then distributed to residents at six family practice residencies. Residents were given one point for the identification of each correct EKG finding and scored based on the number correct over a total of 18. Results: Sixty-one residents (20 first year, 23 second year, and 18 third year) completed readings for 10 EKGs and were evaluated for their ability to identify 18 EKG findings. The median score out of 18 possible points for all first-, second-, and third-year residents was 12, 12, and 11.5, respectively. Twenty-one percent of residents did not correctly identify a tracing of an acute myocardial infarction. Data analysis showed no statistically significant difference among the three groups of residents. Conclusions: We evaluated the accuracy of EKG reading skills of family practice residents at each year of training. This study suggests that EKG reading skills do not improve during residency, and further study of curricular change to improve these skills should be considered.

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One of the common diagnostic tests available to physicians is the electrocardiogram (EKG). The use of the EKG has become a routine part of the evaluation of patients with cardiac complaints. In the past, many primary care physicians had their office EKG readings verified by a cardiologist. In today's cost-containment environment, reimbursement for such EKG "over reads" is rarely available, and primary care physicians must be prepared to recognize EKG signs of cardiac abnormalities with greater accuracy and recognize when these abnormalities should lead to intervention or specialty referral.

A review of the recent literature in the area of EKG interpretation found few studies on the EKG interpretation skills of family physicians. There have been studies evaluating the benefits of computer interpretations that evaluated concurrence between computer interpretations and those of family physicians and cardiologists. In a series of 301 EKGs ordered over an 11-month period, Wooley et al[1] found that initial readings by family physicians had a 67% level of agreement with the computer reading on diagnoses of potential clinical significance, compared with 76% inter-rater agreement between the cardiologist and computer readings. In a study by Pinkerton et al[2] designed to evaluate EKG interpretation skills of family practice residents, residents failed to identify classic electrocardiographic findings such as acute myocardial infarction and left ventricular hypertrophy in nearly 20% of cases. Items such as limb lead reversal, pericarditis, and right ventricular hypertrophy went unrecognized more than 60% of the time. Even though the EKG reading accuracy increased with additional years of residency training, the performance of many residents still fell short of the standards set for minimal competence in EKG interpretation.

In a study of emergency department physicians' accuracy in EKG reading, Knox et al[3] compared EKG readings by emergency department physicians with

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those of staff cardiology quality-assurance reviewers. If readings were not in agreement, an expert cardiology panel, using a blinding methodology, chose the superior interpretation. Of 1,000 EKGs, the reading for 190 (19%) were significantly discordant. The expert cardiology panel preferred the emergency department reading in 72 cases (38%) and the staff cardiology reading in 118 (62%).

In the study presented here, we compared the EKG reading skills of family practice residents to our gold standard of interpretation by two community cardiologists. The differences among resident years of training in six different residency training programs were examined.

Methods

A multicenter study was carried out to evaluate the accuracy of EKG reading by family practice residents. The study was conducted over a 2-year period, during academic years 1997–1998 and 1998–1999. Subjects included family practice residents from six family practice residencies in two states. Five of six sites were located in the southern California area, and one was located in Texas. The participating family practice residencies included Santa Monica-University of California, Los Angeles (UCLA) Medical Center, Harbor-UCLA Medical Center, Ventura County Medical Center, Northridge Family Practice, Kaiser-Los Angeles Family Practice, and University of Texas Medical Branch in Galveston. The six programs were selected based solely on their interest in participating in the study. The cardiology curricular content of each residency program is shown in Table 1.

Initially we reviewed 100 EKGs performed at our university-owned community hospital and read by a single cardiologist. Based on the frequency and potential for clinical significance, we chose 18 EKGs that presented common findings and used them for evaluation in this study. The EKGs selected were of three general categories: rate and rhythm, conduction abnormalities, and morphology. Table 2 lists the 18 findings chosen.

We then had the 10 EKGs read by a second cardiologist to confirm agreement on the findings to be assessed. Subsequently, the EKGs were distributed as a packet to residents at the six family practice residency programs.

Instructions were given when distributing the EKG packets to residents in all 3 years of training. The instructions stated that residents should interpret each EKG using any resource they typically used to read EKGs, except seeking the help of a colleague. The residents were not provided with clinical information and were asked to write their interpretations at the bottom of each EKG. The survey was anonymous, and residents' interpretations were identified only by the year of training and the family practice residency site.

Data

The Kruskal-Wallis one-way ANOVA by ranks was computed using SPSS version 8.0® to look for differences in the median scores of all three groups of residents. This non-parametric test was chosen based on the skewed distribution of scores within each group of residents and the unequal number of participants for each group. An alpha value of .05 was chosen to indicate significance. The Bonferroni adjustment was used to evaluate differences among individual groups should a statistically significant difference be detected by the Kruskal-Wallis method. Other data were evaluated by using simple proportions and percentages to illustrate trends.

Results

Sixty-one family practice residents (20 first year, 23 second year, and 18 third year) completed the EKG evaluations, and their scores were available for analysis. The percentage of first-, second-, and third-year residents participating in the study averaged across all six programs was 33%, 38% and 30%, respectively.

Table 2 shows the various EKG findings and the percentage of residents who correctly identified that finding. The median number of correct interpretations out of 18 possible correct readings for all first-, second-, and third-year residents were 12 (67%), 12 (67%), and 11.5 (64%), respectively. There was no statistically significant difference in median scores among residents in each of the three cohorts (P=.49). Overall, residents correctly identified all 18 findings approximately 67% of the time. A third-year resident generated the single lowest score (7/18), while one second-year resident scored the highest (17/18).

The EKG finding most consistently identified correctly was normal sinus rhythm. All of the first- and third-year residents, and all but one of the second-year residents correctly identified this reading. The finding least often identified correctly was the right axis deviation. Fewer than 31% of the second- and third-year residents correctly identified this finding, although 65% of the first-year residents did correctly identify it. Only 79% of all residents were able to identify the acute myocardial infarction (MI) shown in Figure 1.

Discussion

Our study demonstrated that residents fail to identify the correct EKG finding 33% of the time. Although this falls within the acceptable range of published values for expert inter-rater agreement of 60% to 70%, many family medicine educators and clinicians would agree that the scores could be improved.[1] An inter-rater agreement of 60% to 70% may or may not be as important, depending on the abnormalities presented. For example, few would argue that failure to identify an acute MI on the EKG has serious clinical repercussions.

Table 1

Cardiology Curricula of Residency Programs That Participated in the Study

Residency Program	ACLS Required	Cardiology Curriculum
Harbor-UCLA Family Practice Residency	No	Cardiology is a 4-week rotation in the second year. A typical day during the rotation consists of EKG interpretation sessions with an attending cardiologist, followed by consultation rounds and didactic sessions. The residents work side by side with internal medicine residents assigned to the service and have identical responsibilities that include the inpatient consultation service, a weekly cardiology clinic, EKG interpretations, and attendance in cardiology teaching rounds. During the cardiology rotation, the residents may provide night coverage on the family medicine service.
Santa Monica-UCLA Family Practice Residency	Yes	In the second year, residents spend a full month on a dedicated cardiology rotation. They are assigned to a cardiologist preceptor, whom they assist in the office with patient visits, in the catheterization lab, in the echocardiography lab, and on inpatient rounds. The preceptor also provides didactic teaching, and recent journal articles or current management principles are frequently discussed. The resident also attends monthly cardiology clinic in the resident's continuity clinic, where residents' patients are evaluated by the preceptor and the family practice resident on cardiology rotation. In addition to this rotation, residents receive teaching in cardiology during their internal medicine rotation and at noon conferences, where cardiac topics are discussed frequently (ie, EKG reading skills).
Kaiser Sunset Family Practice Residency	Yes	Residents get exposure to cardiology patients in the following settings: 1 month in the critical care unit as a second-year resident, care of numerous cardiology cases on inpatient medicine in the 3 months as first-year residents, 3 months as second-year residents, and 3 months as third-year residents. They can also do treadmills as part of the 2-week clinical procedures rotation.
Northridge Family Practice Residency	Yes	All residents care for inpatients with cardiac problems during their rotation on the adult inpatient family medicine service. First- and second-year residents are the primary physicians responsible for the care of the patient admitted with cardiologic problems. The resident requests necessary consultations from the cardiologist and specialists and writes all orders during the admission. During their rotation on the inpatient service, residents have scheduled formal cardiology rounds twice weekly, with informal sessions for patient management teaching and admissions throughout each week. There are no non-family practice residents on the service.
Ventura Family Practice Residency	Yes	Structured experience in cardiology occurs in both inpatient and outpatient settings. In the inpatient service, residents will admit patients with cardiac conditions. Supervision is by the full-time board-certified cardiologist. Cardiology experience is also available in the outpatient clinics as part of the half days in the 'outpatient specialty" blocks. In these three block rotations, the resident will work with faculty one on one in a general cardiology clinic, ischemic heart disease clinic, and in a treadmill clinic. Structured educational experience in cardiology is estimated to be a minimum of 30 hours of outpatient training and a minimum of 1 hour per day during inpatient block rotations or 170 total hours.
University of Texas Medical Branch Family Practice Residency	No	Four-week rotation in cardiac intensive care unit in the first year and a 4-week rotation in "Heart Station" in the second year. The first-year rotation is full time, with call about every fourth night. The Heart Station is 20 hours spent reading EKGs and performing stress tests—the residents do 20–50 stress tests per month.

EKG—electrocardiogram
ACLS—Advanced Cardiac Life Support

In our study, 21% of residents missed the acute MI shown on the EKG in Figure 1.

Our findings justify the need for family practice residency programs to evaluate the EKG reading skills of their residents, evaluate the curriculum currently being used in the residencies, and find effective strategies for teaching EKG interpretation. Our findings also raise a concern about EKG reading skills of family practice residency graduates who are currently practicing clinicians. Unless postgraduation learning has taken place, it is possible that many practicing physicians might also fail to identify key EKG abnormalities like MI.

Limitations

In considering the results of our study, some limitations need to be addressed. As pointed out in our methodology, no clinical scenarios were given with the EKG tracings. As a clinician, the patient presentation and history are a vital tool in diagnosis. It could be argued that EKG tracings alone are not sufficient to guide the

physician. However, in the case of the acute MI, noting any ST segment changes on EKG is routine and does not require a clinical scenario.

A second limitation in our study was the large number of abnormal EKG findings. In a typical family practice office, normal sinus rhythm is the most common EKG finding encountered. Thus, the packet of EKGs presented to the residents was not a true reflection of what a physician would encounter in everyday practice.

Third, the response rate to our EKG study was quite low. Only about one third of residents completed the survey. It is difficult for us to speculate about the characteristics of the residents who submitted their EKG reading interpretations in comparison with those who did not, though one might hypothesize that responding residents were those most interested and most confident in their EKG reading skills. If so, then the nonrespondents may have made even more errors. Clearly, therefore, the low resident response rate limits generalizability and may introduce selection bias. The small number of participants also limits the ability to detect statistically significant differences among residents in each of the 3 years of training.

Table 2

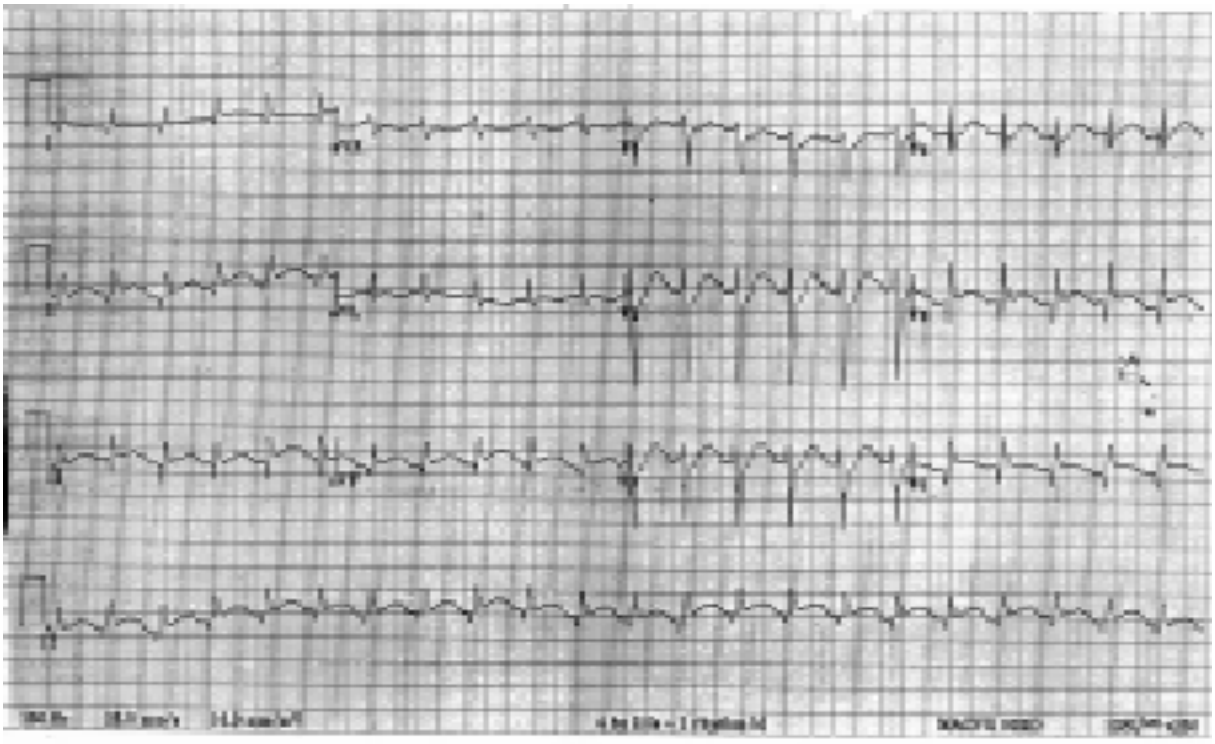
18 EKG Tracings Evaluated in This Study

EKG Reading	% of Residents Who Achieved Correct Reading
Rate and rhythm	
• Normal sinus rhythm (2)	77, 99
• Sinus tachycardia	91
• Sinus bradycardia (2)	83, 86
• Atrial flutter 2:1	46
• Paced rhythm	46
• Atrial fibrillation: rate uncontrolled	63
• Atrial fibrillation: rate controlled	58
Blocks and bundles	
• Right bundle branch block (2)	80, 74
• First-degree AV block	83
• Left bundle branch block	44
Morphology	
• Left ventricular hypertrophy	67
• Old myocardial infarction (MI)	52
• Acute MI: inferolateral ST elevation	79
• Right axis deviation	41

EKG—electrocardiogram
AV—atrioventricular

Figure 1

Electrocardiogram Demonstrating Acute Intero-lateral Myocardial Infarction*



* The myocardial infarction was correctly identified by 79% of residents in the study.

Fourth, because some programs contributed a disproportionately larger number of residents than other programs, direct comparison among all six programs, instead of grouping by year of residency, was not possible. Also, to maintain anonymity, site-specific scores were not reported. Each site did, however, receive a confidential assessment of its residents' performance to allow the sites to address any potential deficits.

Fifth, our analysis did not account for misidentified abnormalities and "overcalls" (ie, indicating more findings than were actually present). For instance, a resident may have noted that a particular EKG had abnormalities indicative of further investigation but would not receive credit for simply noting that it was not normal.

Sixth, there was no accounting for the variable levels of motivation and time spent completing the EKG tracings. Some residents might have spent hours reviewing the EKGs, while others might have done a cursory review of EKG tracings. We have no way of assessing the effort that residents devoted to evaluating the EKG tracings in this study.

Finally, participants in this study did not have the assistance of a computer interpretation of the EKGs. In many primary care settings, the clinician would be able to use the computer reading as an aid to interpretation. A number of studies have demonstrated that access to computer interpretations improves concordance significantly.[4] Nonetheless, the use of computerized EKGs is not a substitute for clinical judgment and the ability to identify important EKG abnormalities.

Curricular Changes

The findings of this study suggest the need for improvement in EKG-reading curricula in residency programs. Some possible curricular changes could include EKG-reading workshops, targeted cardiology rotation curriculum, one-on-one didactic lectures that focus on problem areas for the resident, and self-directed learning with tools such as CD-ROMs. Some logistical problems with EKG workshops include economic constraints, inconvenient locations, and work obligations that might prohibit clinicians from attending workshops. The self-directed learning tools have the advantage of lower cost, ability to self-pace, ongoing availability, usefulness at a variety of knowledge levels, time convenience, and the ability to use modules in different locations. Because these self-directed learning tools have the limitations of need for self-motivation, follow-up testing would be recommended.

A potential curriculum might include incorporating advanced cardiac life support in the resident orientation period. This could provide the new residents with another opportunity to review arrhythmia interpretation and help decrease anxiety during the first code blue.

Evaluation of residents with regard to EKG reading accuracy could also be incorporated into the family practice curriculum. A package of EKGs could be distributed to all incoming residents, similar to what was done in this study. The faculty would identify the areas of weakness in EKG knowledge and a remediation program could be implemented to include specific readings, practice interpretations of selected EKGs, and one-on-one review of practice tracing with a faculty member.

Finally, effective teaching of the EKG interpretation requires that the faculty possess excellent EKG-reading skills. Our study did not assess the EKG-reading abilities of family medicine faculty to determine how their performance compared to those of the residents. This part of curricula redesign will require programs to self-assess their own EKG reading skills to ensure that they have the requisite knowledge to teach these skills to their residents.

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