The Influence of Race and Gender on Time to Initial Electrocardiogram for Patients with Chest Pain

Kevin M. Takakuwa, MD, Frances S. Shofer, PhD, Judd E. Hollander, MD

Abstract

Objectives: To determine whether race or gender affected time to initial electrocardiogram (ECG) for patients who presented to an emergency department with chest pain.

Methods: This was a prospective cohort study of patients with chest pain. Patients were divided into three groups based on final diagnosis of acute myocardial infarction or unstable angina and all others with noncardiac chest pain. Data were analyzed using ranks in a two-way analysis of covariance adjusted for age.

Results: A total of 4,358 patients were studied; 58.6% were women and 41.4% men, and 70.3% were African American, 26.0% white, and 3.6% other. Overall, nonwhite patients had longer times to initial ECG compared with white patients. These effects were consistent regardless of ultimate diagnosis. Overall, women had longer times to initial ECG than men. However, ECG time differed by final diagnosis. There were no differences in time to ECG for women compared with men with acute myocardial infarction or unstable angina, but women received an ECG significantly slower than men for noncardiac chest pain.

Conclusions: The first screening test for acute coronary syndrome, the ECG, took longer to obtain for nonwhite patients, regardless of final diagnosis. This was unfortunately consistent with the literature that shows racial disparities in all aspects of emergent cardiac care. For women, the overall delay in ECG time can be explained by delays for those women with noncardiac chest pain.

ACADEMIC EMERGENCY MEDICINE 2006; 13:867–872 © 2006 by the Society for Academic Emergency Medicine

Keywords: electrocardiogram, time, gender, race, chest pain, acute coronary syndrome

There are known disparities in cardiac care based on race[1–5] and gender.[1–3,5,6] This has been seen in virtually all aspects of care, from the emergency department (ED) to in-hospital care. Few studies have examined differences in the time to electrocardiogram (ECG), the first diagnostic test that should be performed on patients who present to the ED with symptoms consistent with acute coronary syndrome (ACS). The ECG in conjunction with timing of symptoms often determines whether a pharmacologic strategy (e.g., heparin, G2b3a inhibitor, thrombolysis) or percutaneous intervention will be immediately used. The American College of Cardiology/American Heart Association guidelines specify that an ECG should be obtained and interpreted within ten minutes of suspicion of ACS or arrival to an ED.[7,8] In practice, there should be no race or gender differences in the time to obtain an ECG.

We are unaware of any large study to date that has quantified actual ECG times according to both race and gender. Determining whether such disparities exist in any aspect of medical care, especially a simple test that is done at a critical juncture point and that can direct immediate cardiac interventions known to result in improved morbidity and mortality, is a first step in evaluating performance of patient care. Uncovering why differences may exist is the next step before enacting strategies in an attempt to mitigate any differences that might be found. We wanted to determine if there were race or gender differences in the time to initial ECG for those with time-sensitive ACS, and to then quantify any differences found.

From the Department of Emergency Medicine, Thomas Jefferson University (KMT), Philadelphia, PA; and Department of Emergency Medicine, Hospital of the University of Pennsylvania (FSS, JEH), Philadelphia, PA.

Received January 24, 2006; revision received March 21, 2006; accepted March 23, 2006.

Presented at the SAEM annual meeting, Boston, MA, May 2003, and the American College of Emergency Physicians annual meeting, Boston, MA, October 2003.

Address for correspondence and reprints: Kevin M. Takakuwa, MD, Thomas Jefferson University, 1020 Sansom Street, Suite 239 Thompson Building, Philadelphia, PA 19107. Fax: 215-955-6844; e-mail: kevin.takakuwa@jefferson.edu.

doi: 10.1197/j.aem.2006.03.566
ISSN 1069-6563
PII ISSN 1069-6563583

METHODS

Study Design

Standardized data were collected in all patients presenting with chest pain who required an ECG. We tested the null hypothesis that race and gender would not affect the time to initial ECG. The study was approved by the University of Pennsylvania Committee on Research Involving Human Subjects.

Study Setting and Population

This study was conducted at the Hospital of the University of Pennsylvania, an urban tertiary care hospital with an ED that has an annual census of approximately 49,000 adult visits. About 2,000 of the yearly ED census are patients with chest pain.

Patients 24 years of age or older who presented to the ED between July 6, 1999, and March 25, 2002, with a complaint of chest pain prompting an ECG were included. "Chest pain" did not have to be the chief complaint. Patients younger than 24 years of age were included if they reported cocaine use. Patients were excluded only if they were younger than the stated ages, did not have chest pain, or did not have an ECG obtained. We only included patients with chest pain so we could more clearly define our study population and allow generalizability of the data. We did not specify any clinical impression of cardiac or noncardiac chest pain and included a broad range of ages to enhance generalizability.

Study Protocol

During the study period, trained research assistants were present in the ED 16 hours per day, from 8 AM to midnight, seven days per week, to identify and enroll patients. Patients were treated in the ED by a full-time board-certified or board-eligible emergency physician working alone or in conjunction with housestaff.

Measurements

Regardless of the manner of transport to the ED, once the patient arrived, triage time was set as time 0 in our computerized system. Nurses triaged patients based on their history and general appearance. The length of time until a patient was placed into a room was variable and could range from minutes to hours. ECGs were not obtained in triage. ECGs could be obtained only after patients were placed into an ED examination room. We did not record "in room" time. Most patients arriving by fire rescue are placed in the main ED, some in rooms and some in hallways. Once any patient was placed in a room, ECGs could be ordered by the nurse, house officer, or attending physician.

Patients underwent a structured history and physical examination either at or sometime after ED room or hallway placement. Patient information collected prospectively in the ED included demographic information, vital signs, cardiac risk factors, characteristics of chest pain, associated symptoms, medications, treatment, and disposition. Admitted patients were followed up daily throughout their hospital course. Follow-up was obtained 30 days after presentation by telephoning patients or their proxies. We assumed that if patients or their proxies reported no further problems, then they did not have ACS.

Race and Gender Information. Race and gender were recorded by trained research assistants and classified based on the patient's appearance. When it was not obvious, patients were questioned. This protocol was designed to mimic the way clinicians assess this information in patients.

ECG Information. ECG time was calculated as the difference between the computer-stamped ECG time on the actual ECG and triage time. Triage time was identified by a computer-generated time stamp in the hospital electronic patient tracking system as the time when the patient triage process began. Our institution complies with Joint Commission on Accreditation of Healthcare Organizations–mandated bioengineering inspections of equipment, including ECG machines.

Cardiac Biomarker Assays. For admitted patients, venous blood samples were collected on presentation to the ED in phlebotomy tubes containing no anticoagulant or preservative. Cardiac troponin I, creatine kinase, and creatine kinase-myocardial band (CK-MB) assay were routinely performed.

Definition of ACS. Acute coronary syndrome was defined as a diagnosis of acute myocardial infarction (AMI) or unstable angina (USA) in accordance with the American College of Cardiology and European Society of Cardiology criteria.[9] A diagnosis of AMI was made if the patient had an elevation of cardiac troponin I level $\geq$2 ng/mL or CK-MB enzyme level $\geq$10 ng/mL. USA was considered to occur if there was documented reversible ischemia on a stress test, coronary artery occlusion $\geq$70% in at least one vessel as seen during cardiac catheterization, or elevations of cardiac enzyme levels above laboratory normal but below levels necessary for diagnosis of AMI (troponin I level $\geq$0.4 ng/mL but <2 ng/mL; CK-MB level $\geq$5 ng/mL but <10 ng/mL), in accordance with the standardized guidelines.[10]

Patients who did not meet the definitions of AMI or USA were classified as having noncardiac chest pain. Included in this group were some patients who underwent an ECG but not analysis of cardiac markers. A comparison of patients without markers to those with markers that were negative showed that the patients without markers were a lower-risk group. We therefore believed it was reasonable to group these patients together under noncardiac chest pain.

Data Analysis

To examine differences between race and gender with regard to the time to ECG, an analysis of covariance was performed adjusting for age. Final diagnosis and an interaction term between race and/or gender and final diagnosis were also included in the model. We performed our analysis in several ways, including ordinary least squares and Mantel–Haenzel chi-square. Because of the large floor effect (25% of patients had time to ECG <6 minutes) and the non-normality of the data, the means were highly skewed to the right and did not represent true central tendency of the data in the ordinary least squares model. For this reason, we chose to transform the data. We used ranks as opposed to natural log because it more closely represented medians and because the natural log of 0 is undefined. Categorical data analysis affirmed what we found in the analysis of covariance. Data are presented as median initial time to ECG with interquartile ranges (IQRs). For analysis purposes, race was divided into two groups: nonwhite and white. All analyses were performed using SAS statistical software (version 9.1; SAS Institute, Inc., Cary, NC).

RESULTS

Of 4,492 total patient visits, 4,358 (97%) had complete information and were included in this study. The mean (±SD) age was 52.2 (±15.7) years. Of these, African American patients comprised 70.3% (n = 3,065), white patients comprised 26.0% (n = 1,134), and patients of other ethnicities comprised 3.6% (n = 159). Women comprised 58.6% (n = 2,552) and men 41.4% (n = 1,806) of the study population. Chest pain characteristics, past medical history, and cardiac history are shown by race in Table 1 and by gender in Table 2.

Race

When adjusted for age and final diagnosis, white patients received an ECG significantly faster (24 minutes; IQR, 2–63 minutes) than nonwhite patients (39 minutes; IQR, 7–85 minutes; p = 0.01). This difference persisted regardless of final diagnosis category. The median time for nonwhite patients to undergo an ECG was 21 minutes (IQR, 0–50 minutes) compared with ten minutes (IQR, 0–47 minutes) for white patients with AMI and 25 minutes (IQR, 3–62 minutes) compared with 15.5 minutes (IQR, 1–52 minutes) for white patients with USA. The difference in ECG time, however, was largest for patients with noncardiac chest pain. In this diagnostic group, the median time for nonwhite patients to receive an ECG was 43 minutes (IQR, 9–91 minutes) compared with white patients at 28 minutes (IQR, 3–67 minutes), for a difference of 15 minutes (Figure 1).

Table 1
Chest Pain Characteristics and Past Medical History by Race

	Nonwhite Patients		White Patients		
	n	%	*n*	%	p-value
Chest pain characteristics					
Chest pain chief complaint	1,943	60	696	61	0.53
Pain location left chest	1,317	41	435	38	0.16
Pain location midchest	1,237	38	464	11	0.13
Quality: pressure*	1,345	42	519	46	0.02
Radiates to neck/left arm	912	28	347	61	0.15
Past medical history					
Hypertension*	1,685	52	444	39	<0.0001
Diabetes*	608	19	168	15	0.002
Tobacco*	1,240	38	398	35	0.05
Family history*	622	19	254	22	0.03
Increased cholesterol*	481	15	286	25	<0.0001
Prior acute myocardial infarction	354	11	134	12	0.38
Known coronary artery disease*	552	17	304	27	<0.0001
Known angina*	385	12	172	15	0.006
Congestive heart failure*	342	11	96	8	0.04

*p ≤ 0.05.

Table 2
Chest Pain Characteristics and Past Medical History by Gender

	Women		Men		
	n	%	*n*	%	p-value
Chest pain characteristics					
Chest pain chief complaint*	1,502	59	1,137	63	0.007
Pain location left chest*	958	38	794	44	<0.0001
Pain location midchest*	1,055	41	646	36	<0.0001
Quality: pressure	1,099	43	765	42	0.69
Radiates to neck/left arm	720	28	539	30	0.25
Past medical history					
Hypertension	1,278	50	851	47	0.06
Diabetes	469	18	307	17	0.24
Tobacco*	843	33	795	44	<0.0001
Family history	511	20	365	20	0.88
Increased cholesterol*	414	16	353	20	0.005
Prior acute myocardial infarction*	228	9	260	15	<0.0001
Known coronary artery disease*	433	17	423	23	<0.0001
Known angina*	294	12	263	15	0.003
Congestive heart failure	249	10	189	10	0.44

*p ≤ 0.05.

Gender

Men were significantly more likely to receive an initial ECG sooner (28 minutes; IQR, 4–64 minutes) than women (40 minutes; IQR, 7–89 minutes; p = 0.009). This difference, however, was only seen for the noncardiac chest pain group. For time-sensitive ACS, there were no significant time differences to the initial ECG between women and men in the AMI or USA groups. The median time to

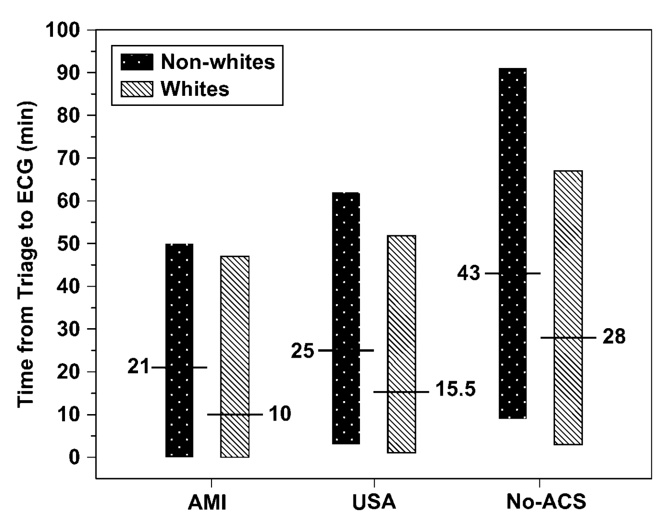

Figure 1. ECG time by diagnosis and race. Bars represent interquartile ranges, and cross lines represent median values.

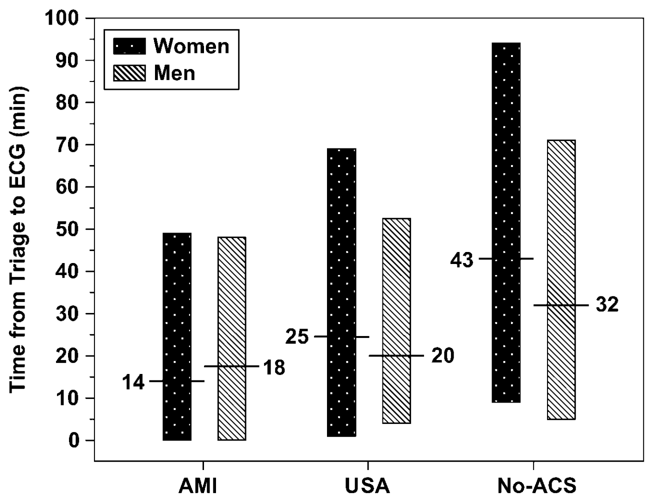

Figure 2. ECG time by diagnosis and gender. Bars represent interquartile ranges, and cross lines represent median values.

ECG was 14 minutes (IQR, 1–49 minutes) for women and 17.5 minutes (IQR, 0–48 minutes) for men who had a final diagnosis of AMI (p = 0.67). The median time to ECG was 24.5 minutes (IQR, 1–69 minutes) for women and 20 minutes (IQR, 4–53 minutes) for men who had a final diagnosis of USA (p = 0.08). There was a significant gender difference for the chest pain patients with noncardiac chest pain. In this diagnostic group, women had a significantly longer median time to receive an initial ECG (43 minutes) compared with men (32 minutes; $p < 0.0001$; Figure 2).

DISCUSSION

Race

Our results show that nonwhite patients had initial ECGs performed later than white patients. Nonwhite patients waited longer for initial ECGs in all final diagnosis categories, including ACS. There are several possible explanations for these findings. First, it is possible that belonging to a smaller group in terms of census led to white patients being treated differently. Perhaps by standing out more, white patients, who made up approximately one fourth of the ED patient population, consequently received greater attention regarding their chest pain complaint.

Another plausible explanation is that the pretest probability of ACS was higher in white patients than nonwhite patients at our hospital. The ED nursing staff, which largely determines whether a patient receives an immediate ECG, might have consciously or subconsciously recognized the pattern through experience that white patients at our hospital are more likely to have ACS than African American patients. As it turns out, 25.8% of white patients with chest pain had ACS, whereas 17.0% of nonwhite patients had a final diagnosis of ACS. The staff may have therefore worked faster to get early ECGs for this group.

However, the increased prevalence of a family history of coronary artery disease in white patients should have been balanced out by the increased prevalence of diabetes in nonwhite patients (19% compared with 15% for white patients). It is well established that the risk of coronary artery disease is increased in people with diabetes.[11–13] Perhaps the nursing staff failed to recognize the increased incidence of diabetes as a significant risk factor in nonwhite patients.

Another possibility is that African American patients, who made up 95% of the nonwhite patients in this study, might present with more atypical cardiac symptoms than white patients,[14–17] resulting in delayed ECGs. One study suggested that there might be racially mediated biological differences in African American patients[18] that translate into differences in cardiac symptoms. Another study found that African American patients were less likely to attribute their chest pain to a cardiac etiology,[19] which might have influenced hospital staff and delayed initial time to ECG.

One study reported that African American patients with a primary complaint of chest pain were less likely than white patients to be admitted to the hospital,[20] and another study on a computerized survey instrument found that physicians' estimates of the probability of coronary artery disease were lower for African American patients.[21] These studies may reflect a sentiment that African American patients with chest pain are not as likely to have ACS and generally are not taken as seriously as white patients. It is also possible that ECGs were ordered later in African American patients to screen patients with lower initial suspicion of coronary artery disease or due to heightened awareness that not all patients with ACS present typically.

The racial findings cannot be clearly explained by differences in chest pain characteristics, past medical history, or past cardiac history (Table 1). Broad inclusion criteria were used to capture all patients who might have ACS, and this study did not require chest pain to be a chief complaint. Both minority patients and white patients had the same chest pain characteristics with regard to chief complaint, left-sided or midchest pain, and radiation to the neck or left arm. However, white patients described their chest pain as pressure more often than minority patients. In addition, nonwhite patients were more likely to have hypertension, diabetes, a history of smoking, and chronic heart failure, while white patients were more likely to have a family history of cardiac disease, increased cholesterol levels, known heart disease, and known angina.

Regardless of the reasons why there were racial differences noted in the time to ECG, the differences are concerning, especially because we serve such a large minority population. As a result of the data from this study, our ED now performs ECGs at triage, based on defined criteria, and has established a ten-minute rule for obtaining an ECG in any patient who has chest pain or symptoms consistent with ACS. If all hospitals uniformly adapted the American College of Cardiology/American Heart Association guidelines,[7,8] we suspect race and gender differences, at least with respect to getting a screening ECG, would be eliminated.

Gender

There were no significant differences in time to initial ECG for women with ACS compared with men. In fact, the overall delayed effect for women was due to patients with noncardiac chest pain receiving ECGs later than men. We have several explanations for our findings. One possibility is that men are being "overtreated." That is, men who are identified as lower suspicion for ACS are getting faster initial ECGs when they are not needed. Our data show that ECG times were the same for the two ACS diagnoses. For both women and men with noncardiac chest pain, however, times to ECG were longer, but more so for the women. This may be a similar phenomenon to the "overuse" of angioplasty in white men,[22] where white men without disease received a higher level of treatment than women and African American patients without disease.

Men may also have received ECGs faster because they have a higher pretest probability of having disease. Demographically, men are at higher risk for coronary heart disease and AMI than are women,[23] so even without classic symptoms of ACS, men still received ECGs faster.

Another explanation for the gender differences may be due to the belief that women present with symptoms of ACS differently than men,[24] although this belief has been questioned.[25] Perhaps physicians ordered the ECGs later in this group because women did not report classic cardiac chest pain symptoms or there was a low suspicion of coronary disease. Further, there might have been an inherent gender bias on the part of the nurses who are mostly women and who largely determined who received an immediate ECG.

When patients come to the ED, no staff member knows what the final diagnosis will be. That the hospital staff was able to recognize the acuteness of ACS and get ECGs equally fast regardless of gender demonstrates that gender did not influence early treatment of ACS. We unfortunately cannot say the same about race.

Other Studies

We performed a MEDLINE search using the keywords "ECG," "electrocardiogram," "time," "sex," "gender," and "race" and found few articles relevant to this study. One study, based on a national registry, found that the overall proportion of those receiving an ECG was higher for men than women and for white patients compared with African American patients.[26] However, for patients 55 years or older, there were no race or gender differences. We wonder if these results reflect a higher suspicion of cardiac disease in younger white patients and men, overtreatment of younger white patients and men, or lack of suspicion of disease and consequent undertreatment of younger African American patients and women. A limitation to this study is that it is a retrospective study based on medical record review. Another limitation is that only percentages of patients by gender and race receiving ECGs are reported, not actual times to ECGs.

A small study on race and gender found similar results to our study, that African American patients waited longer for an ECG than white patients and there were no gender differences.[27] Limitations to this study were a small size (n = 379) and that the study was based on a retrospective chart review. Another study showed that women with chest pain had fewer ECGs than men,[28] and another found that women waited longer for ECGs.[29] A study about gender differences in thrombolytic therapy noted that women had a longer time to ECG by seven minutes compared with men.[30]

LIMITATIONS

Our study is limited by its single location in an urban academic environment. The results may be applicable to an inner-city population that sees a predominantly African American population but are not generalizable to suburban or rural populations or hospitals that treat a different race and gender mix. Our data cannot be generalized to patients with "anginal equivalents" in the absence of chest pain. Another limitation is that a few of the ECG times were not recorded accurately on the cardiogram due to an incorrect setting of the clock timer. These patients had handwritten times on the ECGs. We also did not perform any specific validation of ECG times. However, this should not make a difference in our results because any inaccuracies would be expected in all ECGs obtained, regardless of patient race and gender.

We also note that race and gender were recorded by trained research assistants and classified based on the patient's appearance to mimic the way clinicians assess this information in patients. It is possible that this information was incorrect. However, because the self-reported demographics of our patient population show that the majority of patients seen in our ED are either white or African American, it is unlikely that race was often misclassified. Thus, our study is limited to the perception of race as opposed to actual race. Finally, there was no research assistant between midnight and 8:00 AM, limiting data collection to daytime and evening hours.

CONCLUSIONS

Nonwhite patients with chest pain waited longer for ECGs than white patients, regardless of final diagnosis. These findings are consistent with the literature that shows that African American patients receive worse emergent cardiac care than white patients. In contrast, women overall waited longer to get initial ECGs than men, but this could be explained by women without ACS waiting longer for ECGs. Women with ACS received their ECGs as promptly as men with the same diagnosis.

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