

Racial Differences in Coronary Artery Calcification in Older Adults

Anne B. Newman, Barbara L. Naydeck, Jeff Whittle, Kim Sutton-Tyrrell,
Daniel Edmundowicz, Lewis H. Kuller

Abstract—Reports on race-related differences in coronary artery calcium (CAC) are just beginning to emerge and have not been well studied in the elderly. This study was undertaken to assess whether such differences exist and the relationship between CAC and cardiovascular risk factors in a cohort of elderly community-dwelling adults. CAC was measured by using electron-beam tomography in 614 adults (aged 67 to 99 years), of whom 59% were women and 23% were black. The median CAC score was lower in blacks than in whites for men (159 versus 787, respectively; $P<0.001$) and for women (134 versus 233, respectively; $P=0.02$) after adjustment for age, cardiovascular disease, and risk factors for cardiovascular disease, although this difference was stronger and remained significant among men only. Lower CAC scores were also observed in the subgroup of blacks with a history of myocardial infarction. The lower CAC scores in blacks compared with whites observed in this study is consistent with either a lower prevalence of coronary artery disease or a lower extent of calcification of coronary artery disease. (*Arterioscler Thromb Vasc Biol.* 2002;22:424-430.)

Key Words: coronary artery calcification ■ race ■ elderly ■ cardiovascular disease

There is still uncertainty regarding differences between blacks and whites in the prevalence, progression, and risk of coronary artery disease (CAD). Mortality rates from CAD are higher in black women than in white women,¹ and blacks with acute myocardial infarction (MI) have been reported to have poorer survival after hospitalization in some, though not all, studies.^{2,3} Compared with whites, blacks tend to have more carotid disease and left ventricular hypertrophy by noninvasive testing,⁴ yet blacks undergoing angiography for clinical symptoms tend to have a lower extent of coronary disease than do whites.⁵ Moreover, there is evidence that the patterns of CAD have evolved in these groups over time, perhaps in different ways, complicating the simultaneous interpretation of current and earlier studies.

See page 359

Blacks have higher rates of hypertension⁶ and diabetes² than do whites. In a cohort of older adults, blacks, compared with whites, had a higher prevalence of clinical cardiovascular disease (CVD) and a similar prevalence of subclinical CVD, which were largely explained by the higher prevalence of risk factors.⁴ These risk factors might be expected to lead to a higher prevalence of CAD.^{2,7,8}

Coronary artery calcification has shown good correlation with angiographically diagnosed CAD.⁹ The ability to non-invasively quantify coronary artery calcium (CAC) by using electron-beam tomography (EBT) offers the potential to

address some of the issues related to prevalence of CAD in specific populations and the relationship of CAD to (and possible interactions with) risk factors. Reports on differences in CAC by race are just beginning to emerge. Two studies using EBT^{10,11} reported similar levels of calcium in blacks and whites, whereas 1 fluoroscopy study reported a lower prevalence of calcification in a middle-aged, predominantly male, black population.¹²

We have completed a study of CAC in older adults, one quarter of whom were black. In the present report, we describe the prevalence and extent of coronary artery calcification and determine whether the observed racial differences in CAC could be explained by differences in cardiovascular risk factors.

Methods

Participants from the Pittsburgh, Pa, Cardiovascular Health Study (CHS) field center were recruited to return for EBT between May 1998 and June 2000.¹³ The CHS was established to determine the risk factors for CVD in older adults.^{14,15} Of 727 participants seen at the final examination, 614 (84%) underwent EBT scanning. Nonparticipants were either too ill or could not travel (61%), had died after the last clinic visit (16%), or had refused to participate (23%). Of note, an additional cohort (mostly black) was added 3 years after the initial enrollment; thus, most of the minority participants were somewhat younger than the original, mostly white, cohort at the time of the scan. All gave informed consent for a protocol that was approved by the Institutional Review Board of the University of Pittsburgh.

Received September 19, 2001; revision accepted November 5, 2001.

From the Division of Geriatric Medicine (A.B.N., B.L.N.) and the Department of Epidemiology (A.B.N., K.S.-T., D.E., L.H.K.), University of Pittsburgh, and the Geriatric Research Educational and Clinical Center (J.W.), Pittsburgh VA Healthcare System, University of Pittsburgh School of Medicine, Pittsburgh, Pa.

Correspondence to Anne B. Newman, MD, MPH, University of Pittsburgh School of Medicine, Division of Geriatric Medicine, 3520 Fifth Ave, Suite 300, Pittsburgh, PA 15213. E-mail anewman@pitt.edu

© 2002 American Heart Association, Inc.

Arterioscler Thromb Vasc Biol. is available at <http://www.atvbaha.org>

DOI: 10.1161/hq0302.105357

TABLE 1. Baseline Risk Factors and Prevalence of CVD by Race and Sex: the CHS (N=614)

	Women			Men		
	White (N=282)	Black (N=85)	<i>P</i>	White (N=189)	Black (N=58)	<i>P</i>
Age (mean±SD at time of EBT), y	80.5±3.8	78.6±4.2	0.0001	81.2±4.3	79.3±4.7	0.005
Age category, n (%)						
67–74 y	9 (3.2)	19 (22.4)		3 (1.6)	14 (24.1)	
75–79 y	131 (46.5)	35 (41.2)		84 (44.4)	21 (36.2)	
80–99 y	142 (50.4)	31 (36.5)	<0.0001	102 (54.0)	23 (39.7)	<0.0001
Baseline CVD risk factors						
Hypertension, n (%)	67 (24.3)	48 (56.5)	<0.0001	53 (28.3)	22 (37.9)	0.166
Diabetes, n (%)	19 (6.9)	20 (23.8)	<0.0001	24 (13.0)	14 (24.1)	0.042
BMI (mean±SD)	26.3±4.6	29.4±4.6	<0.0001	26.2±3.3	27.7±4.4	0.024
Ever smoked cigarettes, n (%)	164 (58.4)	44 (51.8)	0.281	114 (60.3)	41 (70.7)	0.153
Median pack-years for those who smoked	24.8	22.0	0.89	28.5	15.0	0.037
COPD, n (%)	73 (26.1)	28 (33.3)	0.19	32 (17.0)	10 (17.2)	0.97
Baseline laboratory values						
Total cholesterol (mean±SD), mg/dL	211.6±31.1	206.0±36.1	0.164	187.2±32.5	185.3±33.9	0.70
HDL (mean±SD), mg/dL	57.4±15.5	56.6±12.1	0.611	45.6±9.4	49.5±11.0	0.010
LDL (mean±SD), mg/dL	125.9±30.3	119.4±34.7	0.097	115.4±29.8	111.1±31.2	0.349
Triglycerides (median), mg/dL	121.0	105.0	0.027	117.0	83.0	0.0003
Fibrinogen (median), mg/dL	314.0	345.0	0.001	301.0	322.0	0.064
C-reactive protein (median), mg/dL	1.85	2.45	0.035	1.40	2.39	0.003
Atherosclerosis group						
None/undetected (205), n (%)	107 (37.9)	24 (28.2)		57 (30.2)	17 (29.3)	
Subclinical CVD (205), n (%)	100 (35.5)	30 (35.3)		53 (28.0)	22 (37.9)	
Clinical CVD (204), n (%)	75 (26.6)	31 (36.5)	0.14	79 (41.8)	19 (32.8)	0.31
History of MI, n (%)	25 (8.9)	10 (11.8)	0.43	30 (15.9)	6 (10.3)	0.30

COPD indicates chronic obstructive pulmonary disease. For atherosclerosis group, the numbers in parentheses indicate the number of individuals in the atherosclerosis subgroup.

Coronary Artery Calcification

Coronary artery calcification was assessed with an Imatron C-150 scanner by the Agatston scoring method,¹⁶ as previously described.¹³ The present analysis uses the total CAC score.

Demographic and Cardiovascular Risk Factors

The present cohort consisted of 471 white and 143 black participants. Two participants of mixed race were included as black. Age is from the time of EBT scan, and cardiovascular risk factors were assessed between 1992 and 1993. Blood pressures were measured according to a standard protocol. Hypertension was defined as a seated average systolic blood pressure >160 mm Hg or seated average diastolic blood pressure >95 mm Hg or self-reported hypertension and use of antihypertensive medication. Blood was collected and analyzed at the 1992 to 1993 examination,¹⁷ with the exception of C-reactive protein, which was run on stored baseline samples in 1997.¹⁸ Diabetes was defined as the use of insulin or oral hypoglycemics or as a glucose level >126 mg/dL (7.0 mmol/L).¹⁹ Body mass index was calculated from height and weight (in kilograms [weight] per meter [height] squared). Cigarette smoking was reported as ever smoker versus never smoker, because there were few current smokers. Smoking exposure was assessed as pack-years of use. Chronic obstructive pulmonary disease was defined by self-report of asthma, bronchitis, or emphysema.

Definitions of CVD

Prevalent clinical CVD was ascertained at the time of the scan by using baseline and adjudicated events data. Baseline self-report data were validated by medical records.²⁰ Events occurring after baseline

were ascertained via phone contact or at the clinic examination every 6 months, validated by medical record review, and adjudicated by committee.²¹ CVD included physician diagnosis of MI, treated angina, coronary artery bypass surgery, percutaneous transluminal coronary angioplasty, congestive heart failure, stroke or transient ischemic attack, carotid surgery, peripheral vascular bypass surgery, angioplasty, or intermittent claudication. Subclinical CVD was assessed at the 1992 to 1993 examination and was defined as an ankle-arm index <0.90, internal carotid or common carotid wall thickness greater than the CHS population 80th percentile, carotid stenosis >25%, major ECG abnormalities, or a positive Rose questionnaire²² for angina or intermittent claudication in the absence of a clinical diagnosis of prevalent clinically manifest CVD.⁴

Statistical Analysis

The CAC score was highly skewed and was not transformed to normality by common transformations; therefore, analyses used median CAC scores or the score in quartile cut points. Demographics and CVD risk factors were described, and the relationships between these characteristics and the CAC score were determined in race-sex strata by using χ^2 or Fisher exact tests for categorical variables and Student *t* tests or nonparametric tests for continuous variables, with a 2-sided *P*<0.05 level used to assess statistical significance. Spearman correlations were used to assess relationships between the CAC score and other continuous variables. Stepwise ordinal logistic regression was used to test sex-specific associations between CAC score quartile and race, controlling for age at scan, clinical CVD, and CVD risk factors. Analyses were performed by using the SAS system (Statistical Analysis System, version 8.0 for Windows).

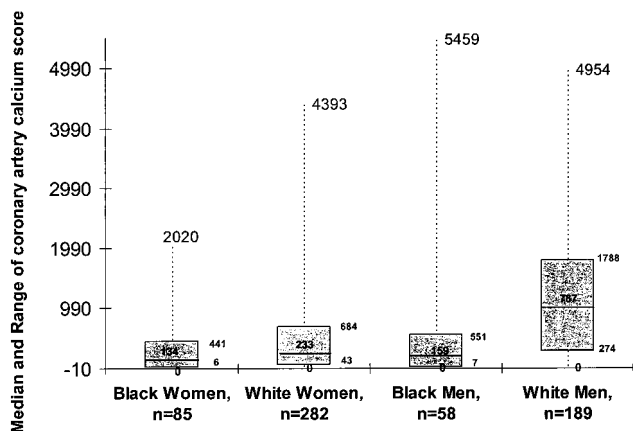


Figure 1. Distribution of CAC scores by sex and race: the CHS, Pittsburgh (n=614).

Results

CAC was assessed in 367 (282 white and 85 black) women and 247 (189 white and 58 black) men. Although the prevalence of clinical CVD and prior MI was similar in blacks and whites, cardiovascular risk factors varied in sex-stratified analysis (Table 1). Hypertension and diabetes were more prevalent among blacks than whites, but all risk factors did not follow this pattern. Fibrinogen and C-reactive protein were significantly higher among blacks than whites and highest among black women.

Median CAC scores were lower in blacks than in whites (134 in black women versus 233 in white women, $P=0.020$; 159 in black men versus 787 white men, $P<0.0001$; Figure 1) and were increased by age, but in each age group, the score in blacks was lower than the score in whites (Figure 2). CAC scores were also higher in those with CVD, but again, they were lower in blacks than in whites at all levels (Figure 3).

The distributions of CVD risk factors across CAC score quartile in each race and sex group are presented in Tables 2 and 3. Hypertension was significantly associated with a higher CAC score among white men only ($P=0.039$). Diabetes was not significantly associated with the CAC score in any group. Lipid levels and markers of thrombosis and inflammation were not significantly different across score quartiles, with 3 exceptions. Triglyceride levels for black men varied across CAC score quartile but with no apparent trend ($P=0.052$). Among white women, median pack-years of

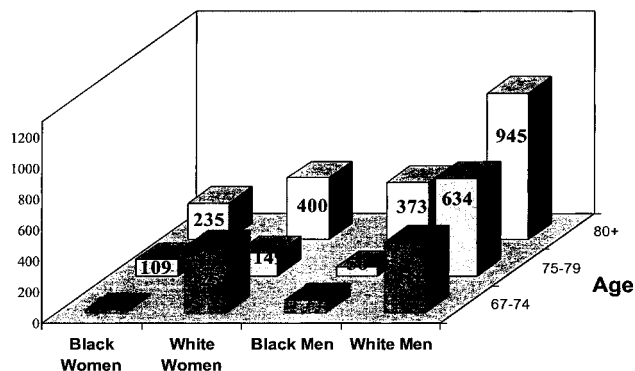


Figure 2. Median CAC scores by sex, race, and age: the CHS, Pittsburgh (n=614).

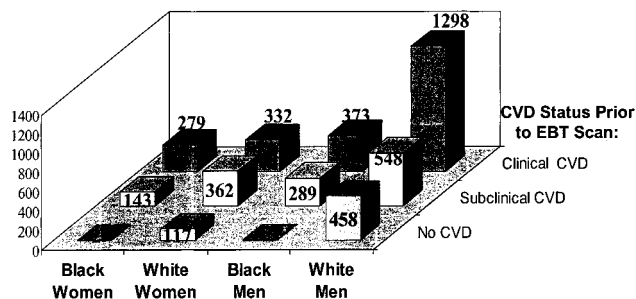


Figure 3. Median CAC scores by sex, race, and CVD status: the CHS, Pittsburgh (n=614).

smoking increased across CAC quartiles ($P=0.01$), and C-reactive protein levels were higher in the top 3 quartiles of the CAC score than in the first quartile ($P=0.002$). Spearman correlations showed pack-years of smoking to be significantly correlated with CAC score among black men ($r=0.37$, $P=0.006$), white men ($r=0.19$, $P=0.010$), and white women ($r=0.15$, $P=0.015$) but not among black women ($r=0.10$, $P=0.39$). Fibrinogen was not significantly correlated with the CAC score ($r=0.20$ and $P=0.14$ for black men and $r=0.18$ and $P=0.10$ for black women compared with $r=0.04$ and $P=0.58$ for white men and $r=-0.006$ and $P=0.92$ for white women). C-reactive protein was significantly correlated with the CAC score only among women ($r=0.23$ and $P=0.037$ among black women and $r=0.14$ and $P=0.017$ for white women).

By use of the CAC score quartiles in logistic regression, age, male sex, presence of clinical CVD, pack-years of smoking, and triglyceride levels were found to be independently associated with a higher CAC score, but a significant interaction between race and sex was found. Therefore, models using sex-specific CAC score quartiles were developed to test these relationships within sex (Table 4). Compared with their white male or female counterparts, blacks had significantly lower odds of having a CAC score in a higher quartile after adjustment for age and clinical CVD, although the magnitude of the association was greater for men than for women. After further adjustment for CVD risk factors, black race remained associated with a lower CAC quartile in men, with an odds ratio of 0.20 (95% CI 0.11 to 0.38, $P<0.0001$). In the final model for men, independent predictors of a higher score were white race, the presence of clinical CVD, higher total cholesterol, and smoking history. The protective odds ratio for black race in women remained similar in magnitude but lost statistical significance with adjustment for risk factors, and in the final model, independent predictors of a higher CAC score quartile among women were age, clinical CVD, pack-years of smoking, triglycerides, and C-reactive protein. To determine whether there could be residual confounding due to the slightly younger age range of the blacks in the present study, we then restricted the analysis set so that 110 blacks and 454 whites were of the same age distribution (75 to 91 years, mean 80 years). The odds ratios and significance for a protective effect of black race did not change. We also modeled the effect of race and CVD risk factors by using overall CAC score quartiles in those without clinical CVD and then in those with neither clinical nor subclinical CVD and found similar results (sex, age, chole-

TABLE 2. CVD Risk Factors for Men by Race and CAC Score Quartile: the CHS

	CAC <57, N=45 (18%)	CAC 57–<333, N=43 (17%)	333–<918, N=68 (28%)	CAC ≥918, N=91 (37%)
Hypertension, n (%)				
Blacks				
Yes	10 (45.5)	4 (18.2)	6 (27.3)	2 (9.1)
No	16 (44.4)	5 (13.9)	9 (25.0)	6 (16.7)
Whites				
Yes	3 (5.7)	7 (13.2)	14 (26.4)	29 (54.7)
No	16 (11.9)	26 (19.4)	39 (29.1)	53 (39.6)
Diabetes, n (%)				
Blacks				
Yes	6 (42.9)	4 (28.6)	2 (14.3)	2 (14.3)
No	20 (45.5)	5 (11.4)	13 (29.6)	6 (13.6)
Whites				
Yes	3 (5.7)	7 (13.2)	14 (26.4)	29 (54.7)
No	16 (11.9)	26 (19.4)	39 (29.1)	53 (39.6)
Median pack-years (ever smokers)				
Blacks (37)	7.3	33.6	18.5	15.0
Whites (111)	19.0	36.5	21.0	31.5
Total cholesterol (mean±SD), mg/dL				
Blacks	178.4±35.9	204.1±16.8	184.1±27.8	189.0±47.0
Whites	180.4±24.3	181.3±32.3	188.3±32.2	190.5±34.5
HDL (mean±SD), mg/dL				
Blacks	48.7±11.9	48.3±9.1	46.9±7.6	58.3±12.1
Whites	47.8±9.5	46.9±9.3	44.9±9.4	45.1±9.5
LDL (mean±SD), mg/dL				
Blacks	105.6±32.4	121.6±27.7	117.1±24.2	106.6±41.8
Whites	108.9±22.6	110.7±29.0	116.2±27.7	118.4±32.8
Median triglycerides, mg/dL				
Blacks	82.5	113.0	75.0	76.5
Whites	114.0	102.0	131.0	117.0
Median C-reactive protein, mg/dL				
Blacks	1.48	2.93	2.60	2.05
Whites	1.47	1.33	1.175	1.49
Median fibrinogen, mg/dL				
Blacks	307.5	346.0	331.0	333.0
Whites	287.0	293.0	304.0	303.5

There were 247 (58 black and 189 white) men in the study. For median pack-years, the numbers in parentheses indicate the number of individuals in the subgroup of smokers.

terol, and pack-years of smoking as independent predictors of a higher score; data not shown).

Last, the relationship between history of MI and CAC was examined in men and women by race. Seventy-one participants had a history of MI, and blacks had lower scores than whites among this group (median CAC score of 256 in black women, 684 in white women, 1029 in black men, and 1596 in white men). We did not have adequate power to determine whether the relationship between race with CAC score in those with a history of MI was independent of age and CVD risk factors.

Discussion

Older black men and women in the present study had lower CAC scores than did older white men and women. These

differences were more pronounced in men and were counter to the higher baseline prevalence of hypertension and diabetes in these older blacks. The present findings are in accord with those of Doherty et al¹² and extend their findings to women and to those in late life. To our knowledge, this is the largest study to date describing CAC in older black men and women. However, in younger cohorts, there appears to be less of a difference in the extent of CAC observed between blacks and whites.^{10,11} This raises the possibility that older blacks are less likely to survive with a similar extent of CAC than are older whites. Another possibility is that there may be differences related to race in the calcification process of atherosclerotic lesions.

TABLE 3. CVD Risk Factors for Women by Race and CAC Score Quartile: the CHS

	CAC <57, N=110 (30%)	CAC 57–<333, N=111 (30%)	333–<918, N=85 (23%)	CAC ≥918, N=61 (17%)
Hypertension, n (%)				
Blacks				
Yes	17 (35.4)	15 (31.3)	12 (25.0)	4 (8.3)
No	17 (45.6)	10 (27.0)	5 (13.5)	5 (13.5)
Whites				
Yes	18 (26.9)	15 (22.4)	19 (28.4)	15 (22.4)
No	57 (27.3)	69 (33.0)	47 (22.5)	36 (17.2)
Diabetes, n (%)				
Blacks				
Yes	6 (30.0)	7 (35.0)	4 (20.0)	3 (15.0)
No	27 (42.2)	18 (28.1)	13 (20.3)	6 (9.4)
Whites				
Yes	3 (16.8)	8 (42.1)	4 (21.1)	4 (21.1)
No	72 (28.1)	76 (29.7)	62 (24.2)	46 (18.0)
Median pack-years (ever smokers)				
Blacks (43)	23.8	24.8	13.6	37.0
Whites (158)	15.0	25.0	29.5	29.6
Total cholesterol (mean±SD), mg/dL				
Blacks	203.4±37.0	206.3±40.4	206.2±34.6	214.1±25.5
Whites	211.2±30.4	206.7±26.7	212.1±30.2	219.8±38.8
HDL (mean±SD), mg/dL				
Blacks	58.5±14.4	55.8±10.0	55.8±9.8	53.2±12.5
Whites	58.8±15.2	57.0±14.2	58.8±16.2	54.3±16.9
LDL (mean±SD), mg/dL				
Blacks	117.3±36.4	120.5±39.0	122.1±30.1	118.9±27.3
Whites	126.4±31.2	122.2±26.6	125.9±29.5	131.6±35.3
Median triglycerides, mg/dL				
Blacks	101.0	102.0	113.0	154.0
Whites	117.0	121.0	117.5	149.5
Median C-reactive protein, mg/dL				
Blacks	1.985	2.53	2.58	6.97
Whites	1.34	2.06	2.315	1.89
Median fibrinogen, mg/dL				
Blacks	331.0	324.0	371.0	381.0
Whites	310.0	321.0	316.0	298.0

There were 367 (85 black and 282 white) women in the study. For median pack-years, the numbers in parentheses indicate the number of individuals in the subgroup of smokers.

These results are consistent with angiographic studies of older populations with clinical CAD. In these studies, blacks are typically more likely to have no obstructive (>70%) stenoses and are less likely to have involvement of either the left main coronary artery or all 3 major epicardial vessels.⁵ It is significant that the present data represent a community-based population not selected on the basis of symptoms or medical care, because there are considerable data demonstrating substantial differences in the use of coronary angiography among blacks and whites.²³ These differences may have led to the observed differences in disease previously reported. Our data may be less susceptible to this bias.

On the other hand, these studies seem at odds with the findings of the Pathobiological Determinants of Atherosclerosis in Youth (PDAY) study.²⁴ In that study of individuals

aged 15 to 34 years who died because of external causes and who underwent autopsy, blacks were more likely than whites to have fatty streaks and as likely to have raised lesions, controlling for age, sex, and CAD risk factors. It is not clear whether there are differences in the progression of disease among older individuals or whether the selection process leading to death at a young age and subsequent autopsy differs among blacks and whites and leads to a spurious reversal of the pattern seen in the present study. Poorer survival of older black men could have resulted in apparently lower scores in the survivors. Cohort and time trends in exposures between the young and old are also potential explanations.

These data also raise the possibility that blacks may experience MI at lower CAC scores than whites, in that,

TABLE 4. Additive Logistic Regression Modeling the OR for Blacks vs Whites of Having a CAC Score in a Higher Sex-Specific Quartile: the CHS, Pittsburgh

	Risk of Higher CAC Quartile*	OR Adjusted for Age at Scan	OR Adjusted for Age and Clinical CVD†	OR Adjusted for Age, Clinical CVD, and Traditional CVD Risk Factors‡	OR Adjusted for Age, Clinical CVD, and Traditional CVD Risk Factors, with New Risk Factors CRP and Fibrinogen§
Men					
Black vs white	0.22	0.25	0.24	0.20	0.19
95% CI	0.13–0.39	0.14–0.44	0.14–0.43	0.11–0.38	0.10–0.35
P	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Women					
Black vs white	0.55	0.67	0.62	0.73	0.71
95% CI	0.35–0.85	0.43–1.05	0.40–0.98	0.45–1.17	0.44–1.14
P	0.007	0.08	0.042	0.19	0.17

OR indicates odds ratio; CRP, C-reactive protein. There were 614 individuals in the study.

*Sex-specific quartile cut points are as follows: for men, 166, 625, 1433, and ≥ 1433 ; for women, 30, 202, 660, and ≥ 661 .

†OR adjusted for age and prevalence of clinical CVD.

‡Forward stepwise adjustment for systolic and diastolic blood pressures (individually), body mass index, diabetes, total cholesterol, HDL, LDL, triglycerides, ever smoking, and pack-years of smoking.

§Forward stepwise adjustment for systolic and diastolic blood pressures (individually), body mass index, diabetes, total cholesterol, HDL, LDL, triglycerides, ever smoking, pack-years of smoking, CRP, and fibrinogen.

cross-sectionally, blacks with a history of MI had lower scores than did whites. In the Doherty study,¹² although blacks were less likely to have calcium present, they had higher rates of MI or new-onset angina than did whites but not higher rates of CHD death or revascularization, and black race was independently predictive of the combined outcome. We observed racial differences in the prevalence of several CVD risk factors that should be examined as possible contributing factors to the risk of acute thrombosis, independent of the extent of CAC. For example, blacks in the present study had higher levels of fibrinogen and C-reactive protein than did whites. In a histopathologic study of carotid plaque, hyperfibrinogenemia was shown to be associated with plaque rupture, thrombosis, a thinner plaque cap, and infiltration by macrophages (in other words, plaque that is less stable).²⁵

Calcification of coronary plaque has been postulated to contribute to the stability of the atherosclerotic lesion.²⁶ Conversely, it is possible that the process of intimal calcification might play a role in destabilizing the lesion.^{27,28} Available pathological data suggest that the correlation between CAC and the anatomic extent of coronary artery arteriosclerosis is strong²⁹ and that it likely predicts events, inasmuch as those with more calcium have more total lesions (unstable as well as stable), but we know of no study that specifically evaluates whether this correlation differs by race or sex. Two well-described mechanisms for arterial thrombosis (plaque rupture and plaque erosion) have been associated with lower calcium content in histopathologic studies,³⁰ but these mechanisms have not been reported to differ by race. Clearly, more work is required to examine racial differences in the pathology and epidemiology of plaque biology. Racial characteristics may differentially influence responses to endothelial stressors as well as repair mechanisms, such as thrombosis and calcification. Such research may have important implications for therapeutic approaches to vascular disease based on race, not unlike current therapeutic approaches to hypertension.

Although they are less subject to the bias of hospital-based and referral studies, these findings must be interpreted with

some caution because the CHS cohort, although community-based, was not strictly a random sample of older blacks and whites because of the exclusions for serious illness and refusals. However, because all participants were recruited through Medicare regardless of insurance, these data may provide better evidence regarding the extent of disease than hospital-based studies, which are likely to be more biased because of insurance and access issues. Furthermore, we did not have adequate power in the present analysis to fully determine the associations between risk factors and CAC within the black race group or even whether risk factors differ between blacks and whites within sex groups. Larger studies are under way to more carefully examine these issues. Finally, it must be acknowledged that the designation of race by self-report represents a heterogeneous range of ethnicity and socioeconomic status. The associations with race may well be due to exposures for which race is a surrogate. Nevertheless, further exploration of differences might lead to the identification of new approaches to address racial disparities in CVD outcomes.

Acknowledgments

This study was supported by National Heart Lung and Blood Institute (NHLBI) grant R01 HL-64587 and NHLBI contracts N01 HC-85079 and N01 HC-85086. We gratefully acknowledge the participants, physicians, and staff of the University of Pittsburgh Epidemiology Research Laboratories and the participating institutions of the CHS, including Bowman Gray School of Medicine and ECG Reading Center of Wake Forest University; University of California, Davis; Johns Hopkins University and MRI Reading Center, University of Pittsburgh; University of California, Irvine; Echocardiography Reading Center, Georgetown Medical Center; Ultrasound Reading Center, New England Medical Center; Central Blood Analysis Laboratory, University of Vermont; Pulmonary Reading Center, University of Arizona; Coordinating Center, University of Washington; and the NHLBI Project Office.

References

1. Roig E, Castaner A, Simmons B, Patel R, Ford E, Cooper R. In-hospital mortality rates from acute myocardial infarction by race in U.S. hospitals: findings from the National Hospital Discharge Survey. *Circulation*. 1987; 76:280–288.

2. White AD, Rosamond W, Chambless L, Neal T, Conwill D, Cooper LS, Folsom AR. Atherosclerosis Risk in Communities (ARIC) study investigators. Sex and race differences in short-term prognosis after acute coronary heart disease events: the Atherosclerosis Risk in Communities (ARIC) study. *Am Heart J.* 1999;138(pt 1):540–548.
3. Peterson ED, Wright SM, Daley J, Thibault GE. Racial variation in cardiac procedure use and survival following acute myocardial infarction in the Department of Veterans Affairs. *JAMA.* 1994;271:1175–1180.
4. Kuller L, Fisher L, McClelland R, Fried L, Cushman M, Jackson S, Manolio T. Differences in prevalence of and risk factors for subclinical vascular disease among black and white participants in the Cardiovascular Health Study. *Arterioscler Thromb Vasc Biol.* 1998;18:283–293.
5. Oberman A, Cutter G. Issues in the natural history and treatment of coronary heart disease in black populations: surgical treatment. *Am Heart J.* 1984;108(pt 2):688–694.
6. Langford HG, Oberman A, Borhani NO, Entwisle G, Tung B. Black-white comparison of indices of coronary heart disease and myocardial infarction in the stepped-care cohort of the Hypertension Detection and Follow-up Program. *Am Heart J.* 1984;108(pt 2):797–801.
7. Cooper RS, Ghali JK. Coronary heart disease: black-white differences. *Cardiovasc Clin.* 1991;21:205–225.
8. Tofler GH, Stone PH, Muller JE, Willich SN, Davis VG, Poole WK, Strauss HW, Willerson JT, Jaffe AS, Robertson T. Effects of gender and race on prognosis after myocardial infarction. *J Am Coll Cardiol.* 1987;9:473–482.
9. Agatston AS, Janowitz WR, Kaplan G, Gasso J, Hildner F, Viamonte M. Ultrafast computed tomography-detected coronary calcium reflects the angiographic extent of coronary arterial atherosclerosis. *Am J Cardiol.* 1994;74:1272–1274.
10. Bild DE, Folsom AR, Lowe LP, Sidney S, Kiefe C, Westfall AO, Zheng ZJ, Rumberger J. Prevalence and correlates of coronary calcification in black and white young adults (CARDIA study). *Arterioscler Thromb Vasc Biol.* 2001;21:852–857.
11. Hsia J, Godinho C, Adams-Campbell L, Howard B, Wasserman AG. Coronary calcification in African-American and white women in the Women's Health Initiative Observational Study. *J Am Coll Cardiol.* 1999;33:415A.
12. Doherty TM, Tang W, Detrano RC. Racial differences in the significance of coronary calcium in asymptomatic black and white subjects with coronary risk factors. *J Am Coll Cardiol.* 1999;34:787–794.
13. Newman AB, Naydeck B, Sutton-Tyrrell K, Edmundowicz D, Gottdiener J, Kuller JH. Coronary artery calcification in older adults with minimal clinical or subclinical cardiovascular disease. *J Am Geriatr Soc.* 2000;48:256–263.
14. Fried LP, Borhani NO, Enright P, Furberg CD, Gardin JM, Kronmal RA, Kuller LH, Manolio TA, Mittelmark MB, Newman A, et al, for the Cardiovascular Health Study Research Group (CHS). The Cardiovascular Health Study: design and rationale. *Ann Epidemiol.* 1991;1:263–276.
15. Tell GS, Fried LP, Hermanson B, Manolio TA, Newman AB, Borhani NO, for the Cardiovascular Health Study (CHS) Collaborative Research Group. Recruitment of adults 65 years and older as participants in The Cardiovascular Health Study. *Ann Epidemiol.* 1993;3:358–366.
16. Agatston AS, Janowitz WR, Hildner FJ, Zusmer NR, Viamonte M, Detrano R. Quantification of coronary artery calcium using ultrafast computed tomography. *J Am Coll Cardiol.* 1990;15:827–832.
17. Cushman M, Cornell E, Howard P, Bovill E, Tracy R. Laboratory methods and quality assurance in The Cardiovascular Health Study. *Clin Chem.* 1995;41:264–270.
18. Macy EM, Hayes TE, Tracy RP. Variability in the measurement of C-reactive protein in healthy subjects: implications for reference intervals and epidemiological applications. *Clin Chem.* 1997;43:52–58.
19. Report of the expert committee on the diagnosis and classification of diabetes mellitus. *Diabetes Care.* 1997;20:1183–1197.
20. Mittelmark MB, Psaty BM, Rautaharju PM, Fried LP, Borhani NO, Tracy RP, Gardin JM, O'Leary DH. Prevalence of cardiovascular diseases among older adults: the Cardiovascular Health Study. *Am J Epidemiol.* 1993;137:311–317.
21. Ives DG, Fitzpatrick AL, Bild DE, Psaty BM, Kuller LH, Crowley PM, Cruise RG, Theroux S. Surveillance and ascertainment of cardiovascular events: the Cardiovascular Health Study. *Ann Epidemiol.* 1995;5:278–285.
22. Rose G, McCartney P, Reid DD. Self-administration of a questionnaire on chest pain and intermittent claudication. *Br J Prev Soc Med.* 1977;31:42–48.
23. Whittle J, Conigliaro J, Good CB, Lofgren RP. Racial differences in the use of invasive cardiovascular procedures in the Department of Veterans Affairs Medical System. *N Engl J Med.* 1993;329:621–627.
24. Strong JP, Malcom GT, Tracy RE, Newman WP III, Herderick EE, Cornhill JF. Prevalence and extent of atherosclerosis in adolescents and young adults: implications for prevention from the Pathobiological Determinants of Atherosclerosis in Youth Study. *JAMA.* 1999;281:727–735.
25. Mauriello A, Sangiorgi G, Palmieri G, Virmani R, Holmes DR Jr, Schwartz RS, Pistoletti R, Ippoliti A, Spagnoli LG. Hyperfibrinogenemia is associated with specific histocytological composition and complications of atherosclerotic carotid plaques in patients affected by transient ischemic attacks. *Circulation.* 2000;101:744–750.
26. Taylor AJ, Burke AP, O'Malley P, Farb A, Malcom GT, Smialek J, Virmani R. A comparison of the Framingham risk index, coronary artery calcification, and culprit plaque morphology in sudden cardiac death. *Circulation.* 2000;101:1243–1248.
27. Bini A, Mann KG, Kudryk BJ, Schoen FJ. Noncollagenous bone matrix proteins, calcification, and thrombosis in carotid artery atherosclerosis. *Arterioscler Thromb Vasc Biol.* 1999;19:1852–1861.
28. Demer LL. Lipid hypothesis of cardiovascular calcification. *Circulation.* 1997;95:297–298.
29. Rumberger JA, Simons DB, Fitzpatrick LA, Sheedy PF, Schwartz RS. Coronary artery calcium area by electron-beam computed tomography and coronary atherosclerotic plaque area: a histopathologic correlative study. *Circulation.* 1995;92:2157–2162.
30. Farb A, Burke AP, Tang AL, Liang Y, Mannan P, Smialek J, Virmani R. Coronary plaque erosion without rupture into a lipid core: a frequent cause of coronary thrombosis in sudden coronary death. *Circulation.* 1996;93:1354–1363.