Traditional Risk Factors and the Incidence of Sudden Coronary Death With and Without Coronary Thrombosis in Blacks

Allen P. Burke, MD; Andrew Farb, MD; Joseph Pestaner, MD; Gray T. Malcom, PhD; Arthur Zieske, MD; Robert Kutys, MS; John Smialek, MD†; Renu Virmani, MD

Background—Blacks have a high rate of sudden coronary death (SCD). We determined the rate of SCD in men and women 30 to 69 years of age in a 6-year period recorded at a state Medical Examiner’s Office.

Methods and Results—In a subset of 327 whites and 130 blacks, hearts were systematically studied to determine the extent of coronary disease, presence and type of thrombus (acute rupture, acute erosion, stable plaque), and heart weight. These parameters were correlated with the presence of conventional risk factors. The estimated rate of SCD in blacks was similar to that in whites under the age of 40 years but increased compared with whites with advancing age, becoming 1.5 times the rate for whites in the 7th decade (95% of the increase in the 6th decade was due to sudden death with stable plaque). Among the autopsied group with severe coronary atherosclerosis, HDL cholesterol was higher and hypertension more prevalent in blacks, but there was no difference in the prevalence of healed infarcts, plaque burden, heart weight, acute thrombi, or rates of diabetes, cigarette smoking, and total cholesterol.

Conclusions—When compared with a control autopsy group of 568 deaths, multivariate analysis showed a significant association in blacks between stable plaque and left ventricular hypertrophy (risk ratio, 7.6), type 1 diabetes (risk ratio, 3.6), hypertension (risk ratio, 3.5), elevated total cholesterol (risk ratio, 3.1) and type 2 diabetes (risk ratio, 2.9). Because these risk factors are associated with SCD in blacks, they may be important targets for reducing the disparately high rate of SCD in blacks as compared with whites. (Circulation. 2002;105:419-424.)

Key Words: hypertrophy ■ risk factors ■ thrombosis ■ death, sudden

Because the rate of sudden coronary death (SCD) in black Americans is reported to be greater than that of white Americans, the need for a better understanding of the mechanism of SCD in blacks has been emphasized.1,2 It is unknown if there are significant racial differences in the pathological features of coronary artery disease specifically relating to SCD. It is presumed that in most instances of SCD, ventricular tachyarrhythmias arise from ischemic foci within the myocardium. In ~60% of SCD, an acute thrombus is identified at autopsy to account for an ischemic death.3 Myocardial hypertrophy, heart failure, and ventricular scarring are believed to lower the threshold for ventricular ectopy and are likely to be especially important in SCD in cases without acute thrombus.

Hypertension and left ventricular hypertrophy are more prevalent in blacks than in whites.4–7 However, the prevalence of cardiomegaly or ventricular hypertrophy in the presence of coronary disease has not been studied in an autopsy population comparing blacks and whites. In the current study we compared various pathological findings that are related to mechanisms of SCD (coronary thrombosis, myocardial hypertrophy, and ventricular scarring) in whites and blacks in a series of autopsy cases in men and women 30 to 69 years of age. By use of population data and computerized autopsy and inspection reports, we estimated rates of SCD with and without acute thrombus in blacks and whites and estimated rates by decade in the inspected (nonautopsied) cases. Finally, we compared risk factor profiles by race by using a set of control subjects to determine odds ratios for death from coronary disease for each risk factor among the pathological categories of plaque rupture, plaque erosion, and stable plaque. The purpose of these analyses was to determine what pathological substrates and corresponding risk factors account for the high rate of SCD that has been reported in blacks.
Methods

Rates of SCD
Computerized records of the Office of the Chief Medical Examiner in the State of Maryland, to which all unexplained sudden deaths in the state are referred, were retrospectively reviewed from 1994 to 1999. Unexpected SCD in the state of Maryland is determined by inspection, in which cases a coronary death is determined by scene investigation, or by complete autopsy. Sudden death was defined as symptoms commencing within 6 hours of death (witnessed arrest) or death occurring within 24 hours after the victim was last seen alive in his normal state of health; coronary death was defined as at least 1 epicardial coronary artery with ≥75% cross-sectional area lumen narrowing by atherosclerotic plaque or plaque with superimposed thrombus and no other cause of death. Of the 5139 designated SCD during the study period in the Office of the Chief Medical Examiner in the State of Maryland, complete autopsies were performed on 1593, for a rate of 31%. There was a total of 12,909 autopsies of noncardiovascular deaths during this period, with a 91% autopsy rate in these cases. Of the 1593 SCD autopsied cases, 457 were included in the current study (29%), and an additional 563 (35%) were studied by one of the coauthors but not included in the study. Of the 1593 autopsy cases of SCD, the autopsy rate varied with age: The autopsy rate was 78% in the 30- to 39-year age range, 54% in the 40- to 49-year age range, 24% in the 50- to 59-year age range, and 12% in the 60- to 69-year age range. The protocol for the study of sudden cardiac deaths seen in consultation from the medical examiner’s office was approved by the internal review board (Research Committee) of the Armed Forces Institute of Pathology.

For the first 5 years of this study, the total number of ischemic heart disease deaths according to vital statistics was 7662. According to data from the Office of the Medical Examiner, the percentage of these deaths that were sudden in men and women declined from nearly 100% in the 4th decade to 54% of white men, 76% of black men, 42% of white women, and 58% of black women in the 7th decade.

Case Selection for Detailed Examination of the Heart
From 1994 to 1999, hearts (cases and control subjects) from 1025 autopsied cases at the Office of the Chief Medical Examiner were examined in detail, with data on risk factors collected. The criteria for selection included availability of risk factor data and the discretion of the medical examiner on call to request diagnostic consultation. There were initially 1038 cases, from which 13 cases were discarded because of inadequate serum for risk factor determination. Basically, 2 to 3 days per week were selected as case entry days to the study, when one of the coauthors was available in the morgue for data and blood collection and cardiac dissection according to the study guidelines. Of these, 762 were selected on the basis of sudden unexpected death presumed to be of coronary origin by complete autopsy. For the purposes of this study, the rate of SCD was estimated as the sum of adjusted inspection cases and the autopsied cases. For each age decade (30 to 39, 40 to 49, 50 to 59, and 60 to 69 years), the rates of SCD were calculated for the following 4 groups: black men, white men, black women, and white women. Left ventricular hypertrophy was present if there was insulin dependence and body mass index <25 kg/m²; type 2 diabetes was based on glycosylated hemoglobin >8% in the absence of type 1 diabetes.

Statistical Analysis
An adjusted rate of SCD in the inspection cases was estimated by a sampling of autopsied cases because not all cases of sudden unexpected death presumed to be of cardiac origin by inspection prove to be of coronary origin by complete autopsy. The rate of SCD was determined for 100,000 population/y by means of population statistics from the census bureau for the state of Maryland (www.census.gov/population/estimate), which are given by age, race, and sex. For univariate analysis to compare risk factors among groups, χ² contingency tables for categorical and ANOVA means tables with Fisher’s post hoc test for continuous variables were used. Logistic regression was used to determine associations between risk factors and the presence of coronary disease. The dependent variables (stable plaque, plaque rupture, or plaque erosion versus control subjects) were analyzed with independent continuous (age, body mass index) and noncontinuous variables (smoking, hypertension, diabetes, elevated TC, top tertile, and decreased HDL-C, lowest tertile). All control subjects (cardiovascular deaths and noncardiovascular deaths) were included for univariate and multivariate analysis for risk factors other than hypertension and left ventricular hypertrophy. When hypertension was a variable for risk factor association, the analysis was repeated excluding the cardiomyopathy control subjects; when left ventricular hypertrophy was a variable for risk factor association, the analysis was repeated excluding both the cardiomyopathy and valve disease control subjects.

Results

Estimates of Overall Rates of SCD
The rate of severe coronary disease in the 762 natural deaths caused by cardiovascular diseases was 67% for whites and 47% for blacks. These population-adjusted rate of SCD

Characterization of Coronary Lesions
Cases of SCD with acute thrombus were categorized as plaque rupture and plaque erosion, as previously defined. SCD without acute thrombi were categorized as stable plaque. Plaque burden was assessed in SCD and control subjects and was calculated by adding the maximal percent cross-sectional area luminal narrowing in 4 arterial beds: left main, left anterior descending with diagonals, left circumflex with marginals, and right coronary with posterior descending artery (range, 0% to 400%).

Heart Weight
The heart was weighed after removal of cavity blood clots and the aorta (2.5 cm from the sinotubular junction). Heart weight was normalized for body weight after determining a linear relation between body mass (kg) and heart weight (kg) in control black women, black men, white women, and white men. Left ventricular hypertrophy was present if heart weight was greater than 95% confidence intervals by sex and body weight as defined previously by Kitzman et al.

Risk Factor Analysis
The postmortem evaluation of total cholesterol (TC), HDL cholesterol (HDL-C), glycohemoglobin for diabetes, and thiocyanate as a marker for cigarette smoking was performed as previously described. In every case, the available history was used as corroborating evidence in the autopsy determination of risk factors. Hypertension was considered present if either postmortem kidney evaluation was positive or if there was a clinical history. Type 1 diabetes was presumed if there was insulin dependence and body mass index <25 kg/m²; type 2 diabetes was based on glycosylated hemoglobin >8% in the absence of type 1 diabetes.
increased with advancing age (Figure 1). The rate for blacks was consistently higher in each group (Figure 1).

Rates of SCD by Presence or Absence of Thrombus
In the 457 cases of SCD, there were 327 whites and 130 blacks (Table 1). There was no racial difference in the rate of acute thrombi, but ruptures were more frequent in whites (Table 1). The frequency of acute thrombosis decreased with advancing age (60% in the 4th decade, 60% in the 5th decade, 45% in the 6th decade, and 30% in the 7th decade). When the percentage of the type of thrombus was applied to the rate of total SCD by race and sex, the rate of thrombus was similar in both races, but the rate of death with stable plaque was higher in blacks (Figures 2 and 3).

Racial Differences in Heart Weights, Plaque Burden, and Frequency of Healed Infarcts in SCD
When all cases of SCD were considered, there was no significant difference in adjusted mean heart weight by race (Table 1). When analyzed by age at the time of death, the adjusted heart weight of all cases of SCD increased from the 4th to the 7th decade (412 ± 88 g, 450 ± 86 g, 485 ± 121 g, respectively, P < 0.0001). The overall mean plaque burden and incidence of healed infarcts were similar in whites and blacks (Table 1). There were no racial differences in plaque burden when assessed by decade (Figure 4) or when stable plaque was studied separately (231 ± 81% in blacks, 226 ± 82% in whites; P = 0.7).

Risk Factor Profiles, SCD Versus Control Subjects: Whites and Blacks
Figures 5 and 6 demonstrate the univariate relation between risk factors and plaque types (stable plaque, plaque rupture, plaque erosion, and control subjects) stratified by race. Patterns of association between risk factors and mechanism were similar in blacks and whites. In both races, stable plaque was associated with hypertension and diabetes mellitus; acute thrombus with cigarette smoking; and plaque rupture with

<table>
<thead>
<tr>
<th>TABLE 1. Number, Age, and Sex Distribution of Blacks and Whites Dying With SCD and Cardiac Findings at Autopsy</th>
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<tbody>
<tr>
<td>Blacks (n=130)</td>
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<td>Women, n (age±SD, y)</td>
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<td>Acute thrombi, n (%)</td>
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<tr>
<td>Acute ruptures</td>
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<td>Acute erosions</td>
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<td>Heart weight, g±SD</td>
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<tr>
<td>Men</td>
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<tr>
<td>Women</td>
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<tr>
<td>Plaque burden</td>
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<td>Healed infarcts, %</td>
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</table>

Figure 1. Estimated population-based rates of SCD in blacks and whites. For the 4th decade (ages 30 to 39 years), estimated rate of SCD (autopsied cases plus adjusted number of inspected cases/population, adjusted per 100 000 per year) was 7.6 yearly for white men, 1.9 yearly for white women, 9.0 yearly for black men, and 3.4 yearly for black women. Rates increased with advancing age, reaching 226 for white men, 72 for white women, 337 for black men, and 124 for black women in the 7th decade.

Figure 2. Estimated population-based rates of SCD caused by acute thrombus. Rate of death per 100 000/y with acute rupture was lower in black men in the 4th and 5th decades (2.2 and 14.8 in blacks vs 4.1 and 17.9 in whites) and higher in black men in the 6th and 7th decades (44.6 and 77.6 vs 36.2 and 72.3, respectively). For plaque erosion, rates were low but similar in blacks and whites. Plaque ruptures are infrequent in premenopausal women; plaque erosions occur at a low rate compared with ruptures and appear to peak in the 5th decade.

Figure 3. Estimated population-based rates of SCD caused by stable plaque. Excess rate of SCD in blacks is largely due to excess in stable plaque. Gap widens with advancing age. Rate was consistently higher in blacks compared with whites in all age ranges, with the gap increasing with advancing age (2.8 vs 1.6 in the 4th decade, 20.9 vs 11.2 in the 5th decade, 90.7 vs 46.5 in the 6th decade, and 252.9 vs 169.5 in the 7th decade). Values by sex are shown in the figure.
Discussion

Incidence of SCD: Blacks Versus Whites

The current study demonstrates that the rate of SCD in black men and women is greater than in whites in the 6th and 7th decades. The rates of SCD caused by coronary thrombosis are fairly similar in both races; the increase in blacks is due largely to an increase in deaths with stable plaque. The majority of SCD in blacks caused by stable plaque are associated with left ventricular hypertrophy and hypertension. The data suggest that blacks do not have an inherent increased risk for premature SCD before the age of 50 years, nor do they have an increased risk for the development of fatal coronary thrombosis.

Left Ventricular Hypertrophy, Hypertension, and Blacks Dying With Stable Coronary Plaque

Because of an increase in death caused by stable plaque, there is a relative increase in the incidence of sudden death in blacks compared with whites after the age of 50 years. When the data in the current study are analyzed, it is not apparent that the mechanism of sudden death differs fundamentally by race because the mean heart weight and frequency of cardiac scars are similar in blacks and whites dying with stable plaque. We have shown previously that thin-cap atheromas are less frequent in blacks than in whites, probably because acute ruptures represent a smaller proportion of SCD in blacks. The current study demonstrates that the actual rate of acute ruptures is similar in blacks and whites and that the smaller proportion of ruptures in blacks is secondary to an increase in the rate of SCD caused by stable plaque. The data in the current study showing no difference in plaque burden in SCD between blacks and whites and in whites only, elevated TC was an independent risk factor for erosion.

Figure 4. Mean plaque burden of men and women dying with severe coronary disease. Mean plaque burden increases with advancing age, but there are no significant racial differences.

Figure 5. Risk factors in SCD compared with control subjects, blacks vs whites, by mechanism (rupture with thrombus, erosion with thrombus, stable plaque). Distribution of smokers was significantly different among groups (A) in whites (P=0.0001) and blacks (P=0.002) (C); 33.5% of blacks vs 62.1% of whites were smokers; by plaque type, 42.2% of blacks dying with stable plaque, 62.9% of blacks dying with rupture, and 73.9% of blacks dying with erosion were smokers; in whites, the corresponding rates were 51.8%, 68.3%, and 82.1%. Diabetes mellitus, defined by a history of insulin-dependent diabetes or a postmortem glycohemoglobin >8% (B), is more frequent in stable plaque in whites (P=0.008) and blacks (P=0.01) compared with control subjects; 24.8% of blacks were diabetic vs 20.4% of whites; by plaque type, 29.6% of blacks dying with stable plaque, 23.5% of blacks dying with plaque rupture, 12.5% of blacks dying with erosion were diabetic; the corresponding rates in whites were 26.1%, 15.6%, and 13.0%. Compared with control subjects, HDL-C is lower in rupture in whites (P=0.002) and blacks (P=0.02) (C). Mean HDL-C was 41.7±18.4 mg/dL in blacks vs 37.5±15.3 mg/dL in whites (P=0.03); by plaque type, mean HDL-C in blacks was 44.4±22.2 mg/dL (stable plaques), 37.5±9.8 mg/dL (rupture), and 39.2±12.7 mg/dL (erosion) and in whites 39.2±16.6 mg/dL (stable), 34.5±12.7 mg/dL (rupture), and 39.6±16.2 mg/dL (erosion). Compared with control subjects, TC is higher in rupture in whites (P=0.0001) and blacks (P=0.0001) (D) and higher in stable plaque in blacks (P=0.02). Mean TC was 221.8±79.0 mg/dL in blacks vs 227.6±58.4 mg/dL in whites (Figure 5D); by plaque type, mean TC in blacks was 215.5±78.9 mg/dL (stable plaques), 272.9±67.0 mg/dL (rupture), and 172.0±54.1 mg/dL (erosion) and in whites 212.1±61.9 mg/dL (stable), 248.1±48.1 mg/dL (rupture), and 230.4±53.8 mg/dL (erosion). Mean TC was greater in blacks with rupture than in whites with rupture (P=0.03) and greater in whites with erosion than in blacks with erosion (P=0.0003). ANOVA means table with Fisher’s post hoc test, B through D.
whites are consistent with angiographic studies, which have shown only modest increases in plaque burden in blacks compared with whites after acute myocardial infarction. The current study suggests that the reportedly high rates of SCD in blacks may be largely due to the high prevalence of hypertensive vs 31.4% of whites (P=0.002); by plaque type, 62.9% of blacks dying with stable plaque, 35.3% of blacks dying with plaque rupture, and 16.7% of blacks dying with erosion were hypertensive; the corresponding rates in whites were 35.8% (P=0.0001 vs blacks), 29.1%, and 21.7%. B, Compared with control subjects, heart weight was significantly increased in blacks (P=0.001) and in blacks (P<0.0001) with stable plaque (ANOVA means table with Fisher’s post hoc test). Adjusted heart weight was 462.2±101.7 g in blacks vs 476.0±111.9 g in whites; by plaque type, mean heart weight in blacks was 483.2±97.3 g (stable plaques), 448.1±101.2 g (rupture), and 419.1±102.6 g (erosion) and in whites 486.9±111.9 g (stable), 473.0±124.1 g (rupture), and 446.1±95.0 g (erosion). Percentage of hearts with left ventricular hypertrophy was 57.8% in blacks dying with coronary atherosclerosis and 58.1% of whites; in blacks, 70.4% of those dying with stable plaque, 50.0% with rupture, and 30.4% with erosion had enlarged hearts vs 63.4%, 58.3%, and 39.1% in whites, respectively.

**Risk Factor Prevalence in SCD: Blacks and Whites**

In addition to hypertension and left ventricular hypertrophy, prior studies have shown that black patients with symptomatic coronary heart disease have a higher prevalence of diabetes and tobacco use. Although the current study shows that blacks dying with severe coronary atherosclerosis have a higher rate of diabetes versus whites when those dying with stable plaque or plaque rupture are considered, the increase is modest and not statistically significant. The lack of significant increase in diabetes and smoking in blacks as compared with whites in the current study may be due to the relatively small sample size and differences in risk factor susceptibility between acute coronary syndromes and sudden death. Because diabetes and elevated TC are linked to death with stable plaque in blacks, albeit not as strongly as hypertension, the need for treatment of all three risk factors (hypertension, hypercholesterolemia, and diabetes) in reducing the rates of SCD in blacks in the 6th and 7th decades cannot be overemphasized.

**Risk Factors and Relation to Fatal Thrombus: Blacks and Whites**

The current data show an overall similarity of the risk factors profiles in blacks and whites when specific mechanisms of SCD are considered. The association between acute fatal plaque rupture and increased cholesterol is even more marked in blacks than in whites. The relatively high odds ratios for LDL lipoprotein levels and plaque rupture in blacks are reflected by the fact that HDL levels are elevated in all groups of blacks over whites, including control subjects, except for the group dying with plaque rupture. The association in blacks between plaque erosion and cigarette smoking is not as strong as in whites, suggesting that other factors may be more important in blacks for the pathogenesis of plaque erosion than in whites. Because TC is an independent risk factor for SCD caused by stable plaque in blacks and not in whites, the lowering of TC should be a major target of risk factor control in blacks.

**Limitations**

Because the autopsy rate was <25% in reported sudden death cases >50 years of age, the data in the older decades may be less likely to reflect the true rate of coronary deaths. However, the sample demonstrated that the rate of coronary disease in sudden unexpected natural deaths was lower in blacks than in whites, and the estimate of coronary deaths in the nonautopsied sample was adjusted to reflect this finding. Therefore, even though the true incidence of coronary disease in unexpected deaths in older men and women must remain an estimate because complete autopsies on all such cases is impossible, we believe that the current estimate is useful in comparing coronary deaths that are unexpected in whites and blacks. Further limitations include the fact that methods of determining risk factors were limited to a single collection at postmortem examination; duration of risk factor exposure was generally not available; and full information regarding risk factor modification (eg, aspirin and statin use) was not obtained. However, despite the relatively small numbers of patients in some strata and wide confidence intervals shown in Table 2, the detailed autopsy evaluation provides insights not possible in larger controlled studies based on death certificate data. Other limitations inherent in the study design are the case-control nature of the autopsy study, the fact that only a small portion of total deaths could be analyzed, resulting in selection bias, and the fact that generalizations to other populations are impossible. Also, control subjects included cardiovascular and noncardiovascular deaths because limiting control subjects to trauma deaths was not feasible.
**Conclusions**

Rates of SCD are similar in blacks and whites in the 4th decade; in later decades, there is an increasing gap, with a higher rate in black men and women. Excess deaths in blacks are largely due to an increase in deaths with stable plaque and left ventricular hypertrophy. Our data emphasize the importance of early diagnosis and proper control of hypertension and diabetes, which probably would reduce the incidence of SCD in blacks.

**Acknowledgments**

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**References**


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**TABLE 2. Odds Ratios and Confidence Intervals of the Influence of Risk Factors in Blacks and Whites Dying With Stable Plaque, Plaque Rupture, and Plaque Erosion**

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<thead>
<tr>
<th>Risk factor*</th>
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<th>Whites</th>
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<td></td>
<td>OR†</td>
<td>95% CI</td>
<td>P</td>
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<td>1.6–7.5</td>
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<td>Left ventricular hypertrophy‡</td>
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<tr>
<td>Plaque rupture</td>
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<tr>
<td>Elevated TC</td>
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<td>Female sex</td>
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<td>0.7–5.6</td>
<td>0.20</td>
<td>7</td>
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</table>

*Risk factors included in each analysis included hypertension/left ventricular hypertrophy (for definition, see reference 11), diabetes types 1 and 2, smoking, elevated TC (highest tertile), low HDL-cholesterol (lowest tertile), age, sex, and body mass index. Results are not shown for covariates with a P value of >0.15 in both groups.
†Odds ratios for modifiable risk factors with significant association in bold.
‡All independent variables were considered in the same analysis with the exception of hypertension and left ventricular hypertrophy, which were each considered separately with all other variables; when these were run together, hypertension was no longer significantly associated with stable plaque (P >0.1, blacks and whites).
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