Epidemiology of Heart Failure Stages in Middle-Aged Black People in the Community: Prevalence and Prognosis in the Atherosclerosis Risk in Communities Study

Ramachandran S. Vasan, MD; Solomon K. Musani, PhD; Kunihiro Matsushita, MD, PhD; Walter Beard, MD; Oluoshola B. Obafemi, MD; Kenneth R. Butler, PhD; Patricia P. Chang, MD, MHS; Thomas H. Mosley, PhD; Ervin Fox, MD

BACKGROUND: Black individuals have a higher burden of risk factors for heart failure (HF) and subclinical left ventricular remodeling.

METHODS AND RESULTS: We evaluated 1871 Black participants in the Atherosclerosis Risk in Communities Study cohort who attended a routine examination (1993–1996, median age 58 years) when they underwent echocardiography. We estimated the prevalences of 4 HF stages: (1) Stage 0: no risk factors; (2) Stage A: presence of HF risk factors (hypertension, diabetes mellitus, obesity, smoking, dyslipidemia, coronary artery disease without clinical myocardial infarction), no cardiac structural/functional abnormality; (3) Stage B: presence of prior myocardial infarction, systolic dysfunction, left ventricular hypertrophy, regional wall motion abnormality, or left ventricular enlargement; and (4) Stage C/D: prevalent HF. We assessed the incidence of clinical HF, atherosclerotic cardiovascular disease events, and all-cause mortality on follow-up according to HF stage. The prevalence of HF Stages 0, A, B, and C/D were 3.8%, 20.6%, 67.0%, and 8.6%, respectively, at baseline. On follow-up (median 19.0 years), 309 participants developed overt HF, 390 incurred new-onset cardiovascular disease events, and 651 individuals died. Incidence rates per 1000 person-years for overt HF, cardiovascular disease events, and death, respectively, were Stage 0, 2.4, 0.8, and 7.6; Stage A, 7.4, 9.7, and 13.5; Stage B 13.6, 15.9, and 22.0. Stage B HF was associated with a 1.5- to 2-fold increased adjusted risk of HF, cardiovascular disease events and death compared with Stages 0/A.

CONCLUSIONS: In our large community-based sample of Black individuals, we observed a strikingly high prevalence of Stage B HF in middle age that was a marker of high cardiovascular morbidity and mortality.

Key Words: Black participants • cardiovascular disease • epidemiology • heart failure

See Editorial by Okoh and Morris

Multiple investigations have documented a substantial burden of clinical heart failure (HF) in Black people in the United States.1–10 HF often presents in younger Black people11,12 and is characterized by high morbidity and mortality.13,14 Several reports also have noted race-related differences in cardiac remodeling features based on imaging studies.15–19 Black people have a greater burden of HF risk factors,13,20,21 heightened afterload sensitivity,22 and a higher prevalence of subclinical left ventricular remodeling.23–26
CLINICAL PERSPECTIVE

What Is New?
• Approximately two thirds of Black people in the community-based ARIC (Atherosclerosis Risk in Communities) Study have evidence of structural heart disease (termed Stage B heart failure) in midlife as determined by echocardiographic evaluation.
• Black people with Stage B heart failure in the ARIC Study were at high risk for developing fatal and nonfatal coronary heart disease or stroke, and death from all causes.

What Are the Clinical Implications?
• Our findings emphasize the critical need to screen for and detect both risk factors for heart disease and structural heart disease earlier in their life course in Black people, and to treat the modifiable risk factors optimally to prevent cardiovascular disease and heart failure in midlife and beyond.

Nonstandard Abbreviations and Acronyms

| Abbreviation | Description |
|--------------|-------------|
| ACC          | American College of Cardiology |
| AHA          | American Heart Association |
| ARIC Study   | Atherosclerosis Risk in Communities Study |
| CARDIA       | Coronary Artery Disease Risk in Young Adults |

People by using the American College of Cardiology/American Heart Association (ACC/AHA) classification system for HF. Briefly, the ACC/AHA classification schema includes 5 stages that reflect sequential phases of disease progression, with 1 stage indicating a state of health (Stage 0), 2 subsequent stages (Stage A and B) indicating varying propensity for developing clinical HF, and the last 2 stages (Stages C and D) reflecting presence of overt disease with its associated substantial mortality risk. A prior investigation of HF stages in Black people (as part of evaluation of a biracial ARIC [Atherosclerosis Risk in Communities] cohort study) studied older participants at an average age of 75 years, an age that approximates the average life expectancy for Black people in the United States. The prevalence of HF stages in Black people in their midlife and the long-term outcomes associated with these stages have not been well characterized. Accordingly, we evaluated the prevalence of HF stages in middle-aged Black people in the ARIC study. We hypothesized that a greater prevalence of structural heart abnormalities without HF signs and symptoms (Stage B) in midlife would be associated with higher risk of HF but would also be an indicator of greater non-HF-related cardiovascular morbidity and mortality. We tested this hypothesis in the community-based ARIC study sample in an examination where the cohort was middle-aged.

METHODS

Data from the ARIC study (including that used for the current article) are available at the NHLBI data repository BioLINCC at https://biolincc.nih.gov/studies/aric/

Study Sample
The design and selection criteria for the ARIC study have been described previously. Briefly, 15,792 people aged 45 to 64 years were recruited at a baseline examination (1987–1989), randomly chosen from 4 US communities (ie, Forsyth County, NC; Jackson, MS; Minneapolis suburbs, MN; and Washington County, MD), ARIC is a biracial cohort. In Jackson, MS, a representative sample was enrolled exclusively from the Black residents of the city. For the present investigation, we included Black people from the Jackson, MS site of the ARIC study who attended their third examination visit and underwent routine echocardiography (“visit 3” 1993–1996; N=1871, mean age 59 years). This sample was used to describe the prevalence of various ACC/AHA HF stages in midlife in Black people. The study protocol was approved by the Institutional Review Board of the parent study (ARIC) and all participants provided written informed consent.
Echocardiographic Methods
The design of the echocardiographic protocol for the ARIC study at visit 3 has been described elsewhere.36 Briefly, images were acquired using the Acuson XP128/10c echocardiography machine (GPS medical). A single cardiologist performed all echocardiographic readings. The interventricular septal thickness, posterior wall thickness, LV internal dimensions in end-diastole and systole, left atrium diameter, and aortic root diameter were obtained using M mode according to the conventions established by the American Society of Echocardiography at the time of the index examination. LV mass was derived using the formula described by Devereux et al using the M-mode data.37 LV systolic function was considered reduced if left ventricular ejection fraction (LVEF) was <50%. LVEF was derived semiquantitatively using a modified Quinones technique and visual assessment of the LV apex. Abnormal LV structure and LVEF were used to classify Stage B HF and defined as the following: abnormal LVEF, regional wall motion abnormality, and LV hypertrophy (based on criteria of de Simone et al).38

Cardiovascular Disease Risk Factors
Hypertension was classified based on self-reported medication use or the average of measured blood pressure readings of ≥140/90 mm Hg at any ARIC visit consistent with prior reports.31 Diabetes mellitus was defined based on self-report of a physician diagnosis of diabetes mellitus, antidiabetic medication use, fasting glucose ≥126 mg/dL, or nonfasting glucose ≥200 mg/dL. Body mass index was assessed at visit 3, and obesity was defined as body mass index ≥30 kg/m². Estimated glomerular filtration rate was calculated from visit 4 serum creatinine using the creatinine-based Chronic Kidney Disease Epidemiology Collaboration equation.39

Definition of ACC/AHA HF Stages and Related Methods Including Covariate Definitions
Table 1 lists the criteria used for determining the prevalence of different HF stages at visit 3. For this purpose, a combination of clinical covariates, echocardiographic criteria, and definitions of clinical outcome events were used.40

Outcome Events
Cardiovascular disease (CVD) events and all-cause mortality in ARIC were ascertained via continuous surveillance of hospitalizations and death certificates, annual telephone follow-up with the participant or a proxy, and linkage with the National Death Index. Incident coronary heart disease (CHD) was defined as a first occurrence of either adjudicated hospitalization for definite/probable myocardial infarction, or death caused by CHD.41 Fatal CHD was defined as the subset of incident CHD events that were confirmed to be

| HF Stage | Criteria for Definition |
|----------|-------------------------|
| Healthy/0 | Healthy participants, no cardiovascular risk factors, no symptoms of dyspnea or physical sign of edema |
| A        | Presence of at least 1 of the following HF risk factors:  |
|          | • Hypertension (SBP/DBP ≥140/90 mm Hg)  |
|          | • Diabetes mellitus (fasting glucose ≥126 mg/dL or use of diabetes mellitus medication)  |
|          | • Obesity (BMI ≥30 kg/m²)  |
|          | • Smoking (current smokers or smokers during the past year)  |
|          | • Dyslipidemia (total/HDL >5 or triglycerides ≥150 mg/dL or use of lipid-lowering treatment)  |
|          | • Coronary artery disease (excluding myocardial infarction) but no cardiac structural/functional abnormality on imaging studies  |
| B        | Presence of any of the following:  |
|          | • Prior clinical myocardial infarction (ARIC definition)  |
|          | • Echocardiographic evidence of asymptomatic left ventricular systolic dysfunction: left ventricular ejection fraction of <0.50 (corresponding to visual assessment of left ventricular ejection fraction [qualitative variable] and also by M-mode measurements of fractional shortening of <0.29)  |
|          | • Left ventricular hypertrophy (L VH= (LV Mass/ht².7) >51 g/m²³)  |
|          | • Regional wall motion abnormality  |
|          | • Left ventricular enlargement  |
| C/D      | Presence of HF using ARIC criteria:  |
|          | • Based on review of hospitalization records for any evidence of relevant HF symptoms (new onset or worsening of shortness of breath, edema, paroxysmal nocturnal dyspnea, orthopnea, or hypoxia) or any mention of HF as the reason for the hospitalization. If the hospitalization included such evidence, a second more detailed abstraction of the medical records was completed that included recording elements of HF diagnostic criteria (based on Framingham, modified Boston, National Health and Nutrition Examination Survey, and Gothenburg criteria), HF diagnostic scheme using ICD-9-CM codes, diagnostic tests (imaging tests), biomarkers, and medications (see references 31,40). |

ACC/AHA indicates American College of Cardiology/American Heart Association; ARIC, Atherosclerosis Risk in Communities Study; BMI, body mass index; HDL, high-density lipoprotein; HF, heart failure; ICD-9-CM, International Classification of Diseases, Ninth Revision, Clinical Modification; and SBP/DBP, systolic blood pressure/diastolic blood pressure.
definite fatal CHD events. Incident stroke was defined as a first occurrence of adjudicated hospitalization or death caused by definite/probable ischemic stroke. For the present investigation, atherosclerotic CVD was defined as CHD or stroke or peripheral arterial disease. Incident clinical HF was defined as the first occurrence of a physician-adjudicated diagnosis of HF hospitalization during follow-up after visit 3, or presence at visit 5 of a self-report of HF or treatment for HF among those without a prior HF hospitalization with at least 1 of the following supportive criteria: (1) subsequent confirmation of HF by a treating physician or the participant, or (2) a blood NT-terminal pro-B-type natriuretic peptide concentration ≥125 pg/mL at visit 5.

Statistical Analysis

We assessed the prevalence of HF stages for pooled sexes at visit 3. We repeated analyses separately for women versus men and also stratified by age less than or equal to the median age of 58 years versus >58 years, given reports of the occurrence of early onset of LV remodeling and overt HF in younger Black adults.

We estimated the incidence rates of overt HF, atherosclerotic CVD (composite of coronary artery disease, cerebrovascular disease, and peripheral arterial disease), death caused by atherosclerotic CVD, and all-cause mortality on follow-up according to HF Stage at visit 3. Kaplan–Meier curves were used to display cumulative incidence of individual events on follow-up (separately for each outcome), and the differences among the various HF stage strata tested using the log-rank test. Individuals with prevalent myocardial infarction were excluded from Stage B (N=89) for these analyses because they are a very high-risk group within this HF stage.

We used Cox proportional hazards regression to compare the relative risk of individual events (expressed as hazards ratios and their 95% CI; separate analyses for each individual event subtype) in participants with Stages B and C/D compared with the referent group of

Table 2. Characteristics of the Black Participants at ARIC Visit 3 According to Heart Failure Stage

| Characteristics                   | Healthy/0 (N=71) | A (N=386) | B (N=1253) | C/D (N=161) | P Value* |
|-----------------------------------|-----------------|-----------|------------|-------------|----------|
| Prevalence, %                     | 3.8             | 20.6      | 67.0       | 8.6         | <0.001   |
| Age, y                            | 55±4            | 57±5      | 58±5       | 58±5        | <0.001   |
| Women, %                          | 56.3            | 65.0      | 63.1       | 78.9        | <0.001   |
| BMI, kg/m²                        | 25.7±2.5        | 27.7±4.6  | 31.4±5.8   | 34.6±7.6    | <0.001   |
| Normal weight, %                  | 39.4            | 30.8      | 11.9       | 9.4         | <0.001   |
| Overweight, %                     | 60.6            | 39.2      | 35.0       | 23.1        | <0.001   |
| Obese, %                          | 0.0 (0)         | 30.0      | 53.1       | 67.5        | <0.001   |
| Systolic BP                        | 116±11          | 124±17    | 131±19     | 133±19      | <0.001   |
| Diastolic BP                       | 72±8            | 75±10     | 77±11      | 78±10       | <0.001   |
| Hypertension, %                   | 0.0             | 46.3      | 57.2       | 84.4        | <0.001   |
| Antihypertensive Medication, %    | 0.0             | 42.9      | 51.7       | 83.7        | <0.001   |
| Diabetes mellitus, %              | 0.0             | 15.8      | 25.6       | 47.5        | <0.001   |
| Current smokers, %                | 0.0             | 20.8      | 20.2       | 16.3        | <0.001   |
| Total: HDL ratio                  | 3.25±1.03       | 3.94±1.36 | 3.96±1.30  | 3.98±1.21   | <0.001   |
| Triglycerides, mg/dL              | 81.4±35.0       | 113.1±77.3| 111.1±58.5 | 123.0±61.3  | <0.001   |
| Estimated GFR                     | 96.4±16.5       | 93.5±17.3 | 94.2±17.6  | 91.5±20.0   | <0.001   |
| History of myocardial infarction, %| 0.0             | 0.0       | 7.1        | 20.5        | <0.001   |
| E/A Ratio                         | 1.97±0.52       | 1.72±0.46 | 1.64±0.47  | 1.51±0.59   | <0.001   |
| LV ejection fraction, %           | 0.0             | 0.0       | 98.8       | 85.1        | <0.001   |

Definition of HF Stages in ARIC: Stage 0: Healthy, no risk factors; Stage A: presence of HF risk factors (hypertension, current smoking, obesity, total cholesterol ≥200, diabetes mellitus, obesity, coronary artery disease), no cardiac structural/functional abnormality; Stage B: presence of prior myocardial infarction, LV systolic dysfunction, LV hypertrophy (see Table 1 for definitions); Stage C/D: Prevalent clinical HF. ARIC indicates Atherosclerosis Risk in Communities Study; BP, blood pressure; GFR, glomerular filtration rate; HDL, high-density lipoprotein; HF, heart failure; and LV, left ventricular.

*Trend test P value using analysis of variance for continuous variables and Cochran-Mantel-Haenszel test for categorical variables.
We performed secondary analyses where we modeled time to CVD events and overt HF with the following 3 tests: (1) compare model fitness between model 1 (CVD risk factors alone), and models 2, 3 (additional inclusion of echocardiographic abnormality, left ventricular hypertrophy [model 2], LV dysfunction [model 3]); (2) test whether regression coefficient for hypertension and echocardiographic abnormalities are different from zero in models 2 and 3; and (3) evaluate the C-statistic for the 3 models.

All analyses were conducted using SAS software versions 9.4 and Kaplan-Meier curves generated.

Table 3. Sex-Specific Prevalence of AHA/ACC HF Stages at ARIC Visit 3: Overall and at or Below Versus Above Median Age (≤58 Versus >58) Y (N=1871)

| HF Stages | Women, N (%) | Men, N (%) |
|-----------|--------------|------------|
|           | ≤ Median Age | >Median Age | All Ages | ≤ Median Age | >Median Age | All Ages |
| Total (no.) | 650 | 559 | 1209 | 364 | 298 | 662 |
| Healthy/0 | 29 (4.5) | 11 (2.0) | 40 (3.3) | 24 (6.6) | 7 (2.4) | 31 (4.7) |
| A | 147 (22.6) | 104 (18.6) | 251 (20.8) | 86 (23.8) | 49 (16.4) | 135 (20.4) |
| B | 425 (65.4) | 366 (65.4) | 791 (65.4) | 241 (66.2) | 221 (74.2) | 462 (69.8) |
| C/D | 49 (7.5) | 78 (14.0) | 127 (10.5) | 13 (3.6) | 21 (7.1) | 34 (5.1) |

ACC/AHA indicates American College of Cardiology/American Heart Association; ARIC, Atherosclerosis Risk in Communities Study; and HF, heart failure.
RESULTS

Prevalence of HF Stages in Midlife

The baseline characteristics of study participants at visit 3 are shown according to their HF stage (Table 2). At visit 3 (median age 58 years), very few individuals were healthy (Stage 0). Nearly 20% of the participants were grouped as Stage A and almost two thirds of them were categorized as HF stage B (Figure 1). Prevalence of HF stage C/D was twice as high in women (10.5%) compared with men (5.1%). The prevalence of risk factors, CHD, and echocardiographic evidence of left ventricular hypertrophy or LV systolic dysfunction increased across the HF stages (by definition). The vast majority (89%) of participants with prevalent Stage C/D HF had a normal LVEF (Table 2).

Table 3 shows the prevalence of HF stages in women and men stratified by median age ≤58 years versus >58 years at visit 3. Nearly 63% of women and 66% of men below age 58 years were categorized as Stage B HF.

Incidence of Adverse CVD Events and Deaths

On follow-up after visit 3 (median 19.0 years, range 1.3 to 20.8 years), 309 participants experienced clinical HF, 390 incurred a new atherosclerotic CVD event, 208 died because of CVD, and 651 individuals died overall. In the subset without prevalent myocardial infarction in stage B (N=1782), there were 282 HF events, 361 CVD events, 180 CVD deaths, and 598 deaths.

Incidence rates per 1000 person-years for overt HF, CVD, and death, respectively, were Stage 0, 2.4, 0.8, and 7.6; Stage A, 7.4, 9.7, and 13.5; and Stage B, 13.6, 15.9, and 22.0. Table 4 shows the incidence rates of these events on follow-up after visit 3 according to HF stage at that visit (89 individuals with prevalent myocardial infarction in Stage B were excluded for these analyses). Figure 2 Panels A-D show the Kaplan–Meier curves for individual outcomes according to HF stage and the corresponding log-rank P values. Very few events were observed in the minority of participants who were healthy at visit 3. Absolute event rates for each of the event subtypes escalated across the HF stages. The absolute incidence rates

using R version 3.5.2. A 2-sided P value of <0.05 was used to denote statistical significance. SKM had access to all study data and takes responsibility for its integrity and data analysis.

| HF Stage | 0 | A | B | C/D | Pooled |
|----------|---|---|---|-----|--------|
| Clinical HF | | | | | |
| Cases/no. at risk | 3/71 | 48/386 | 231/1164 | NA | 282/1162 |
| Total-person-y | 1276 | 6480 | 17 913 | NA | 28 793 |
| Event rates* | 2.4 (0.8–7.3) | 7.4 (5.6–9.8) | 12.9 (11.3–14.7) | NA | 9.8 (8.7–11.0) |
| Hazard ratio† | Referent | 1.75 (1.28–2.39) | NA | ... |
| CVD‡ | | | | | |
| Cases/no. at risk | 1/71 | 61/379 | 257/1127 | 42/132 | 361/1709 |
| Total-person-y | 1294 | 6297 | 17 384 | 1724 | 26 698 |
| Event rates* | 0.8 (0.1–5.5) | 9.7 (7.5–12.5) | 14.8 (13.1–16.7) | 24.4 (18.0–33.0) | 13.8 (12.2–15.0) |
| Hazard ratio† | Referent | 1.48 (1.12–1.95) | 2.66 (1.79–3.96) | ... |
| CVD death | | | | | |
| Cases/no. at risk | 2/71 | 19/386 | 115/1164 | 44/161 | 180/1782 |
| Total-person-y | 1307 | 6805 | 19 469 | 2239 | 29 820 |
| Event rates* | 1.5 (0.4–6.1) | 2.8 (1.8–4.4) | 5.9 (4.9–7.1) | 19.6 (14.6–26.4) | 6.0 (5.2–7.0) |
| Hazard ratio† | Referent | 2.06 (1.27–3.35) | 7.41 (4.30–12.75) | ... |
| All-cause mortality | | | | | |
| Cases/no. at risk | 10/71 | 92/386 | 402/1164 | 94/161 | 598/1782 |
| Total-person-y | 1307 | 6805 | 19 469 | 2239 | 29 821 |
| Event rates* | 7.6 (4.1–14.2) | 13.5 (11.0–16.6) | 20.8 (18.7–22.8) | 42.0 (34.3–51.4) | 20.1 (18.5–21.7) |
| Hazard ratio† | Referent | 1.49 (1.19–1.87) | 3.24 (2.43–4.34) | ... |

Heart Failure stage A was the referent group because of too few events in the Stage 0 group. We excluded prevalent MI from stage B (N=89) for these analyses. Individuals with prevalent CVD in each stage were excluded for analyses of CVD incidence. CVD indicates cardiovascular disease; HF, heart failure; and MI, myocardial infarction.

*Per 1000 person-y (95% CI).
†Age- and sex-adjusted hazard ratios (95% CI) for baseline HF stages.
‡Excluding HF.
Figure 2. Kaplan–Meier plots for outcomes grouped by heart failure stages. A, Incident clinical HF. B, CVD events. C, CVD death. D, All-cause death. The numbers of subjects at risk by HF stages are noted at each time point. P values indicate the log-rank test. Individuals with prevalent MI in Stage B were excluded for these analyses. Additionally, participants with prevalent CVD were excluded for analyses of incident CVD. Prevalent HF events at visit 5 (but after visit 3) that did not have an exact time of onset were deemed to have occurred at the midpoint between the 2 examinations for participants, which accounts for the steep change in slope between 8 and 12 y of follow-up. CVD indicates cardiovascular disease; HF, heart failure; and MI, myocardial infarction.
for atherosclerotic CVD and death were higher than the rates of overt HF among people with Stage B HF. Compared with the referent group (Stage A), those with Stage B HF experienced a 1.5 to 2-fold increased risk of developing clinical HF, an atherosclerotic CVD event, or death from any cause. Stage C/D HF was associated with a very high incidence rate of CVD and mortality. In analyses stratifying by median age at visit
3 (58 years), no effect modification by age was observed for various risks associated with the HF stages (Table 5).

In secondary analyses (Table 6), we evaluated the incremental contributions of left ventricular hypertrophy and LV dysfunction beyond CVD risk factors to the risk of developing incident clinical HF and CVD (separate analyses for both outcomes and for both echocardiographic variables). For both incident clinical HF and incident CVD, a model with echocardiographic LV dysfunction in addition to hypertension was a better fit than one with hypertension only, although the model C-statistic was essentially unchanged across models 1 to 3 for both events.

**DISCUSSION**

The present investigations describe the prevalence of various ACC/AHA HF stages in midlife in community-dwelling Black participants in the ARIC study. Our principal findings are 3-fold. First, very few individuals had a healthy profile in our sample at the initial visit. In contrast, a very high proportion of Black people have Stage B HF characterized by structural heart disease in midlife, including in individuals below the median age of 58 years. The high prevalence of Stage B was consistent across the 2 sexes. In parallel, we observed a relatively high prevalence of overt HF (Stage C/D) in this age group in both sexes, with prevalence in women being twice as high as that in men (10.5% versus 5.1%, respectively). HF with preserved ejection fraction was predominant in those with Stage C/D HF.

Second, longitudinal follow-up of participants after the initial visit (visit 3) demonstrated that individuals with Stage B HF are at very high risk for developing atherosclerotic CVD, CVD death, and death from all causes. Although the relative risk of developing overt HF was 1.75-fold higher in those with Stage B HF (compared with the referent group with Stage A), participants in this group were more likely to develop atherosclerotic CVD or die than to incur clinical HF (in terms of absolute rates of these CVD events).

Third, the presence of echocardiographic left ventricular hypertrophy and LV dysfunction was associated with the risk of developing clinical HF and CVD.

**Comparison With the Published Literature**

Several reports have been published on the prevalence of ACC/AHA HF stages in White people in the community in the United States. In these reports between 50% and 80% of older White adults (age 70 years) had Stage B HF per the AHA/ACC classification system, whereas only 15% to 20% had Stage A HF. It is striking that we observed a similar very high prevalence
of Stages B HF in Black people in midlife (67% at visit 3, median age 58 years) in the present investigation. It is noteworthy that a separate evaluation of the ARIC cohort at an older age (mean age 75 years) demonstrated a much lower prevalence of Stage B HF of ≈25%, suggesting perhaps that the numbers of individuals with Stage B HF may decrease with aging, presumably because of cardiovascular morbidity and mortality.

Overall, our data are consistent with a greater burden of subclinical disease at a younger age in Black people in the CARDIA (Coronary Artery Disease Risk in young Adults) study.15,16 As noted previously, our observations in ARIC may stem from the greater burden of risk factors for HF in Black people as well as to their greater propensity to develop adverse LV remodeling upon exposure to these risk factors.22 The higher prevalence of Stage C/D HF in Black people in midlife is consistent with prior reports11,12 underscoring the development of overt HF at a relatively young age in Black people.

Prevalence of HF stage C/D at visit 3 was higher in women (10.5%) than in men (5.1%) in our investigation. This striking sex-related difference in prevalent HF in young Black people has not been highlighted previously. It is noteworthy that in a previous report that underscored the occurrence of HF at a young age in Black people, a larger proportion of Black women (62%) were represented than Black men (38%), with the point estimate of cumulative incidence of HF being slightly higher in women compared with men (1.1% versus 0.9%, respectively).11

We performed 3 tests (1) to compare a model fitness between models 1 vs 2 and 1 vs 3 using likelihood ratio test, (2) tested whether regression coefficient for hypertension, LVH, and LV dysfunction are different from zero, and (3) evaluated the C-statistic (± SE) for all models. CVD indicates cardiovascular disease; HDL, high-density lipoprotein; HF, heart failure; LV, left ventricular; and LVH, left ventricular hypertrophy.

Table 6. Association of CVD Risk Factors and Echocardiographic Abnormality With Incidence of Clinical HF and CVD Events

| Predictors | Hazard Ratio (95% CI) for Incident Clinical HF | Hazard Ratio (95% CI) for Incident CVD |
|------------|-----------------------------------------------|-------------------------------------|
|            | Model 1 | Model 2 | Model 3 | Model 1 | Model 2 | Model 3 |
| Age, per unit | 1.02 (0.99–1.04) | 1.02 (0.99–1.04) | 1.02 (0.99–1.04) | 1.06 (1.04–1.08) | 1.05 (1.03–1.07) | 1.05 (1.03–1.07) |
| Male sex    | 1.37 (1.08–1.82) | 1.31 (1.01–1.71) | 1.32 (1.02–1.72) | 1.61 (1.28–2.01) | 1.55 (1.24–1.94) | 1.55 (1.24–1.95) |
| Body mass index, per unit | 1.03 (1.01–1.05) | 1.02 (1.00–1.05) | 1.03 (1.01–1.05) | 1.01 (0.99–1.03) | 1.01 (0.99–1.03) | 1.01 (0.99–1.03) |
| Diabetes mellitus | 1.69 (1.29–2.22) | 1.65 (1.26–2.15) | 1.67 (1.27–2.18) | 2.07 (1.65–2.60) | 2.02 (1.61–2.54) | 2.03 (1.61–2.55) |
| Current smoking | 1.58 (1.17–2.12) | 1.45 (1.07–1.96) | 1.48 (1.09–1.99) | 2.14 (1.67–2.75) | 1.98 (1.54–2.56) | 1.99 (1.54–2.57) |
| Total: HDL ratio, per unit | 1.07 (0.99–1.17) | 1.08 (0.99–1.18) | 1.08 (0.99–1.18) | 1.14 (1.06–1.21) | 1.13 (1.06–1.21) | 1.13 (1.06–1.21) |
| Hypertension | 1.73 (1.34–2.23) | 1.64 (1.27–2.13) | 1.67 (1.29–2.17) | 1.95 (1.55–2.46) | 1.90 (1.51–2.40) | 1.91 (1.51–2.40) |

Echocardiographic abnormality

| Predictor | Hazard Ratio (95% CI) for Incident Clinical HF | Hazard Ratio (95% CI) for Incident CVD |
|-----------|-----------------------------------------------|-------------------------------------|
| LVH or LV dysfunction* | 1.59 (1.10–2.30) | 1.58 (1.15–2.16) |
| LVH* | ... | 1.40 (1.01–1.94) |
| LV dysfunction* | ... | 1.70 (1.18–2.45) |

We observed higher rates of atherosclerotic CVD and death (relative to incident HF) during long-term follow-up in people with Stage B HF at visit 3. The high mortality experienced by Black people with Stage B HF in midlife may explain why the prevalence of this stage is much lower in elderly Black people, as noted above.31 Other investigators also have reported that Black people with multiple HF risk factors may be more prone to experience CVD and death, rather than HF.

Strengths and Limitations

Our study is strengthened by the assessment of HF stages at a key time point in life in Black people in the community (ie, middle age). The comprehensive assessment of the prognosis of different HF stages in midlife is an additional strength. Nonetheless, several
limitations warrant acknowledgment. It is important to note that our data represent a period from 2 decades ago. It is likely that temporal trends in the prevalence of risk factors such as obesity and diabetes mellitus may influence the current prevalence of HF stages in middle-aged Black people. Additionally, a direct comparison with prevalence of HF stages in middle-aged Black people versus White people in the ARIC study was not feasible because echocardiography was performed only in Black participants at the Jackson site at visit 3 of the cohort. Unlike a recent report that used more comprehensive echocardiographic data (including data on LV diastolic dysfunction and measures of LV strain) to better evaluate the true burden of Stage B HF in Black people, we used simpler echocardiographic criteria for Stage B HF in the present investigation. This may have resulted in an inflation of prevalence of Stage A HF, and an underestimation of the relative prevalence of Stage B HF. The lack of availability of more sophisticated echocardiographic assessment at visit 3 could have biased our estimates of prevalence of HF stages; in a recent report, 14% of the participants were reclassified from Stage A to Stage B HF with the use of more novel measures of LV impairment. Also, our participants were recruited from a single community site, which may limit the generalizability of our findings.

Clinical Implications

Our observations on a large community-based sample of Black people underscore the low prevalence of a healthy risk factor profile over their life course. We also observed a strikingly high prevalence of structural heart disease (Stage B HF) in midlife; similar high proportions of prevalence of Stage B HF are seen in much older White people in other reports. The high prevalence of Stage C/D HF in middle-aged Black individuals, especially so in Black women, warrants further investigation. Overall, these findings are consistent with the “telescoping in time” of adverse LV remodeling in Black people in the general population, relative to White people. The high burden of both HF risk factors and structural heart disease in midlife is marked by substantial CVD and mortality risk on follow-up. Overall, our observations underscore the critical need to screen for and detect both HF risk factors and structural heart disease earlier in their life course in Black people, and to treat modifiable risk factors optimally to reduce their burden of CVD in midlife and overt HF in later life.

CONCLUSIONS

In our large community-based sample of middle-aged Black people assessed for prevalence of ACC/AHA HF stages, we observed a very high burden of structural heart disease (Stage B) in midlife. Additionally, the higher prevalence of Stage B HF in midlife was a marker of CVD and all-cause mortality risk (rather than purely a marker of HF risk). Additional investigations of younger Black people are necessary to elucidate the basis of their substantial burden of structural heart disease, and of prevalent Stage C/D HF in Black women. Such studies may identify modifiable risk factors that can be targeted to mitigate the elevated mortality risk in middle-aged Black people, and alleviate their overall burden of subclinical and overt disease in midlife.

ARTICLE INFORMATION

Received March 8, 2020; accepted January 21, 2021.

Affiliations

From the Section of Preventive Medicine, Department of Medicine (R.S.V.) and Section of Cardiology, Department of Medicine (R.S.V.), Boston University School of Medicine, Boston, MA; Department of Epidemiology, Boston University School of Public Health, Boston, MA (R.S.V.); Department of Medicine, University of Mississippi Medical Center, Jackson, MS (S.K.M., W.B., O.B.O., K.R.B., T.H.M., E.F.); Department of Epidemiology, Johns Hopkins Bloomberg School of Public Health, Baltimore, MD (K.M.); and Division of Cardiology, Department of Medicine, University of North Carolina at Chapel Hill, NC (P.P.C.).

Acknowledgments

The authors thank the staff and participants of the ARIC study for their important contributions.

Sources of Funding

The Atherosclerosis Risk in Communities study has been funded in whole or in part with Federal funds from the National Heart, Lung, and Blood Institute, National Institutes of Health, Department of Health and Human Services, under Contract nos. (HHSN268201700001I, HHSN268201700002I, HHSN268201700003I, HHSN268201700005I, HHSN268201700004I).

Disclosures

None.

REFERENCES

1. Aronow WS, Ahn C, Kronzon I, Koenigsberg M. Congestive heart failure, coronary events and atherothrombotic brain infarction in elderly blacks and whites with systemic hypertension and with and without echocardiographic and electrocardiographic evidence of left ventricular hypertrophy. Am J Cardiol. 1991;67:295–299. DOI: 10.1016/0002-9149(91)90562-Y.
2. Ghali JK, Kadakia S, Cooper R, Ferlinz J. Precipitating factors leading to decompensation of heart failure. Traits among urban blacks. Arch Intern Med. 1988;148:2013–2016. DOI: 10.1001/archinte.1988.00380100087021.
3. Gordon HS, Nowlin PR, Maynard D, Berbaum ML, Deswal A. Mortality after hospitalization for heart failure in blacks compared to whites. Am J Cardiol. 2010;105:694–700. DOI: 10.1016/j.amjcard.2009.10.051.
4. Mathew J, Davidson S, Narra L, Hafeez T, Garg R. Etiology and characteristics of congestive heart failure in blacks. Am J Cardiol. 1996;78:1447–1450. DOI: 10.1016/S0002-9149(96)00635-2.
5. Roberts CB, Couper DJ, Chang PP, James SA, Rosamond WD, Heiss G. Influence of life-course socioeconomic position on incident heart failure in blacks and whites: the Atherosclerosis Risk in Communities Study. Am J Epidemiol. 2010;172:717–727. DOI: 10.1093/aje/kwq193.
by ethnicity; the multi-ethnic study of atherosclerosis. Arch Intern Med. 2008;168:2138–2145. DOI: 10.1001/archinte.168.19.2138.

22. Fernandes-Silva MM, Shah AM, Hegde S, Goncalves A, Claggett B, Cheng S, Nadruz W, Kitzman DW, Kontey SH, Matsushita K, et al. Race-related differences in left ventricular structural and functional remodeling in response to increased afterload: the ARC Study. JACC Heart Fail. 2017;5:157–165. DOI: 10.1016/j.jchf.2016.10.022.

23. Philipp EJ, Weil HF, Francis CA, Marx HJ, Jenkins PL, Pearson TA, Reed RG. Race-related differences among patients with left ventricular dysfunction: observations from a biracial angiographic cohort. Harlem-Bassett LPA investigators. J Card Fail. 2000;6:187–193. DOI: 10.1054/jcaf.2000.9677.

24. Dries DL, Exner DV, Gersh BJ, Cooper HA, Carson PE, Domanski MJ. Racial differences in the outcome of left ventricular dysfunction. N Engl J Med. 1999;340:609–616. DOI: 10.1056/NEJM199902253400804.

25. Prendergast HM, Dudley S, Kane J, Daviglus M, Marcucci J, Acosta A, Bunney EB, Richardson D, O’Neal T. Progression of left ventricular diastolic dysfunction in ethnic minorities. High Blood Press Cardiovasc Prev. 2014;21:205–211. DOI: 10.1007/s40292-013-0031-2.

26. Thomas KL, East MA, Velazquez EJ, Tuttle RH, Shaw LK, O’Connor CM, Peterson ED. Outcomes by race and etiology of patients with left ventricular systolic dysfunction. Am J Cardiol. 2005;95:956–963. DOI: 10.1016/j.amjcard.2005.07.002.

27. Shaw J, Zhang L, Holmes AA, Taub CC. The impact on race of the prognosis of preclinical diastolic dysfunction: a large multicenter urban population study. Am J Med. 2019;132:222.e1–222.e10. DOI: 10.1016/j.amjmed.2019.02.006.

28. Huffman MD, Berry JD, Ning H, Dyer AR, Garside DB, Cai X, Daviglus ML, Lloyd-Jones DM. Lifetime risk for heart failure among white and black Americans: cardiovascular lifetime risk pooling project. J Am Coll Cardiol. 2013;61:1510–1517. DOI: 10.1016/j.jacc.2013.01.022.

29. Taylor HA, Penman AD, Han H, Dele-Michael A, Skelton TN, Fox ER, Benjamini EJ, Arnett DK, Mosley TH Jr. Left ventricular architecture and survival in African-Americans free of coronary heart disease (from the Atherosclerosis Risk in Communities [ARIC] Study). Am J Cardiol. 2007;99:1413–1420. DOI: 10.1016/j.amjcard.2006.12.065.

30. Liao Y, Cooper RS, McGee DL, Mensah GA, Ghali JK. The relative effects of left ventricular hypertrophy, coronary artery disease, and ventricular dysfunction on survival among black adults. JAMA. 1995;273:1592–1597. DOI: 10.1001/jama.1995.035204.0004605.

31. Shah AM, Claggett B, Loehr LR, Chang PP, Matsushita K, Kitzman D, Kontey S, Kucharska-Newton A, Sueta CA, Mosley TH, et al. Heart failure stages among older adults in the community: the Atherosclerosis Risk in Communities Study. Circulation. 2017;135:224–230. DOI: 10.1161/CIRCULATIONAHA.116.023381.

32. Yancy CW, Jessup M, Bozkurt B, Butler J, Casey DE, Drazner MH, Fonarow GC, Geraci SA, Horwich T, Januzzi JL, et al. 2013 ACCF/AHA guideline for the management of heart failure: a report of the American College of Cardiology/American Heart Association Task Force on Practice Guidelines (Committee to revise the 1995 guideline for the evaluation and management of heart failure). J Am Coll Cardiol. 2013;62:e240–e327. DOI: 10.1016/j.jacc.2013.07.018.

33. Hunt SA, Baker DW, Chin MH, Cushman M, Delling FN, Deo R, et al. American Heart Association Committee to revise the 1995 guidelines for the evaluation and management of heart failure. Circulation. 2007;116:1770–1827. DOI: 10.1161/CIRCULATIONAHA.106.649972.

34. Zhang Q, Spertus JA, Larson MG, Levy D, Grodstein F, D’Agostino RB Sr. Racial and ethnic disparities in self-reported quality of care for heart failure in the community. Arch Intern Med. 2008;168:641–648. DOI: 10.1001/archinte.168.6.641.

35. Moritz AR, Zareba W, Rouleau JL. Race: a major factor in the presentation and management of heart failure. Circulation. 2005;112:1588–1600. DOI: 10.1161/01.CIR.0000199533.93010.1B.

36. Vasan RS, Benjamin EJ, Arnett DK, Drazner MH, Fonarow GC, Geraci SA, Januzzi JL Jr, et al. A common model for stroke prevention in patients with heart failure: the Atherosclerosis Risk in Communities Study. Stroke. 2013;44:2577–2583. DOI: 10.1161/STROKEAHA.113.001839.
predict cardiovascular risk. *J Am Coll Cardiol*. 1995;25:1056–1062. DOI: 10.1016/0735-1097(94)00540-7.

39. Levey AS, Stevens LA, Schmid CH, Zhang YL, Castro AF, Feldman HI, Kusek JW, Eggers P, Van Lente F, Greene T, et al. A new equation to estimate glomerular filtration rate. *Ann Intern Med*. 2009;150:604–612. DOI: 10.7326/0003-4819-150-9-200905050-00006.

40. Rosamond WD, Chang PP, Baggett C, Johnson A, Bertoni AG, Shahar E, Deswal A, Heiss G, Chambless LE. Classification of heart failure in the atherosclerosis risk in communities (ARIC) study. *Circ Heart Fail*. 2012;5:152–159. DOI: 10.1161/CIRCHEARTFAILURE.111.963199.

41. White AD, Folsom AR, Chambless LE, Sharret AR, Yang K, Conwill D, Higgin M, Williams OD, Tyroler HA. Community surveillance of coronary heart disease in the Atherosclerosis Risk in Communities (ARIC) Study: methods and initial two years’ experience. *J Clin Epidemiol*. 1996;49:223–233. DOI: 10.1016/0895-4356(95)00041-0.

42. Rosamond WD, Folsom AR, Chambless LE, Wang CH, McGovern PG, Howard G, Copper LS, Shahar E. Stroke incidence and survival among middle-aged adults: 9-year follow-up of the Atherosclerosis Risk in Communities (ARIC) cohort. *Stroke*. 1999;30:736–743. DOI: 10.1161/01.STR.30.4.736.

43. Ammar KA, Jacobsen SJ, Mahoney DW, Kors JA, Redfield MM, Burnett JC Jr, Rodenheffer RJ. Prevalence and prognostic significance of heart failure stages: application of the American College of Cardiology/American Heart Association heart failure staging criteria in the community. *Circulation*. 2007;115:1563–1570. DOI: 10.1161/CIRCULATIONAHA.106.666818.

44. Xanthakis V, Enserro DM, Larson MG, Wollert KC, Januzzi JL, Levy D, Aragam J, Benjamin EJ, Cheng S, Wang TJ, et al. Prevalence, neurohormonal correlates, and prognosis of heart failure stages in the community. *JACC Heart Fail*. 2016;4:808–815. DOI: 10.1016/j.jchf.2016.05.001.