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Operative Status and Survival after Coronary Artery Bypass Grafting

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ABSTRACT

Background: The effect of race on long-term survival of patients undergoing elective and nonelective coronary artery bypass grafting (CABG) is currently unknown. The purpose of this study was to compare long-term survival between black and white CABG patients by operative status.

Methods: Long-term survival of black versus white patients undergoing elective and nonelective CABG procedures between 1992 and 2011 was compared. Survival probabilities were computed using the Kaplan-Meier product-limit method and stratified by race. Hazard ratios (HR) and 95% confidence intervals (CI) were computed using a Cox regression model.

Results: A total of 13,774 patients were included in this study. The median follow-up time for study participants was 8.2 years. Black patients undergoing elective CABG died sooner than whites (adjusted HR = 1.4, 95% CI = 1.2-1.5). Survival was similar between blacks and whites in the nonelective population (adjusted HR = 1.0, 95% CI = 0.96-1.1).

Conclusions: Black race was a statistically significant predictor of long-term survival after elective but not nonelective CABG.

INTRODUCTION

Black race has been shown to be an important predictor of postoperative complications following coronary artery bypass grafting (CABG) [Bridges 2000; Hartz 2001; Rumsfeld 2002]. Several studies have reported that black race is associated with decreased long-term survival after CABG compared with whites [Maynard 1987; Gray 1996; Taylor 1997; Brooks 2000; Cooper 2009]. However, the influence of black race on long-term survival after CABG by operative status (elective versus nonelective) has not been examined.

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Consistent with decreased life expectancy among blacks compared with whites, we hypothesized that black race would be a significant predictor of decreased long-term survival among patients undergoing elective CABG [Bharmal 2012]. In contrast, we hypothesized that survival rates for black and white patients would be similar within the nonelective CABG group due to a similarly poor cardiovascular risk factor profile.

MATERIALS AND METHODS

Study Design

This was a retrospective cohort study of patients undergoing first-time, isolated CABG at the East Carolina Heart Institute between 1992 and 2011. Demographic data, comorbid conditions, coronary artery disease (CAD) severity, and surgical data were collected at the time of surgery. Only black and white patients were included, to minimize the potential for residual confounding (~1% other races). Racial identity was self-reported. The study was approved by the Institutional Review Board at the Brody School of Medicine, East Carolina University.

Definitions

Nonelective CABG patients were defined as a distinct population from elective CABG patients with differing cardiovascular disease pathology. Elective operations denoted procedures in which cardiac function was stable prior to operation and surgery could be performed on an outpatient basis. Nonelective procedures included urgent, emergent, and salvage operations. Urgent procedures required surgery during the same hospitalization in order to minimize the chance of further clinical deterioration (e.g., sudden chest pain, heart failure, acute myocardial infarction [MI], critical stenosis, intraaortic balloon pump, unstable angina with intravenous nitroglycerin, and anticoagulants or rest angina). Patients with ongoing, refractory, or unrelenting cardiac compromise, with or without hemodynamic instability, and nonresponsive to any form of therapy except cardiac surgery defined the emergent surgery group (e.g., ongoing ischemia including rest angina despite maximal medical therapy, acute evolving MI within 24 hours before surgery, pulmonary edema requiring intubation, shock with or without circulatory support).

In contrast, patients undergoing cardiopulmonary resuscitation or extracorporeal membrane oxygenation en route to the operating room or prior to anesthesia induction defined the salvage surgery group. Mortality was defined as any cause of death postoperatively. CAD was defined as at least 50% stenosis and confirmed by angiography before surgery.

Setting

The East Carolina Heart Institute is a 120-bed cardiovascular hospital located in the center of eastern North Carolina, a predominately rural, low-income, and racially dichotomous population. The institute is a population-based tertiary referral center and is the largest stand-alone hospital devoted to cardiovascular care in the state of North Carolina. Cardiovascular disease is the number one cause of death in North Carolina, with an unequal burden occurring in eastern North Carolina [Morris 2012]. Nearly all patients treated at the East Carolina Heart Institute live and remain within a 150-mile radius of the medical center.

Data Collection and Follow-up

The primary sources of data extraction were the Society of Thoracic (STS) Adult Cardiac Surgery Database and the electronic medical record at the Brody School of Medicine. Cardiovascular surgery information at our facility has been reported to the STS for over 20 years. Data quality and cross-field validation are routinely performed by the Epidemiology and Outcomes Research Unit at the East Carolina Heart Institute. An electronic medical record was introduced at the Brody School of Medicine in 1997. Records prior to 1997 were retrospectively scanned into the electronic medical record. Local and regional clinics were consolidated under a single electronic medical record in 2005, which allowed for efficient patient follow-up. The electronic medical record system applies multiple logic comparisons to reliably reduce mismatching of patient data across clinics and follow-up visits. The STS database is linked to the electronic medical record through a unique patient medical record number. The National Death Index was used to obtain death dates for patients lost to follow-up and also used to validate death information captured in our electronic medical record. Linkage with the National Death Index was based on a multiple criteria, deterministic matching algorithm, which included a patient's social security number [Morales 2008]. In our database, less than 5% of validated deaths failed to correctly match with the National Death Index. Beginning in 2012, the use of social security numbers as a patient identifier was proscribed within our university system.

STATISTICAL ANALYSIS

Categorical variables were reported as frequency and percentage, and continuous variables were reported as mean ± standard deviation (SD), median, and range. Variables not previously categorized were divided into quartiles prior to statistical analysis. Quartile categorization is advantageous because it limits the influence of outliers and allows for the assessment of trend across categories. Follow-up time was measured from the date of surgery to the date of death or censoring. Survival probabilities were computed using the Kaplan-Meier product-limit method and stratified by race. The log-rank test was used to compare survival between black and white patients. Cox proportional hazard regression models were used to compute hazard ratios (HR) and 95% confidence intervals (CI) for long-term mortality. The initial multivariable models included variables that have been previously reported to be associated with cardiovascular-related mortality, regardless of their statistical significance in our dataset [Efird 2013a; Efird 2013b; Efird 2013c; O'Neal 2013a; O'Neal 2013b; O'Neal 2013c]. These included age, sex, race, hypertension, CAD severity, heart failure, and prior stroke. The post hoc addition of other variables into the model was performed in a pairwise fashion. The test statistic of Grambsch and Therneau was used to check the proportional hazards assumption [Grambsch 1994]. Statistical significance for categorical variables was tested using the chi-square (χ^2) method and the Deuchler-Wilcoxon procedure for continuous variables. P_{Trend} was computed using a likelihood ratio test. Temporality during the study period was assessed by stratifying the analysis by 3 time periods. Few values were missing (<1% for included variables). However, when values were missing they were entered into the regression models as a separate category. Analyses also were conducted using an iterative expectation-maximization (EM) algorithm [Dempster 1977; Little 2012; Ware 2012]. Both methods yielded similar results. Statistical significance was defined as $P < 0.05$. SAS Version 9.3 (Cary, NC) was used for all analyses.

RESULTS

A total of 13,774 patients were included in this study. The population was predominately white (83%), male (70%), and above 60 years of age (65%). The percentage of patients who underwent elective (40%) CABG was less than the percentage who underwent nonelective (60%) CABG (Tables 1 and 2). Of the nonelective cases, 7,844 (94%) were classified as having an urgent operation. In both elective and nonelective groups, statistically significant racial differences were observed for sex, body mass index, hypertension, diabetes, heart failure, dialysis, peripheral arterial disease, prior MI, and prior stroke. More recent smokers were present among black patients in the elective group than white patients. The median follow-up time for study participants was 8.2 years. Kaplan-Meier unadjusted survival curves are shown for elective and nonelective CABG in Figures 1 and 2, respectively. Median survival for elective CABG was 12 years for black patients and 15 years for white patients. For nonelective cases, median survival for black and white patients was 13 years.

The long-term survival after CABG did not substantively differ between blacks and whites (unadjusted HR = 1.1, 95% CI = 1.07-1.2; adjusted HR = 1.1, 95% CI = 1.06-1.2). Among elective CABG patients, blacks died significantly sooner than whites (adjusted HR = 1.4, 95% CI = 1.2-1.5) (Table 3). In contrast, survival was similar between blacks and whites in the nonelective CABG population (adjusted HR = 1.0, 95% CI = 0.96-1.1) (Table 3). The pairwise inclusion of other variables listed in Tables 1 and 2 did not appreciatively change our multivariable results.

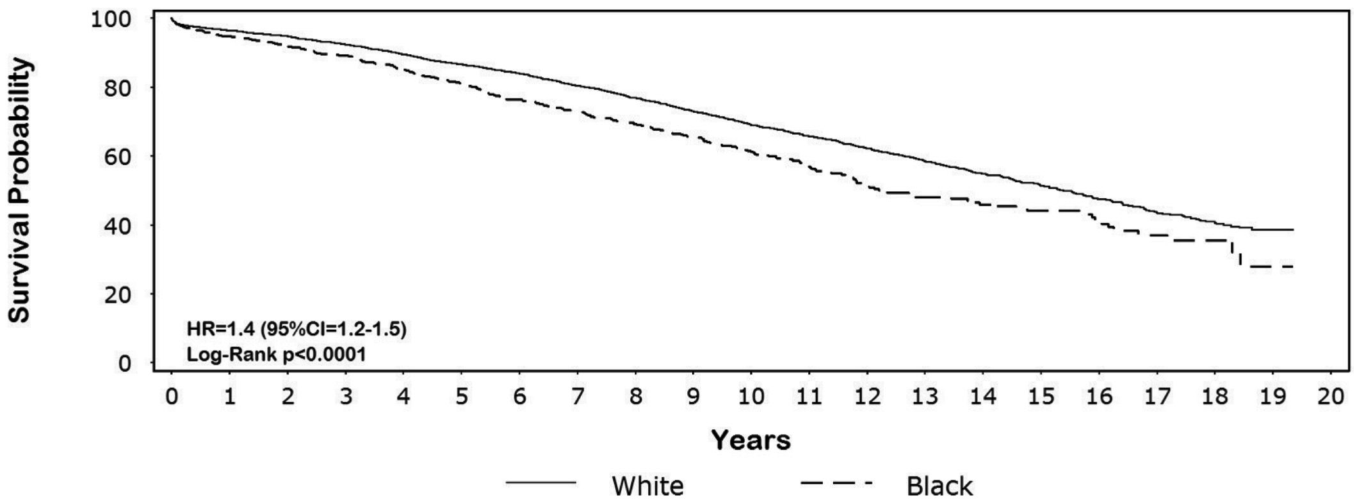

Figure 1. Unadjusted survival after elective CABG (N = 5,456)

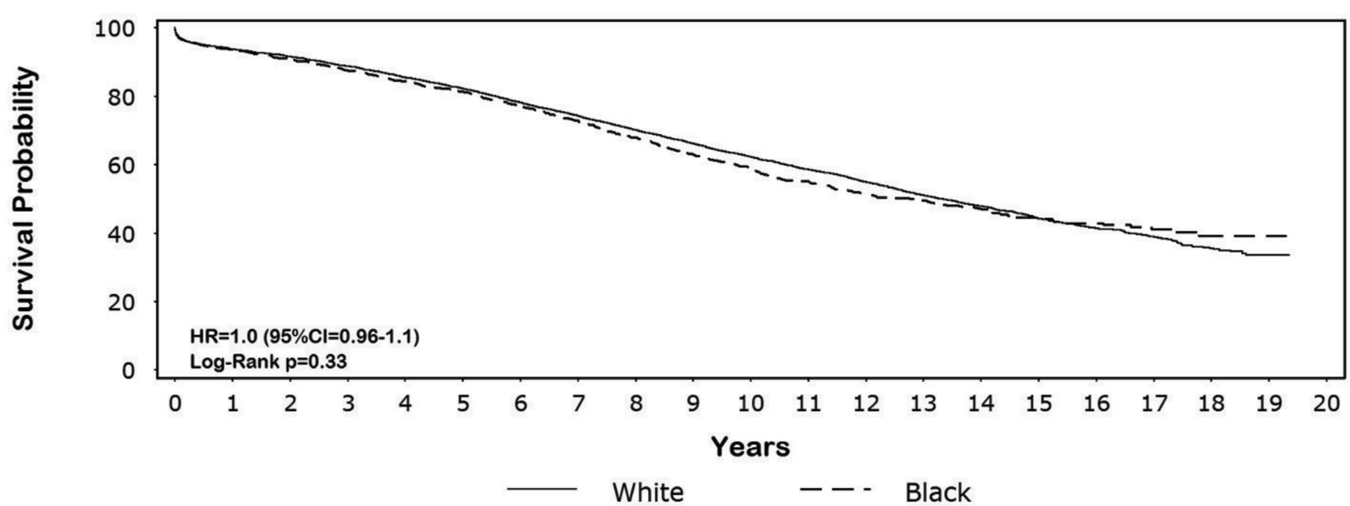

Figure 2. Unadjusted survival after nonelective CABG (N = 8,318)

DISCUSSION

This study highlights an unreported survival difference by operative status in the long-term survival of black versus white CABG patients. Among elective CABG patients, blacks had a higher percentage of comorbid conditions such as hypertension, diabetes, heart failure, and peripheral arterial disease, and died sooner than whites. While a similar profile was observed among nonelective CABG patients, we did not observe a survival difference within this group. Our results within the elective population showing a survival disadvantage for blacks are consistent with the life expectancy among blacks in the general population [Hartz 2001; Rumsfeld 2002; Bharmal 2012]. Presumably, a more severe risk factor profile among blacks leads to earlier mortality. On the other hand, our findings in the nonelective group potentially are explained by similar disease presentation at the time of surgery, independent of comorbid conditions. Among whites, in the absence of a poor risk factor profile, a genetic predisposition to accelerated coronary disease in the nonelective group may represent an alternative explanation of our results [Marenberg 1994]. This phenomenon is well observed in the literature. For instance, familial hypercholesterolemia and hypertrophic cardiomyopathy illustrate the important influence of genes on cardiovascular disease, independent of risk factor profile [Jansen 2004].

Table 1. Patient Characteristics and Survival after Elective CABG (N = 5,456)

Characteristic	Black		White		Univariable HR (95% CI)
	N (%)	5-, 10-, 15-Year Survival (%)	N (%)	5-, 10-, 15-Year Survival (%)	
Overall	934 (17)	81, 61, 44	4,522 (83)	87, 69, 51	1.4 (1.2-1.5)
Age (years)					
Quartile 1 (≤56)	323 (35)	89, 75, 67	1,148 (25)	94, 85, 75	1.0 Referent
Quartile 2 (>56-63)	213 (23)	83, 67, 52	1,057 (23)	90, 74, 59	1.8 (1.5-2.1)
Quartile 3 (>63-71)	222 (24)	75, 51, 34	1,329 (29)	86, 66, 43	2.6 (2.2-3.0)
Quartile 4 (>71)	176 (19)	71, 43, 13	988 (22)†	76, 48, 24	4.5 (3.9-5.2)
Mean ± SD, Median (Range)	61±11, 61 (28-91)		63±9.8, 64 (30-89)†		P_{Trend} < 0.0001
Sex					
Male	554 (59)	80, 60, 45	3,443 (76)	86, 68, 51	1.0 Referent
Female	380 (41)	83, 64, 43	1,079 (24)†	88, 71, 53	0.96 (0.86-1.06)
BMI (kg/m^2)§					
Obese (≥30)	481 (52)	84, 66, 48	1,826 (40)	89, 71, 54	1.0 Referent
Overweight (25-29.9)	316 (34)	80, 59, 43	1,879 (42)	87, 70, 52	1.1 (0.98-1.2)
Normal (18.5-24.9)	124 (13)	74, 53, 37	761 (17)	82, 64, 45	1.3 (1.2-1.5)
Underweight (<18.5)	8 (1)	64, ‡, ‡	38 (1)†	75, 56, 56	1.4 (0.89-2.3)
Mean ± SD, Median (Range)	31±6.3, 30 (15-64)		29±5.5, 28 (13-70)†		P_{Trend} < 0.0001
CAD severity					
1 Vessel	76 (8)	86, 71, 67	393 (9)	93, 81, 70	1.0 Referent
2 Vessel	231 (35)	83, 66, 50	1,180 (26)	89, 73, 56	1.5 (1.2-1.8)
3 Vessel	627 (67)	79, 58, 39	2,949 (65)	85, 66, 47	1.9 (1.6-2.4)
Left main disease					P_{Trend} < 0.0001
No	789 (84)	81, 62, 45	3,895 (86)	87, 70, 52	1.0 Referent
Yes	145 (16)	80, 58, 30	627 (14)	84, 64, 48	1.2 (1.1-1.4)
Recent smoker					
No	691 (74)	80, 61, 43	3,484 (77)	86, 68, 50	1.0 Referent
Yes	243 (26)	82, 62, 48	1,038 (23)*	88, 71, 56	0.87 (0.77-0.97)
Hypertension					
No	132 (14)	77, 58, 43	1,391 (31)	88, 74, 55	1.0 Referent
Yes	802 (86)	82, 62, 45	3,131 (69)†	86, 66, 50	1.2 (1.1-1.3)
Diabetes					
No	480 (51)	80, 64, 49	3,041 (67)	87, 73, 56	1.0 Referent
Yes	454 (49)	81, 58, 37	1,481 (32)†	82, 59, 41	1.6 (1.4-1.7)
Heart failure					
No	761 (81)	84, 64, 48	3,995 (88)	88, 71, 53	1.0 Referent
Yes	173 (19)	68, 47, 17	527 (12)†	76, 47, 31	2.1 (1.9-2.4)
Dialysis					
No	876 (93)	83, 64, 46	4,488 (99)	87, 69, 52	1.0 Referent
Yes	58 (6)	49, 5, ‡	34 (1)†	49, 34, ‡	4.8 (3.7-6.3)
Chronic obstructive pulmonary disease					
No	861 (92)	81, 62, 45	4,171 (92)	87, 70, 52	1.0 Referent
Yes	73 (8)	71, ‡, ‡	351 (8)	75, ‡, ‡	2.0 (1.7-2.4)

continued Table 1. Patient Characteristics and Survival after Elective CABG (N = 5,456)

Characteristic	Black		White		Univariable HR (95% CI)
	N (%)	5-, 10-, 15-Year Survival (%)	N (%)	5-, 10-, 15-Year Survival (%)	
Peripheral artery disease					
No	806 (86)	83, 65, 48	4,010 (89)	88, 71, 54	1.0 Referent
Yes	128 (14)	67, 33, 19	512 (11)*	76, 51, 29	2.1 (1.9-2.4)
Prior MI					
No	612 (66)	83, 62, 47	3,202 (71)	88, 70, 53	1.0 Referent
Yes	322 (34)	77, 60, 37	1,320 (29)†	84, 66, 48	1.3 (1.1-1.4)
Prior stroke					
No	829 (89)	83, 64, 47	4,220 (93)	87, 71, 53	1.0 Referent
Yes	105 (11)	65, 36, 13	302 (7)†	76, 45, 29	2.2 (1.9-2.6)
Prior PCI					
No	740 (79)	80, 60, 43	3,619 (80)	86, 68, 50	1.0 Referent
Yes	194 (21)	82, 67, 47	903 (20)	88, 74, 57	0.83 (0.73-0.94)

*$P < 0.05$,

†$P < 0.01$; χ^2 (categorical variables), Deuchler-Wilcoxon test (continuous variables).

‡Last follow-up not reached.

§Missing category not shown.

STRENGTHS AND LIMITATIONS

Our study is strengthened by its large sample size and long-term follow-up. Furthermore, we were able to accurately determine time of death using a combination of the National Death Index and our comprehensive electronic medical record. The uniqueness of this study lies in its target base. A large priority population in eastern North Carolina allowed for us to report on a group that has experienced historic differences in socioeconomic position and discrimination. Twenty-eight (97%) of the 29 counties in eastern North Carolina fall below the national per capita income of $27,915, with half reporting a value less than $20,000 [United States Census Bureau 2010]. Similarly, 90% of the counties have a higher percentage of blacks than the national value of 13.1% [United States Census Bureau 2010].

The retrospective design of our study may have introduced selection bias. Potentially, referral patterns resulted in an elective black CABG population less likely to survive than an elective white population [Schulman 1999; Trivedi 2006; Castellanos 2011]. Given that this is a natural history study in which the comparison groups were not randomly assigned, there may be residual confounding in our models even though we adjusted for clinically relevant covariates. We also acknowledge that other unmeasured factors could have influenced our results.

Data regarding socioeconomic position, education, and income were not collected, and these factors may have influenced survival, although it is unclear why these variables would have a differential effect by operative status [Koch 2010]. Payer status, which has been shown in some studies to predict survival independent of race, was not consistently collected and consequently was not used in our analysis [Zacharias 2005]. Blacks treated with off-pump CABG have been shown to have better survival than those treated with on-pump procedures [Cooper 2009]. No distinction was made between these operations and long-term survival after CABG. Cause of death is not recorded in the National Death Index and patients' mortality could have had little to do with their heart disease. Patients in this study were recruited over a relatively long period (20 years), over which patient characteristics, practice methods, and clinical care may have changed. However, results were consistent throughout the study after stratification by 3 time periods, indicating the robustness of the data to temporal changes. The status of several variables in our analysis may have changed over time. We did not adjust for these variables in a time-dependent manner due to their potential to be in the causal pathway. Similarly, surgical complications and medication use were not included in our analysis because of their time-dependent status. Additionally, the data reported are from a single center and may not reflect the general CABG population. Our use of quartile boundaries, while desirable for minimizing the influence of outliers, may have yielded overly broad categories and the potential for residual confounding. However, the substitution of continuous variables in our models yielded similar results. We did not examine interactions among variables in our dataset. Given the large number of potential multilevel interactions in our data, it is difficult to interpret such effects. Multivariable Cox regression models, rather than propensity score matching, were used to control for confounding because of potential "no collapsibility bias" inherent to logistic regression-based propensity scores and the possible loss of power due to incomplete matching [Efird 2012]. Alternative methods such as machine learning (e.g., random forest algorithm) may introduce misspecification into the propensity score model

Table 2. Patient Characteristics and Survival after Nonelective CABG (N = 8,318)

Characteristic	Black		White		Univariable HR (95% CI)
	N (%)	5-, 10-, 15-Year Survival (%)	N (%)	5-, 10-, 15-Year Survival (%)	
Overall	1,445 (17)	82, 59, 44	6,873 (83)	82, 62, 44	1.0 (0.96-1.1)
Age (years)					
Quartile 1 (≤56)	468 (32)	89, 74, 60	1,661 (24)	92, 81, 69	1.0 Referent
Quartile 2 (>56-63)	413 (29)	82, 60, 49	1,929 (28)	87, 71, 51	1.7 (1.5-1.9)
Quartile 3 (>63-71)	279 (19)	81, 55, 37	1,497 (22)	81, 58, 36	2.5 (2.2-2.8)
Quartile 4 (>71)	285 (20)	69, 39, 23	1,786 (26)†	69, 40, 20	4.1 (3.7-4.6)
Mean ± SD, Median (Range)	62±11, 62 (28-94)		64±10, 65 (24-90)†		P_{Trend} < 0.0001
Sex					
Male	835 (58)	82, 60, 46	4,846 (71)	83, 64, 46	1.0 Referent
Female	610 (42)	81, 57, 42	2,027 (29)†	81, 58, 41	1.2 (1.09-1.3)
BMI (kg/m^2)§					
Obese (≥30)	692 (48)	85, 63, 50	2,598 (38)	86, 66, 48	1.0 Referent
Overweight (25-29.9)	483 (33)	81, 57, 41	2,802 (41)	83, 65, 47	1.1 (1.002-1.2)
Normal (18.5-24.9)	251 (17)	74, 51, 36	1,381 (20)	75, 51, 33	1.6 (1.4-1.7)
Underweight (<18.5)	14 (1)	54, 44, ‡	43 (1)†	47, 34, 21	2.5 (1.8-3.6)
Mean ± SD, Median (Range)	30±6.1, 29 (16-60)		29±5.3, 28 (13-69)†		P_{Trend} < 0.0001
CAD severity					
1 Vessel	81 (6)	88, 79, 61	428 (6)	89, 77, 67	1.0 Referent
2 Vessel	376 (26)	86, 60, 46	1,891 (28)	85, 66, 49	1.6 (1.3-1.9)
3 Vessel	988 (68)	79, 57, 42	4,554 (66)	81, 59, 40	2.0 (1.7-2.4)
					P_{Trend} < 0.0001
Left main disease					
No	1,095 (76)	82, 59, 45	2,160 (75)	83, 63, 45	1.0 Referent
Yes	350 (24)	79, 57, 43	1,713 (25)	81, 59, 40	1.1 (1.03-1.2)
Recent smoker					
No	1,080 (75)	80, 56, 42	5,144 (75)	82, 62, 44	1.0 Referent
Yes	365 (25)	87, 69, 54	1,729 (25)	82, 63, 46	0.90 (0.83-0.98)
Hypertension					
No	205 (14)	85, 65, 49	2,102 (31)	85, 68, 49	1.0 Referent
Yes	1,240 (86)	81, 58, 43	4,771 (69)†	81, 60, 42	1.3 (1.2-1.4)
Status§					
Urgent	1,379 (95)	82, 59, 44	6,465 (94)	83, 62, 44	1.0 Referent
Emergent	55 (4)	73, 54, 44	365 (5)	82, 68, 55	0.84 (0.72-0.98)
Salvage	11 (1)	27, 27, 27	41 (1)	46, 26, 15	3.2 (2.3-4.3)
Diabetes					
No	766 (53)	84, 66, 53	4,714 (69)	84, 67, 49	1.0 Referent
Yes	679 (47)	79, 51, 34	2,159 (31)†	78, 52, 32	1.6 (1.5-1.7)

continued Table 2. Patient Characteristics and Survival after Nonelective CABG (N = 8,318)

Characteristic	Black		White		Univariable HR (95% CI)
	N (%)	5-, 10-, 15-Year Survival (%)	N (%)	5-, 10-, 15-Year Survival (%)	
Heart failure					
No	1,124 (78)	84, 63, 48	5,913 (86)	85, 65, 47	1.0 Referent
Yes	321 (22)	72, 37, 26	960 (14)†	67, 40, 25	2.1 (1.9-2.3)
Dialysis					
No	1,366 (95)	84, 61, 46	6,819 (99)	83, 63, 45	1.0 Referent
Yes	79 (5)	37, 11, 11	54 (1)†	14, 12, ‡	5.3 (4.3-6.5)
Chronic obstructive pulmonary disease					
No	1,332 (92)	82, 59, 44	6,407 (93)	83, 63, 45	1.0 Referent
Yes	113 (8)	76, 65, ‡	466 (7)	70, ‡, ‡	1.7 (1.4-2.0)
Peripheral artery disease					
No	1,245 (86)	83, 62, 47	6,105 (89)	84, 65, 46	1.0 Referent
Yes	200 (14)	69, 39, 26	768 (11)†	68, 41, 26	2.0 (1.8-2.2)
Prior MI					
No	715 (49)	83, 61, 47	3,728 (54)	84, 65, 46	1.0 Referent
Yes	730 (51)	79, 56, 42	3,145 (46)†	80, 59, 43	1.2 (1.1-1.2)
Prior stroke					
No	1,290 (89)	83, 61, 46	6,369 (93)	83, 64, 46	1.0 Referent
Yes	155 (11)	71, 43, 25	504 (7)†	70, 43, 23	1.9 (1.7-2.1)
Prior PCI					
No	1,158 (80)	82, 58, 44	5,495 (80)	82, 61, 43	1.0 Referent
Yes	287 (20)	81, 62, 47	1,378 (20)	85, 68, 49	0.85 (0.77-0.92)

†$P < 0.01$; χ^2 (categorical variables), Deuchler-Wilcoxon test (continuous variables).
‡Last follow-up not reached.
§Missing category not shown.

Table 3. Multivariable Survival

Characteristic	Multivariable HR (95% CI)	
	Elective CABG (N = 5,456)	Nonelective CABG (N = 8,318)
Race		
White	1.0 Referent	1.0 Referent
Black	1.4 (1.2-1.6)	1.0 (0.94-1.1)
Age (years)		
Quartile 1 (≤56)	1.0 Referent	1.0 Referent
Quartile 2 (>56-63)	1.7 (1.5-2.0)	1.6 (1.4-1.8)
Quartile 3 (>63-71)	2.5 (2.2-2.9)	2.3 (2.1-2.6)
Quartile 4 (>71)	4.3 (3.7-5.0)	3.8 (3.4-4.2)
	$P_{Trend} < 0.0001$	$P_{Trend} < 0.0001$
Sex		
Male		
Female	1.0 Referent	1.0 Referent
	0.79 (0.71-0.88)	0.99 (0.92-1.1)
CAD severity		
1 Vessel	1.0 Referent	
2 Vessel	1.2 (1.01-1.5)	1.5 (1.2-1.8)
3 Vessel	1.5 (1.2-1.9)	1.6 (1.4-2.0)
	$P_{Trend} = 0.036$	$P_{Trend} = 0.025$
Hypertension		
No	1.0 Referent	1.0 Referent
Yes	1.1 (0.99-1.2)	1.1 (1.05-1.2)
Heart failure		
No	1.0 Referent	1.0 Referent
Yes	1.8 (1.6-2.1)	1.9 (1.7-2.0)
Prior stroke		
No	1.0 Referent	1.0 Referent
Yes	1.8 (1.6-2.1)	1.6 (1.4-1.8)

due to the "black box" nature of the algorithm that obscures the etiologic relationship between predictors and outcome and were not used in the current analysis [Breiman 2001; Lee 2010]. While in some cases our Cox proportional hazard model diverged from the proportional hazards assumption, there was no effect modification by time, and results remained clinically interpretable in terms of the average relative hazard over the observation period.

CONCLUSION

Our results showing a survival difference between black and white CABG patients by operative status may provide important etiologic clues regarding cardiovascular outcomes and disease progression. Further research is needed to confirm our findings.

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