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Operative and Late Coronary Artery Bypass Grafting Outcomes in Matched African-American Versus Caucasian Patients

Evidence of a Late Survival-Medicaid Association

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OBJECTIVES This study sought to determine whether African-American versus Caucasian race is a determinant of early or late coronary artery bypass surgery (CABG) outcomes.

BACKGROUND African Americans are referred to CABG less frequently than Caucasians and Medicaid coverage is disproportionately common among those who are referred. How these factors affect the relative early and late CABG outcomes in these groups is incompletely elucidated.

METHODS A retrospective cohort comparison of operative and 12-year outcomes for 304 African-American and 6,073 Caucasian consecutive patients who underwent isolated CABG (1991 to 2003) at an urban community hospital was used. Results were further confirmed in propensity-matched subgroups (n = 301 each).

RESULTS African Americans were younger (62 vs. 64 years, median), more were female (46% vs. 30%), more were on Medicaid (29% vs. 6.3%) and had more comorbidities. These differences were eliminated after matching. A total of 161 operative and 1,080 late deaths have been documented. Operative mortality was similar (African American versus Caucasian: 3.0% vs. 2.5%; p = 0.81). Unadjusted Kaplan-Meier survival at 1, 5, and 10 years (93.4%, 80.3%, and 66.1% vs. 94.8%, 86.5%, and 71.7%) was worse in African Americans (hazard ratio [HR] = 1.38; p = 0.004), but similar for matched groups (HR = 1.03; p = 0.97). After risk adjustment, race did not predict operative (odds ratio = 1.17; p = 0.69) or late (HR = 1.15; p = 0.28) mortality. However, Medicaid status (HR = 1.54; $p < 0.005$) predicted worse survival, which was verified in a case-matched Medicaid (n = 469) versus non-Medicaid analysis. The latter showed that in younger Medicaid patients without companion Medicare coverage, late mortality was nearly doubled (HR = 1.96; p = 0.003) with systematically increasing death hazard after the second year.

CONCLUSIONS African-American race per se is not associated with worse operative or late outcomes underscoring that CABG should be based on clinical characteristics only. Alternatively, Medicaid status, which is more prevalent among African Americans, is associated with worse late survival, especially in non-Medicare patients. Studies are needed to elucidate this late Medicaid-CABG outcome association. (J Am Coll Cardiol 2005;46:1526–35) © 2005 by the American College of Cardiology Foundation

Numerous studies have reported on variations in the use of cardiovascular procedures for treatment of coronary artery disease (CAD) among ethnic groups in the U.S., for example, those of Peterson et al. (1), Gillum et al. (2), McBean et al. (3), and Ayanian et al. (4). These have generally shown that minority patients, and African Americans in particular, are less likely to undergo interventional cardiac procedures, particularly coronary artery bypass graft (CABG) surgery. Arguably, such underuse or late use of surgical coronary revascularization may adversely affect patient outcomes. However, the impact of race on CABG outcomes is incompletely elucidated with limited long-term data. Some studies have suggested worse early (operative) (5,6) and mid-term (7–11) CABG outcomes in African Americans compared with Caucasians. Others have shown that risk-adjusted CABG outcomes in African Americans and Caucasians are similar, or that even when significantly different, the absolute differences in outcomes are small (i.e., not clinically significant) and should not affect the decision of whether to offer the surgery to patients (11–14).

The primary goal of our study was to compare operative as well as 0- to 12-year mortality in African-American versus Caucasian patients in a contemporaneous U.S. CABG series, and to do so in a manner in which potential residual confounding attributable to demographic and clinical risk factors is minimized, in addition to that of medical insurance coverage. The latter was included given the documented differences in the distribution of health coverage among the ethnic groups (14,15) and their correlation to socioeconomic status, which is linked to worse CABG outcomes (16). Accordingly, we analyzed a 13-year single-institution CABG experience with long-term mortality follow-up. The reported analyses incorporated multiple

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Abbreviations and Acronyms

CABG	= coronary artery bypass surgery
CAD	= coronary artery disease
CPB	= cardiopulmonary bypass
HR	= hazard ratio
OM	= operative mortality
OR	= odds ratio
STS	= Society of Thoracic Surgeons
VHA	= Veterans Health Administration

multivariate modeling methods including propensity score-balancing techniques applied in all patients. Lastly, results were further assessed in one-to-one propensity-matched ethnicity-based cohorts.

METHODS

Patients. Study patients were drawn from 6,571 consecutive and unique isolated CABG patients, including those undergoing repeat procedures, between June 1991 and September 2003 at St. Vincent Mercy Medical Center (Toledo, Ohio), an urban community hospital. Only the initial CABG was included if the same patient underwent multiple CABG operations during the study period. Patients with concomitant carotid surgery were excluded, as were patients without a valid Social Security number. Cardiopulmonary bypass (normothermic with cold blood cardioplegia) was used in ~95% of patients, whereas the remaining procedures were performed off-pump. This observational study was approved by the institutional review board. Because of its retrospective nature, requirement for informed consent was waived.

Clinical data and end points. Clinical data on patients undergoing revascularization have been systematically abstracted and prospectively collected in the cardiac surgery clinical database since June 1991, and are regularly reported to the Society of Thoracic Surgeons (STS) national cardiac surgery database. These include demographics, insurance, risk factors and comorbidities, preoperative medications, and operative data, as well as postoperative complications and outcomes. Detailed insurance information, including primary and secondary insurance payors, was derived from hospital and cardiac surgery billing records. The primary end points were all-cause operative mortality (OM) (defined as 30-day or in-hospital, whichever was longer) and 0- to 12-year mortality. Long-term survival data were also collected by service follow-up and searches of the U.S. Social Security Death Index database (September 2004). Allowing for a three-month lag, this corresponds to a follow-up of between 9 and 157 months.

Statistical methods. Continuous data were expressed as mean ± standard deviation. Univariate comparisons were done with the chi-square test for categorical variables and the unpaired *t* test (e.g., age, perfusion time) or the non-parametric Mann-Whitney rank-sum test (e.g., number of grafts) for continuous variables based on the normality (Kolmogorov-Smirnov test) of the data. A $p < 0.05$ cutoff was used to indicate significance. Long-term Kaplan-Meier survival trends for the African-American and Caucasian cohorts were compared with (Breslow test) and without (log rank test) weighting. The number of patients at risk at a given time point was used for weighting. Effects of explanatory variables on OM were derived by logistic regression. Next, multivariable Cox proportional-hazard regression was done to assess the effects of the varying death hazard on long-term mortality predictors and their associated hazard ratios (HR). Three variables related to cardiopulmonary bypass duration were used: 1) aortic cross-clamp time (continuous), which indicates time used for graft placement; 2) off-pump CABG (categorical; yes = 1 , no = 0); and 3) difficult to wean off of cardiopulmonary bypass (CPB), defined as the difference between total CPB time − cross-clamp time (categorical; yes = 1 , no = 0). Selection of the logistic and Cox multivariable regression models was: 1) done with backward elimination (Wald statistic, confirmed using forward and stepwise selection), and 2) considered first-order interactions between variables that were univariately associated with race (Table 1). A $p < 0.05$ significance level was used for model inclusion and $p > 0.1$ for exclusion (SPSS version 10.0, SPSS Inc., Chicago, Illinois).

Propensity modeling and matching. Potential confounding caused by the unbalanced characteristics of African-American versus Caucasian patients on outcome comparisons cannot be discounted, even after conventional multivariate risk adjustment (17,18). We used multiple approaches to minimize these effects. First, we computed two African-American propensity scores derived via: 1) a parsimonious (only variables significant at the $p < 0.05$ level are included) and 2) a non-parsimonious (variables included irrespective of significance) logistic regression models applied to all patients (African Americans = 1, Caucasians = 0). Excluding race, a comprehensive list of all STS required patient variables (including those listed in Table 1) and their significant interactions were considered for inclusion (parsimonious) or included (non-parsimonious) in these logistic regression models. Highly redundant variables were avoided. Year of surgery (1991 to 2003 coded as 1 to 13, respectively) was entered to account for increasing frequency of African-American patients over the study period. Propensity scores were used in two ways: 1) incorporated into subsequent multivariate model analyses as a continuous covariate (propensity-adjusted), or 2) to obtain one-to-one matching of African-American scores with their closest unique Caucasian match via a custom-made computer algorithm that allowed a maximum ±1% score difference (propensity matching). Patient variables and risk factors for the propensity-matched cohorts are checked for differences, and will typically approximate random samples of similar characteristics.

Table 1. Comparison of Selected Preoperative and Operative Data in Unmatched (All Patients) and Matched African-American (AA) and Caucasian CABG Patients

	All Patients			Matched		
	Caucasian	AA	p	Caucasian	AA	p
Patients, n	6,073	304	–	301	301	–
Male, %	70.2	53.9	<0.001	58.8	54.5	NS
Age (yrs)	64 ± 11	62 ± 11	0.001	61.4 ± 10.7	61.7 ± 10.3	NS
BSA (m^2)	2.02 ± 0.24	2.00 ± 0.23	NS	2.00 ± 0.25	2.00 ± 0.23	NS
Obese (BMI >30 kg/m^2), %	38.3	41.8	NS	41.9	41.2	NS
Private insurance, %	48.1	41.1	0.017	35.5	41.5	0.13
Medicare, %	46.9	42.4	0.13	45.2	42.9	NS
Any Medicaid, %	6.3	28.6	<0.001	29.2	27.9	NS
Uninsured, %	1.4	3.3	NS	5.3	3.3	NS
Current smoker, %	21.7	35.5	<0.001	39.2	35.2	NS
Diabetes, %	32.4	43.4	<0.001	39.2	42.9	NS
Insulin-dependent, %	11.6	22.4	<0.001	21.9	21.9	NS
High cholesterol, %	65.8	61.5	<0.001	67.4	61.1	0.13
Renal failure (pre-operative), %	3.0	7.9	<0.001	8.3	7.6	NS
Hypertension, %	80.0	92.8	<0.001	90.7	92.7	NS
Cerebrovascular accident, %	7.0	10.5	0.020	7.6	10.3	NS
Chronic lung disease, %	20.3	18.8	NS	20.3	18.3	NS
Peripheral vascular disease, %	13.8	21.4	<0.001	19.6	21.6	NS
Cerebrovascular disease, %	21.2	22.0	NS	25.9	21.9	NS
Preoperative MI, %	58.2	64.1	0.039	58.8	64.8	0.13
Congestive heart failure, %	10.3	15.3	0.006	13.3	15.1	NS
Unstable angina, %	38.0	35.2	NS	37.2	35.2	NS
Arrhythmia (any), %	15.0	11.2	0.067	10.3	11.0	NS
Double vessel disease, %	23.0	22.0	NS	24.9	22.3	NS
Triple vessel disease, %	71.7	73.4	NS	70.4	73.4	NS
Left main disease >50%, %	19.0	18.4	NS	18.3	18.3	NS
Ejection fraction (%)	50 ± 11	49 ± 12	NS	50 ± 11	49 ± 12	NS
NYHA functional class III, %	45.4	44.1	NS	47.8	44.5	NS
NYHA functional class IV, %	38.9	41.4	NS	39.2	41.5	NS
Preoperative IABP, %	6.7	4.9	NS	5.6	5.0	NS
Previous CV intervention, %	36.0	28.9	0.013	25.9	29.2	NS
Beta-blockers, %	57.7	67.4	0.001	60.8	67.1	0.11
Operative data						
Repeat CABG, %	4.9	4.3	NS	2.7	4.3	NS
Urgent, %	51.1	56.3	0.080	58.8	56.1	NS
Emergent, %	6.9	4.9	0.19	6.6	5.0	NS
No. of grafts	3.1 ± 1.0	3.0 ± 0.9	NS	3.0 ± 0.9	3.0 ± 0.9	NS
Vein	1.8 ± 1.0	1.8 ± 1.0	NS	1.8 ± 1.0	1.8 ± 1.0	NS
Arterial	1.3 ± 0.8	1.3 ± 0.7	NS	1.2 ± 0.7	1.2 ± 0.7	NS
Radial used, %	25.6	26.6	NS	25.2	26.6	NS
IMA used, %	89.3	87.8	NS	90.4	87.7	NS
LIMA, %	87.9	86.8	NS	90.0	86.7	NS
Off-pump CABG, %	4.6	7.6	0.019	5.6	7.3	NS
Cross-clamp time (min)	48 ± 18	47 ± 17	0.041	46 ± 17	47 ± 17	NS
Perfusion time (min)	84 ± 32	82 ± 34	0.045	80 ± 28	82 ± 34	NS
Day of surgery*	2,235 ± 1,206	2,589 ± 1,238	<0.001	2,431 ± 1,143	2,577 ± 1,236	NS

An expanded Table 1 (Table S1) is included in the online version of this article. Continuous data (shown as mean ± standard deviation) were compared by *t* test except for number of grafts (vein/arterial), by rank sum test. Categorical variables were compared by chi-square test; NS = p > 0.2. Day of surgery assumes June 4, 1991 = 1.

BMI = body mass index; BSA = body surface area; CABG = coronary artery bypass graft; CV = cardiovascular; IABP = intraaortic balloon pump; IMA = internal mammary artery; LIMA = left IMA; MI = myocardial infarction.

RESULTS

Demographics, baseline characteristics, and operative variables. The patient series included 6,073 Caucasian (92.4%), 304 African-American (4.6%), and 194 other ethnicity (109 Hispanic) patients. The proportion of Caucasian patients decreased from approximately 94% (early 90s) to around 90% (2001 to 2003) over the study period, whereas African Americans doubled from <4% (early 90s) up to approximately 8% in 2002 to 2003 (Fig. 1). The 2000 to 2003 statistics at our institution show that hospital discharges were 71.4%, 23.4%, and 5.2% for Caucasian, African-American, and Hispanic/other, respectively. The corresponding cardiac surgery discharges were 86.5%, 7.9%, and 5.5%. The latter closely approximated the race distribution (87.6%, 6.9%, and 5.5%, respectively) for the 20 Northwest Ohio and Southeast Michigan counties referral

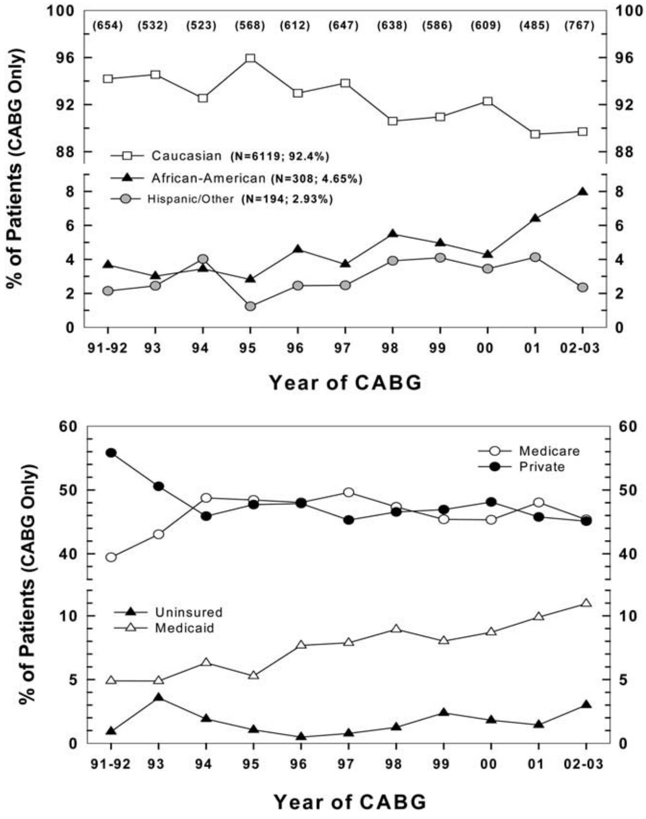

Figure 1. **(Top)** Annual distribution of Caucasian, African-American, and Hispanic/Other coronary artery bypass grafting (CABG) patients at Saint Vincent Mercy Medical Center between 1991 and 2003. **(Bottom)** Annual distribution of Medicare, Medicaid, private insurance, and uninsured among CABG patients at Saint Vincent Mercy Medical Center between 1991 and 2003.

area (87.6%, 6.9%, and 5.5%, respectively). Heretofore, we will only report on the Caucasian and African-American cohorts.

Demographic, comorbidity, and operative data for the African-American and Caucasian cohorts are compared in Table 1. Briefly, African Americans were younger (62 vs. 64 years [mean]), were more female (46% vs. 30%), were more current smokers (35.5% vs. 21.7%), and were characterized by a greater incidence of insulin dependence, hypertension, preoperative renal failure, history of cerebrovascular accident, peripheral vascular disease, congestive heart failure, and prior myocardial infarction. Vessel disease and functional class were similar for the two groups. Notably, Medicaid status was more than four-fold greater among African Americans [28.6 vs. 6.3%; $p < 0.001$]. Also, a substantial increase in Medicaid coverage (primary or secondary) was observed, from 5% in 1991 up to 11% in 2003, which paralleled the increase in African Americans (Fig. 1).

A greater fraction of Caucasians had a history of prior cardiovascular intervention (36% vs. 29%) but not previous CABG (4.9% vs. 4.3%; all must have occurred before June 1991 by study design). Operative data, including number and type of grafting conduits, were mostly similar for the two groups (Table 1). There were trends for more frequent urgent status among African Americans (56% vs. 51%; $p = 0.08$), and off-pump CABG was slightly more frequent (7.6% vs. 4.9%; $p < 0.02$) in African-American patients. To account for potential confounding effects of race group differences, we derived parsimonious and non-parsimonious propensity score models via logistic regression analysis. The results are very similar with both models, and only the parsimonious model results are described. The median (interquartile range) parsimonious model propensity score was 0.064 (0.035 to 0.145) in African Americans, compared with 0.033 (0.021 to 0.050) for Caucasians. The C-statistic (area under the receiver-operator characteristic curve or AUC) for the propensity score model was 0.74, indicating good discrimination power. Given the abundance of Caucasian patients, we were able to match to within a 1% score difference 301 of 304 (parsimonious; 99%) and 296 of 304 (non-parsimonious; 97%) African-American patients. The matched groups had similar demographics, medical coverage, risk factors, coronary disease, and operative variables (Table 1).

Comparison of CABG outcomes. OPERATIVE RESULTS. Operative outcomes are compared in Table 2. Briefly, for the entire cohorts, African Americans were more frequently transfused (37.2% vs. 28.3%, $p = 0.001$), had a greater incidence of postoperative sepsis (3.3% vs. 1.4%; $p = 0.006$), and required an average of one day longer postoperative hospital stay (8.0 vs. 7.0; $p = 0.006$). We also observed, in African Americans, trends for: 1) more bleeding complications requiring chest re-exploration (3.0% vs. 1.6%; $p = 0.07$), 2) more vein harvest site leg infection (2.0% vs. 0.9%; $p = 0.08$), and 3) less new-onset postoperative atrial fibrillation (12.2% vs. 16.0%; $p = 0.07$). All other postoperative complications occurred with similar frequency for the two groups. Operative mortality was similar in African-American (9 of 304; 3.0%) and Caucasian (152 of 6,073; 2.5%) patients (unadjusted odds ratio [OR] = 1.18; $p = 0.61$). For matched groups (Table 2), operative mortality was also similar (3.0% vs. 2.7%; unadjusted OR = 1.13), as were all complication rates and resource use. Older age, emergency or repeat CABG, difficulty to wean off bypass, preoperative renal failure, small body size, congestive heart failure, cerebrovascular disease, history of myocardial infarction, and morbid obesity were identified as multivariate predictors of operative death (Table S2, please see the online version of this article). This model was both reliable (Hosmer-Lemeshow chi-square statistic = 8.17; $p = 0.42$) and accurate (AUC = 0.83). Forcing race (OR = 1.17 [95% confidence interval (CI) 0.55 to 2.50]) into this model did not improve model reliability ($p = 0.70$) or accuracy (AUC = 0.84).

LATE RESULTS. Follow-up was longer for Caucasians (2,214 ± 1,246 vs. 1,815 ± 1,229 days; $p < 0.001$) because a relatively larger fraction of African-American patients had undergone CABG in recent years. A total of 1,241 deaths (161 operative, 1,080 late) have been documented. The

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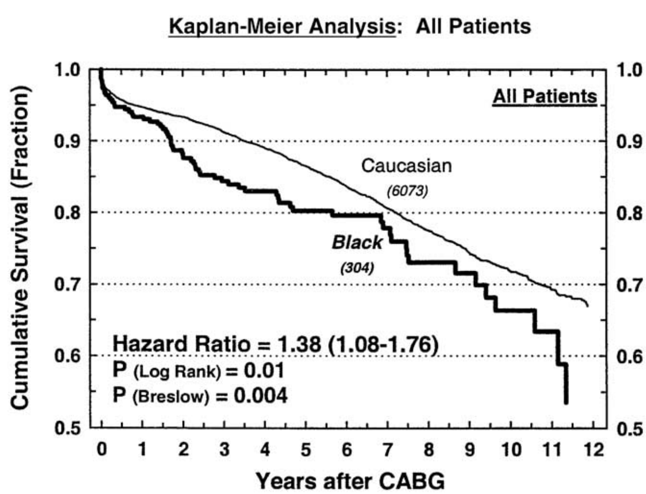
Table 2. Comparison of Operative Outcome Data in Unmatched (All Patients) and Matched African-American (AA) and Caucasian CABG Patients

	All Patients			Matched		
	Caucasian	AA	p	Caucasian	AA	p
Blood transfusion, %	28.3	37.2	0.001	35.9	37.2	0.74
Perioperative IABP, %	3.6	2.6	0.24	4.0	2.7	0.36
Complication (any), %	30.6	34.9	0.12	32.6	34.9	0.55
Reoperation (any), %	6.6	5.8	0.66	8.3	6.3	0.43
Reoperation (bleeding), %	1.6	3.0	0.07	1.3	3.0	0.16
Perioperative MI, %	1.2	1.3	0.30	1.0	1.3	0.70
Atrial fibrillation, %	16.0	12.2	0.07	14.6	12.0	0.34
Mediastinitis, %	1.2	1.0	0.73	1.7	1.0	0.48
Leg infection, %	0.9	2.0	0.08	2.3	2.0	0.78
Sepsis, %	1.4	3.3	0.006	3.3	3.3	1.0
Permanent stroke, %	1.3	2.3	0.14	1.0	2.3	0.20
Transient stroke, %	1.9	2.3	0.59	0.7	2.3	0.10
Ventilator prolonged >24 h, %	6.5	7.9	0.34	8.0	8.0	1.0
Pneumonia, %	1.8	2.0	0.84	4.3	2.0	0.10
Renal failure, %	4.0	4.6	0.61	3.7	4.7	0.54
GI complications, %	2.7	3.3	0.50	3.3	3.3	1.0
Multi-organ failure, %	1.3	1.6	0.54	1.3	1.7	0.74
Total LOS (days)	9.0 ± 8.2	11 ± 10	<0.001	10.0 ± 12.2	11.3 ± 10.0	0.16
Postoperative LOS (days)	7.0 ± 7.6	8.0 ± 8.9	0.006	7.9 ± 11.8	8.2 ± 8.9	0.72
30-day hospital readmission, %	6.4	5.9	0.75	7.6	6.0	0.42
Operative mortality, %	2.5	3.0	0.61	2.7	3.0	0.81

*Continuous data (mean ± std dev) were compared by *t* test or rank sum test and categorical variables by chi-square test.
Abbreviations as in Table 1.

unadjusted Kaplan-Meier survival was significantly worse for African Americans (Fig. 2; HR = 1.38 [95% CI 1.08 to 1.76]; p = 0.004) with worse survival rates at 1, 5, and 10 years in African Americans (93.4%, 80.3%, and 66.1%) versus Caucasians (94.8%, 86.5%, and 71.7%). These survival differences were true for patients >65 years old (p = 0.012) and ≤65 years old (p = 0.028), but were less pronounced in women (p = 0.25) versus men (p = 0.011), particularly during the first two years (Fig. S1, please see the online version of this article).

Using race and propensity score as the only covariates in the Cox regression analysis, we found the African-American propensity score (p < 0.0001) to be a predictor of 0- to 12-year mortality, whereas race was not (HR = 1.15 [95% CI 0.89 to 1.49]; p = 0.28 [parsimonious]). The corresponding propensity-adjusted 0- to 12-year CABG survival comparisons are shown in Figure 3. These results were consistent with the Kaplan-Meier survival analysis of the matched groups (Fig. 3). The latter indicated that when closely matched for preoperative, including medical health coverage, and operative factors, late CABG survival is essentially identical in both ethnic groups (HR = 1.03 [95% CI 0.74 to 1.44]; p = 0.97). With the propensity score included as a model covariate (HR = 1.04 [95% CI 0.19 to 5.59]; p = 0.97), we identified 20 multivariate predictors of long-term mortality (Table 3). Here, too, entering race as a covariate did not significantly improve the model (HR = 1.19 [95% CI 0.92 to 1.53]; p = 0.19). Briefly, survival after CABG was superior in patients with a history of preoperative beta-blocker use. Alternatively, risk factors predicting increased 12-year mortality were older age, Medicaid status,



	AA (n)		Caucasian (n)	
Time (yrs)	dead	At Risk	dead	At Risk
0	0	304	0	6073
1	20	274	318	5701
2	35	230	400	5240
4	47	163	620	4176
6	53	118	843	3000
8	60	68	1027	1879
10	64	31	1134	955
12	67	5	1174	195

Figure 2. Overall unadjusted Kaplan-Meier 0- to 12-year survival in African-American (AA) **(thick lines)** versus Caucasian **(thin line)** coronary artery bypass graft (CABG) patients (patient characteristics are summarized in Table 1). Hazard ratio is calculated from Cox proportional hazard regression with race as a single covariate.

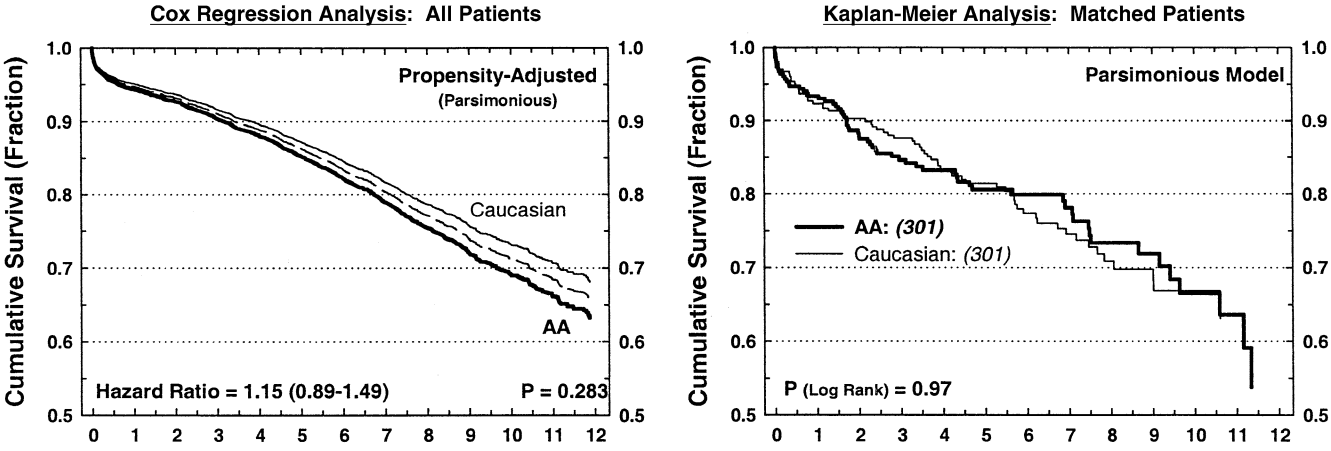


Figure 3. **(Left)** Propensity-adjusted survival derived by proportional hazard Cox regression analysis with race and propensity score (parsimonious model) included as covariates. **Dashed line** = survival at mean of covariates. **(Right)** Kaplan-Meier 0- to 12-year coronary artery bypass graft (CABG) survival in matched African-American (AA) **(thick lines)** versus Caucasian **(thin line)** patients. Corresponding non-parsimonious model results were essentially identical (see Fig. S2 of the online version of this article).

renal failure, diabetes, current smokers, difficulty to wean off CPB, vein-only grafts, low ejection fraction, preoperative diuretics, triple vessel disease, male gender, cerebrovascular disease, peripheral vascular disease, small patient size, emergency surgery, arrhythmia, congestive heart failure, prior cardiovascular intervention, and hypertension (see Table 3 for details).

Medicaid status and late CABG outcomes. Race did not predict CABG outcomes, but Medicaid status, which is more than four-fold more frequent among African Ameri-

Table 3. Multivariate Predictors of 0- to 12-Year Mortality Derived by Cox Regression Analysis Applied in All Patients

Variable	Wald (Chi-Squared)	p Value	Hazard Ratio	95% Confidence Interval
Age (per 10-yr increments)	216.8	0.0000	1.54	1.46–1.61
Renal failure	82.5	0.0000	2.80	2.24–3.50
Diabetes				
No	54.9	0.0000	1	(reference)
Yes (no insulin)	10.9	0.0009	1.27	1.10–1.46
Yes (insulin)	53.5	0.0000	1.83	1.56–2.16
Current smoker	28.4	0.0000	1.51	1.30–1.76
Difficulty to wean off CPB	26.0	0.0000	1.58	1.32–1.88
Vein-only grafts	23.6	0.0000	1.48	1.26–1.73
Ejection fraction				
>40%	19.8	0.0000	1	(reference)
26% to 40%	13.8	0.0002	1.37	1.16–1.61
≤25%	9.5	0.0020	1.50	1.16–1.93
Preoperative diuretics	19.7	0.0000	1.36	1.19–1.56
Triple vessel disease	15.1	0.0001	1.32	1.15–1.53
Men	13.5	0.0002	1.33	1.14–1.55
Cerebrovascular disease	12.4	0.0004	1.27	1.11–1.45
Peripheral vascular disease	11.6	0.0007	1.30	1.12–1.51
Preoperative beta-blockers	10.7	0.0011	0.82	0.73–0.93
Low BSA (<1.7 m^2)	9.5	0.0020	1.37	1.12–1.68
Emergency	9.1	0.0026	1.37	1.12–1.68
Medicaid status	8.0	0.0047	1.54	1.14–2.08
Arrhythmia	6.4	0.0117	1.20	1.04–1.38
Congestive heart failure	4.8	0.0290	1.22	1.02–1.45
Prior cardiovascular intervention	4.4	0.0363	1.14	1.01–1.29
Hypertension*	3.7	0.0549	1.17	1.00–1.37
AA propensity score (forced)	0.0	0.9657	1.04	0.19–5.59
AA (forced into model)	1.7	0.1931	1.19	0.92–1.53

*Approached significance.
AA = African American; BSA = body surface area; CPB = cardiopulmonary bypass.

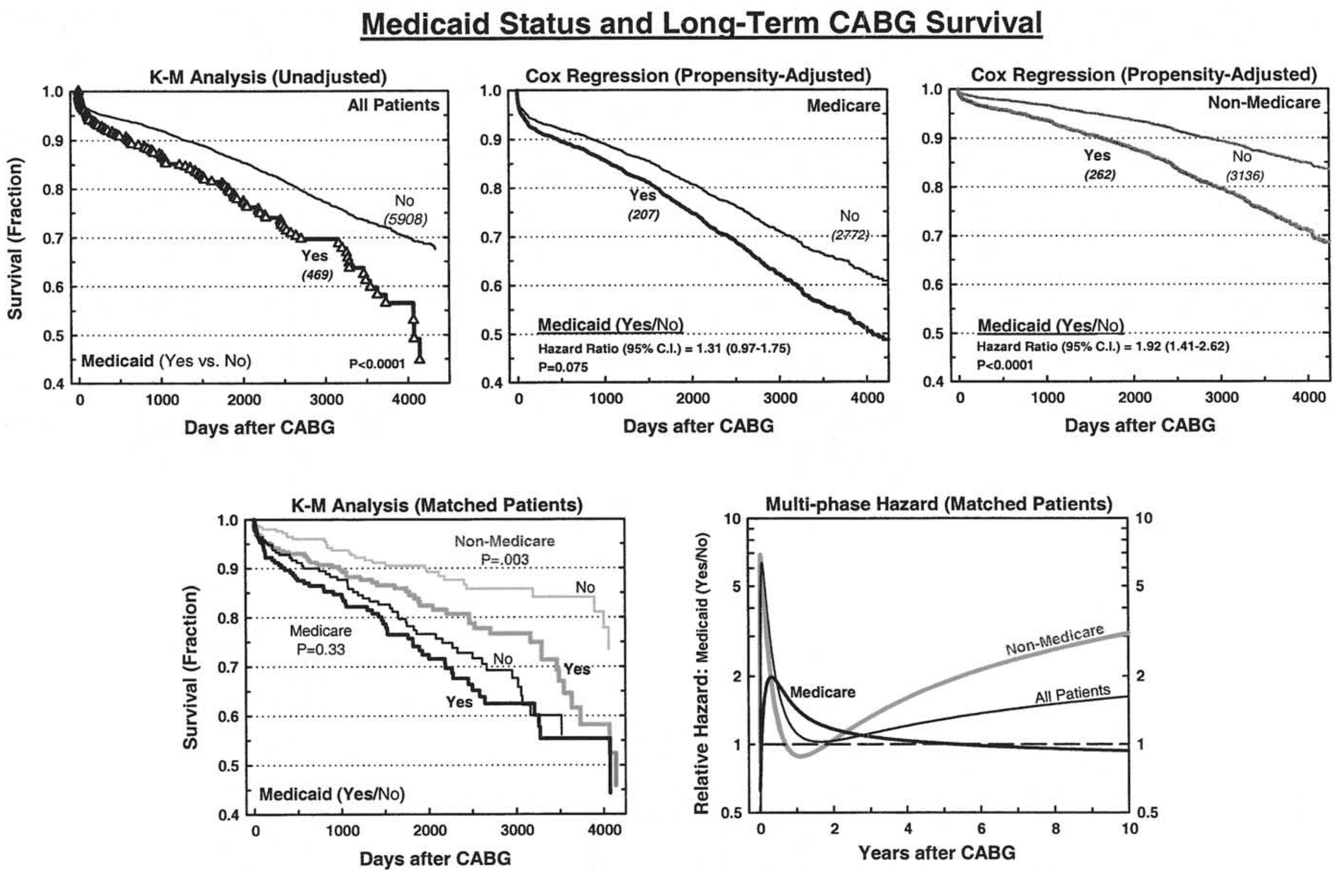


Figure 4. **(Top left)** Unadjusted 0- to 12-year Kaplan-Meier (K-M) survival in unmatched Medicaid **(triangles, thick line)** versus non-Medicaid **(thin line)** coronary artery bypass graft (CABG) patients. **(Top middle)** Propensity-adjusted comparison of survival in Medicaid **(thick line)** versus non-Medicaid **(thin line)** CABG patients with additional Medicare coverage. **(Top right)** Propensity-adjusted comparison of survival in Medicaid **(thick line)** versus non-Medicaid **(thin line)** CABG non-Medicare patients. **(Bottom left)** Unadjusted 0- to 12-year Kaplan-Meier survival in one-to-one propensity-matched Medicaid **(thick line)** versus non-Medicaid **(thin line)** CABG patients: Medicare **(black)**, non-Medicare **(gray)**. **(Bottom Right)** Ten-year relative death hazard functions (Medicaid yes/no) for all patients **(black, thin)**, Medicare cohort **(black, thick)**, and non-Medicare cohort **(gray)** derived from analyses of propensity-matched survival data. CI = confidence interval.

cans, did with a 54% greater 12-year mortality (HR = 1.54; p = 0.0047). We thus assessed, post hoc, this Medicaid-CABG outcome association by comparing survival in Medicaid (n = 469; 235 men [50%], 60 years [median]) vs. non-Medicaid (n = 5,908; 4,191 men [71%], 65 years [median]) patients. Comparisons were also repeated for Medicare (n = 2,979 [207 Medicaid], 71 years [median]) and non-Medicare (n = 3,398 [262 on Medicaid], 57 years [median]) cohorts. These results are summarized in Figure 4 and Table 4. Briefly, for all patients, the unadjusted 0- to 12-year mortality was significantly worse in Medicaid patients (HR = 1.61; p < 0.0001) despite being an average of five years younger. This worse unadjusted Medicaid survival difference was particularly pronounced in the younger, non-Medicare sub-cohort (HR = 2.32; p < 0.0001) compared with a much smaller difference in the Medicare sub-cohort (HR = 1.28; p = 0.06). Covariate risk adjustment confirmed these findings, as did the Kaplan-Meier analysis in closely matched cohorts (Fig. 3, Table 4). Moreover, the propensity-matched analyses showed that CABG survival data exhibits time-varying death hazard (19) over time where: 1) in older Medicare patients, Medicaid status did not increase mortality (HR = 1.20; p = 0.33) with only a limited early association (1 to 2 years), and 2) in the younger non-Medicare patients, the Medicaid-only coverage was associated with nearly twice the mortality risk (HR = 1.96; p = 0.003), which is primarily characterized by a systematically increasing death hazard after the second post-CABG year.

DISCUSSION

Main findings. The objective of this investigation was to elucidate whether operative and long-term outcomes are different for African-American versus Caucasian patients and, if yes, how. Our African-American and Caucasian cohorts showed substantially different patient characteristics (Table 1), including age, gender, and multiple comorbid risk factors. Yet, importantly, operative CABG variables were essentially identical, including arterial/vein grafting and cardiopulmonary bypass. This 1991 to 2003 series was also characterized by: 1) race-dependent distribution of medical insurance payors with a disproportionate Medicaid frequency among African Americans (28.6% vs. 6.3%), and 2)

Table 4. Medicaid Status as a Predictor of 0- to 12-Year Survival After Isolated CABG in 6,377 at Saint Vincent Mercy Medical Center (Toledo, Ohio, 1991 to 2003)

Model	Medicaid, N (Yes/No)	Hazard Ratio	95% Confidence Interval	p Value
All patients (n = 6,377)				
Unadjusted	469/5,908	1.61	(1.33–1.95)	<0.0001
Age-adjusted	469/5,908	2.07	(1.71–2.50)	<0.0001
Covariate-adjusted*	469/5,908	1.46	(1.19–1.80)	0.0003
Matched patients†	449/449	1.47	(1.11–1.95)	0.008
Medicare patients (n = 2,979)				
Unadjusted	207/2,772	1.28	(0.99–1.66)	0.06
Age-adjusted	207/2,772	1.62	(1.25–2.11)	0.0003
Covariate-adjusted*	207/2,772	1.31	(0.97–1.75)	0.075
Matched patients†	193/193	1.20	(0.83–1.75)	0.33
Non-Medicare patients (n = 3,398)				
Unadjusted	262/3,163	2.32	(1.75–3.09)	<0.0001
Age-adjusted	262/3,163	2.66	(2.00–3.55)	<0.0001
Covariate-adjusted*	262/3,163	1.92	(1.41–2.62)	<0.0001
Matched patients†	256/256	1.96	(1.25–3.05)	0.003

*Covariate adjustment was achieved via a propensity score (Medicaid: yes = 1, no = 0) based on variables in Table 1, including race (African American: yes = 1/no = 0). †Patients were one-to-one matched (greedy) using two non-parsimonious Medicaid (yes = 1/no = 0) propensity score models: 1 for Medicare patients (C-index = 0.811) and one for non-Medicare patients (C-index = 0.845).

concurrent parallel trends of increasing number of African-American and Medicaid patients over the study period. The latter may reflect a trend toward a more equitable referral of patients for CABG. However, it also raises the potential of interaction between two factors with implications on CABG outcomes: ethnicity and insurance payor.

Early outcomes showed that African Americans exhibit significantly worse unadjusted postoperative morbidity (complications) and are associated with greater resource use (transfusions, hospital stays). This result in an urban community hospital series is similar to that reported by Rumsfeld et al. (13) in the Veterans Health Administration (VHA) system nationwide (1995 to 2001; n = 33,428). We also found a small absolute (non-significant) difference in unadjusted operative mortality (OM) (3.0% vs. 2.5%), but race was not a predictor of OM by multivariate regression. Bridges et al. (5) analyzed the 1994 to 1997 STS national database and showed that African Americans are associated with a small yet significant increase in OM after risk adjustment (3.83% vs. 3.14%). A similar finding from the STS was reported by Hartz et al. (6). In matched patients, we report similar complication rates, resource use, and OM (Table 2). This result agrees with results from Higgins et al., (12) who found a substantial difference in unadjusted OM (5.5% African-Americans vs. 2.5% Caucasians), but this was explained by the imbalance in risk factors and co-morbidity. Also, like us, they reported more Medicaid status among African Americans, but this did not affect operative outcomes (12).

In our series, the unadjusted 12-year CABG mortality was significantly worse for African Americans (Fig. 1). However, multiple multivariate analyses converged showing that this difference in survival is explained by the imbalance of clinical risk factors in addition to Medicaid coverage among the two groups and not race per se (Tables 3 and 4). This was also consistent with the essentially identical Kaplan-Meier survival results irrespective of race in matched patients (Fig. 2).

Other studies have explored the relationship between race and long-term CABG outcomes with non-uniform findings. In 1997, Taylor et al. (7) reported that 16-year survival was significantly worse in African Americans versus Caucasians for the 1970s Coronary Artery Surgery Study (CASS), and survival differences were more pronounced in CABG-treated versus medically treated patients. An earlier CASS analysis (10) reported that age- and gender-adjusted five-year survival was only worse in medically treated African-American patients. Both studies showed a substantial adverse effect of current smoking status (more prevalent in African Americans) on long-term outcomes (7,10). Unfortunately, nearly two decades later, we also found a greater propensity for current smoker status among African Americans (35.5% vs. 21.7%), which independently increased 0- to 12-year mortality (HR = 1.51). In a review of 12,402 CAD patients (10.3% African Americans) who underwent angiography at Duke University (1984 to 1992), Peterson et al. (1) reported that African Americans were significantly less likely to undergo coronary revascularization (particularly CABG), and this difference could not be explained by clinical factors or coronary disease characteristics. Then, given the significantly worse five-year survival in African-American patients (unadjusted HR = 1.41), the investigators concluded that revascularization (CABG or angioplasty) was underused in African Americans. Note, when adjusted to prognostic factors and treatment, the difference in survival was only marginally higher in African Americans (HR = 1.08 [95% CI 0.97 to 1.20]) (1). In another 1984 to 1992 series, Gray et al. (8) reported that the risk of death within the first five years after CABG in African Americans was twice that in Caucasian patients. Brooks et al for the Bypass Angioplasty Revascularization Investigation (BARI) randomized trial reported increased five-year all-cause mortality in African-American patients (HR = 1.49), and they did not find a significant race and treatment (angioplasty or CABG) interaction effect on survival (9).

In the VHA setting, Maynard and Ritchie (11) reported that for veterans undergoing CABG at 44 medical centers (1994 to 1999), five-year survival was slightly (87% vs. 89%) yet significantly worse in African Americans (HR = 1.09). This analysis, like most VHA analyses, was limited by its reliance on administrative databases that do not allow for comprehensive risk adjustment (20–22). Alternatively, in another VHA analysis in which a more comprehensive clinical database was available, Rumsfeld et al. (13) reported similar six-month CABG mortality in African Americans and Caucasians (adjusted OR = 1.10; p = 0.31). Both studies concluded that ethnicity was not a strong risk factor for adverse outcomes after CABG. Importantly, VHA results are uniquely characterized by similarity of access to health care services irrespective of ethnicity both before and after CABG. This characteristic is not true of the general non-veteran U.S. population such as ours, and hence the applicability of these findings is unclear (20,21).

Our data do not implicate race as a predictor of early or late CABG outcomes. However, we report that Medicaid status, which is more prevalent among African Americans, is independently associated with worse long-term survival (HR = 1.54 overall and 1.96 non-Medicare). To our knowledge, such a strong adverse Medicaid status-long-term CABG outcome association has not been described. Medicaid-funded care is unlikely to be a causal risk factor for worse CABG outcomes, particularly because early or operative outcomes did not vary with Medicaid status. However, it is arguably possible that certain re-engineering of Medicaid care promoting more physician follow-up and access to risk-modification programs (cardiac rehabilitation) may impact long-term outcomes favorably (23,24). This contention is advanced by the fact that the observed late survival-Medicaid association is largely mitigated in patients with the additional Medicare coverage (Fig. 3).

Alternatively, Medicaid is clearly a risk marker of lower socioeconomic status, which can impact long-term CABG outcomes in ways that are independent of the Medicaid system. Low socioeconomic status is a marker of poverty, low educational levels, poor health habits, unemployment, lifelong stress, and fewer opportunities. These can translate to lack of adequate adherence to prescribed medications and unhealthy diets, which are associated with poorer outcomes (15,16,23,24).

Study limitations. This study is an observational single-center investigation performed on patients derived from a prospectively collected comprehensive clinical database. It is not possible to prospectively randomize patient race with CABG. Fortunately, advances in statistical methods have overcome many of the known shortcomings of observational data analyses (17–19). If used properly, these methods may adequately answer important clinical questions. Here, we concomitantly used multiple methods to better corroborate our findings: conventional risk adjustment, propensity adjustment, and balanced scores (or matched) cohorts based on the propensity models. The latter approach successfully identified closely matched African-American and Caucasian patients as well as Medicaid and non-Medicaid patient groups. Convergence of all of these analyses significantly advances our main finding that ethnicity is not an independent predictor of outcomes, whereas Medicaid status is. That said, a potential impact of unmeasured confounding variables on the propensity matching remains a possibility (18), but the comprehensiveness of the propensity models minimizes this possibility. Second, our results are limited by the fact that we only report all-cause mortality. Third, we used the social security death index to validate our service long-term follow-up, which is not necessarily 100% accurate. This, however, is not expected to be race-dependent and should not bias our findings. Fourth, other than the possibility of late referral to CABG of African American patients, we could not fully explain their substantially greater incidence of preoperative co-morbid compared with the older Caucasian group. In this study, we could not evaluate any potential race association/bias before the CABG surgery (e.g., referral to catheterization). Lastly, our analysis was also limited by our inability to fully elucidate what is it about Medicaid patients (at time of CABG) that leads to the substantially worse late outcomes, and how. Patient educational level, household income, and other related socioeconomic data were not available to us. Further, people often move in and out of Medicaid coverage. The length and continuity of Medicaid coverage, in addition to the possibility of adjunct coverage other than Medicare, were also not available to us.

CONCLUSIONS

African-American race per se is not associated with worse operative or late CABG outcomes, which underscores the fact that CABG surgery should be offered based strictly on clinical characteristics and irrespective of race. Alternatively, Medicaid status, which is substantially more prevalent among African Americans and other minority groups, was independently associated with worse late survival, especially in younger patients who lack the additional Medicare coverage. Because of the potentially large social implications of these data, we suggest the need for wider national-scale studies to address the suboptimal late CABG results in Medicaid patients focusing on the adequacy of post-CABG longitudinal care, cardiac risk modification, and the multiple other socioeconomic factors with implications on outcomes.

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APPENDIX

For Tables S1 and S2 and Figures S1 and S2, please see the online version of this article.