Does Black Ethnicity Influence the Development of Stent Thrombosis in the Drug-Eluting Stent Era?

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Background—It has been suggested that black race predicts stent thrombosis (ST) after drug-eluting stent implantation. Whether socioeconomic status or comorbid conditions confound the contribution of black race to the development of ST is unclear.

Methods and Results—We compared 1594 black patients who underwent drug-eluting stent implantation with 5642 nonblack patients. Overall, 108 definite STs were reported. Multivariable Cox regression analysis was performed with adjustment for comorbidities, including median household income as a marker of socioeconomic status, to assess the impact that black race may have on the development of ST. On univariable analysis, black patients were younger (63.43±12.42 versus 65.15±12.59 years; $P<0.001$) and more likely to have a history of hypertension (89.8% versus 81.7%; $P<0.001$), diabetes mellitus (45.5% versus 30.8%; $P<0.001$), chronic renal insufficiency (19.2% versus 10.7%; $P<0.001$), and congestive heart failure (18.7% versus 13.1%; $P<0.001$). Clopidogrel compliance at the time of the ST event was higher in the black than in the nonblack population (87.5% versus 77.8%; $P=0.068$). After multivariable analysis, including adjustment for median income and clopidogrel compliance, black race emerged as a strong predictor of definite late ST.

Conclusions—Black race is an independent predictor of definite drug-eluting stent ST. Because clopidogrel compliance was higher in black patients and socioeconomic status was not associated with ST, further investigation into the potential mechanisms of this influence of race on ST must be pursued. **(*Circulation*. 2010;122:1085-1090.)**

Key Words: drug-eluting stents ■ stents ■ thrombosis

The advent of drug-eluting stents (DES) has changed the landscape of in-stent restenosis treatment and has been associated with a remarkable reduction in the need for repeat target vessel revascularization. This has led to widespread application of this technology, currently used in 75% of patients undergoing percutaneous coronary intervention (PCI) in the United States. DES, however, have not been associated with decreased rates of death or myocardial infarction (MI)[1] and have been associated with the alarming, yet rare, phenomenon of late stent thrombosis (ST). This has led to a mandatory requirement of prolonged dual antiplatelet therapy administration (≥12 months) to prevent the occurrence of ST.[2] Although dual antiplatelet therapy reduces the risk of ST, it has not eliminated this phenomenon, which continues to occur in patients receiving dual antiplatelet therapy and is associated with high rates of morbidity and mortality.[3,4]

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Although the greatest risk of ST occurs in the first 30 days,[5] late ST and very late ST remain a concern because of their unpredictable nature of occurrence and course. Premature cessation of dual antiplatelet therapy has consistently been a leading predictor of ST; other predictors are related to complex lesion and patient confounders.[3,4,6]

Numerous large-scale studies have demonstrated that blacks have more modifiable risk factors for coronary artery disease and higher cardiovascular mortality than their white counterparts.[7–9] Despite historically similar presentation and natural history of MI, black race has been reported to be an independent predictor of mortality after PCI and coronary bypass graft surgery.[10,11] Outcomes after PCI have been controversial, however, because some studies have reported more in-hospital deaths/ST-segment elevation MIs and increased risk of death over time and others have demonstrated no difference in outcomes.[12–14] We reported previously that although blacks experience higher rates of major cardiac events after PCI, socioeconomic disparities may have an impact on clinical outcome in patients undergoing DES implantation.[15]

Here, we aimed to examine the incidence of early, late, and very late ST in the black population in a high-volume PCI

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center and to determine whether socioeconomic status or comorbid conditions confound the contribution of black race to the development of ST.

Methods

Study Group and Design

A retrospective analysis of 7236 consecutive patients who underwent PCI of 13 135 lesions from April 2003 to December 2008 and received ≥1 DES was conducted. Black patients were compared with nonblack patients. Clinical outcomes during the initial hospitalization, at 30 days, and at 12, 24, and 36 months were assessed. This study was conducted under the approval of the local Institutional Review Board. Systematic chart review of patients undergoing coronary angioplasty was performed to acquire baseline demographics, risk factors, procedural characteristics, and overall hospital course. Information was obtained at the time of the procedure, and follow-up was acquired by mail, telephone contact, or office visit. Medical record review to confirm adverse events was performed by an independent clinical event committee.

The interventional strategy, including the type of stent implanted and anticoagulation regimen, was conducted at the operator's discretion. PCI was performed according to guidelines at the time of the procedure.[16] Intraprocedural anticoagulation was ensured through the use of unfractionated heparin or bivalirudin, with or without a glycoprotein IIb/IIIa inhibitor, to achieve an activated clotting time of >250 seconds in all patients. Patients received a 325-mg loading dose of aspirin and were encouraged to continue this regimen indefinitely. Clopidogrel was administered as a loading dose of 300 to 600 mg at the time of DES implantation and maintained at a dose of 75 mg/d. Clopidogrel therapy was recommended for a minimum of 3 to 12 months after Cypher sirolimus-eluting stent (Cordis, Johnson & Johnson, Miami Lakes, Fla) implantation and a minimum of 6 to 12 months after Taxus paclitaxel-eluting stent (Boston Scientific, Natick, Mass) implantation. Patients receiving DES in the setting of acute coronary syndrome or MI were encouraged to continue clopidogrel therapy for ≥12 months.

Outcomes analyzed included ST, all-cause death, Q-wave MI, and target vessel revascularization. ST was classified according to the Academic Research Consortium definitions of event timing and certainty. Only definite STs were included, defined as pathological or angiographic confirmation of thrombus within a stent in a patient presenting with acute coronary syndrome. Timing of ST was classified as early, late, or very late (<30 days, 30 days to 1 year, and >1 year after PCI, respectively). Angiographic success was defined as >20% reduction in the percent diameter stenosis of the lesion and a final residual stenosis of <50%. Q-wave MI was defined as the appearance of new pathological Q waves in the coronary distribution of the treated artery with an increase in creatine kinase-MB to ≥2 times the reference values. Target vessel revascularization was defined as revascularization occurring in any area along the previously treated vessel.

Clopidogrel compliance was expressed as a time-dependent covariate defined as the days to cessation for those patients who ceased their prescription. Race was patient defined and recorded on admission. Patients identified themselves as black, Asian, white, Hispanic, or Native American and were allowed to select only 1 race. ZIP codes were abstracted from the hospital billing database and matched with census bureau data on median household income by ZIP code.[17]

Statistical Analysis

Continuous variables are presented as mean±SD, and categorical variables are presented as percentages. Household income is presented as median income for the patient's ZIP code and the interquartile range. Differences in continuous variables between groups were compared by use of the *t* test or Wilcoxon rank-sum test as appropriate. Proportions were compared by use of the χ^2 test or Fisher exact test when appropriate. A value of $P<0.05$ was considered statistically significant. To test the independent effect of black race on time to event, a Cox proportional-hazards model was constructed. Several studies have identified clopidogrel cessation, median household income, age, history of diabetes mellitus, history of chronic renal insufficiency, history of congestive heart failure, history of in-stent restenosis, and presentation with MI as independent predictors of ST and suggested an inverse relationship between age and the risk of ST. Therefore, these covariates were selected for the model as potential confounders.[18–20] The proportional-hazards assumption for such covariates was then tested. Covariates remaining in the model were expressed as hazard ratios with 95% confidence intervals. Statistical analyses were performed with SAS version 9.1 (SAS Institute, Cary, NC).

Results

Population

The study included 7236 patients who underwent PCI from April 2003 to December 2008. Of those, 22% were black and 78% were nonblack. A total of 65.7% were men, and the average age at presentation was 65±13 years. The median household income (per $10 000) was significantly lower in the black group ($44 197 [25th to 75th percentile, $35 313 to $61 374] versus $60 838 [25th to 75th percentile, $50 844 to $74 933]; $P<0.001$). Blacks were younger and were more likely to have a history of hypertension, diabetes mellitus, chronic renal insufficiency, and congestive heart failure (Table 1).

Blacks had fewer diseased vessels (1.85±0.86 versus 1.96±0.87; $P=0.005$) and less history of in-stent restenosis (4.4% versus 5.4%; $P=0.035$). Angiographic success (lesion based) was high in both groups (black, 97.9% versus nonblack, 98.2%). Of the patients who presented with ST, 82 received sirolimus stents, 26 received paclitaxel stents, 1 received a zotarolimus stent, and 2 received a combination of sirolimus and paclitaxel stents (Table 1).

Outcomes

The rate of early ST at 30 days was 0.83±0.21% and late ST at 1 year was 1.11±0.25%. The rates of very late ST were 1.46±0.29% and 1.76±0.35% at 2 and 3 years, respectively, as shown by Kaplan-Meier analysis (Table 2). The cumulative incidence of late ST from 30 days to 1 year was 0.24%/y, which increased to 0.36%/y from 1 to 2 years. In a comparison of the black population and the nonblack populations, the incidence of early ST at 30 days was 1.71% versus 0.59%; late ST at 1 year, 2.25% versus 0.79%; late ST at 2 years, 2.78% versus 1.09%; and late ST at 3 years, 3.67% versus 1.25% (the Figure). Black race was associated with serious morbidity and mortality; short- and long-term outcomes revealed significantly higher rates of all-cause death and death/MI at 30 days and 12, 24, and 36 months. At 36 months, the rate of all-cause death in blacks was 24.9% compared with 13.1% in nonblacks ($P<0.001$), and the rate of death/MI in blacks was 29.8% versus 15.9% in nonblacks ($P<0.0001$). At the time of ST, blacks were numerically more likely to be taking clopidogrel, although the difference was not statistically significant (87.5% of blacks versus 77.8% of nonblacks; $P=0.068$). Of the patients who stopped clopidogrel before the ST event, the median time to cessation was 11 days (25th to 75th percentile, 3.5 to 384 days) and 18 days (25th to 75th percentile, 4 to 397 days; $P=0.699$) in the black and nonblack populations, respectively.

Table 1. Baseline and Procedural Characteristics

Variable	Black (n=1594) Lesion (n=2829)	Nonblack (n=5642) Lesion (n=10 328)	P
Age (mean±SD), y	63.43±12.42	65.15±12.59	<0.001
Men, %	51.3	69.8	<0.001
Body mass index, kg/m^2	30.40±6.86	29.27±6.07	<0.001
History of smoking, %	51.0	55.4	0.002
History of hypertension, %	89.8	81.7	<0.001
History of diabetes mellitus, %	45.5	30.8	<0.001
History of chronic renal insufficiency, %	19.2	10.7	<0.001
History of hyperlipidemia, %	85.9	88.0	0.024
History of congestive heart failure, %	18.7	13.1	<0.001
Family history of coronary artery disease, %	45.9	55.8	<0.001
Previous MI, %	36.9	35.7	0.415
Previous coronary artery bypass surgery, %	14.7	19.7	<0.001
Previous PCI, %	24.1	26.8	0.041
Presentation with MI, %	14.5	12.3	0.026
Presentation with unstable angina, %	43.9	43.3	0.685
Presentation with cardiogenic shock, %	3.3	2.2	0.012
Household income, median (25th to 75th percentile), $10 000	4.42 (3.53–6.14)	6.08 (50.8–74.9)	<0.001
Lesions dilated, n	1.72±1.33	1.79±1.64	0.089
Diseased vessels, n	1.85±0.86	1.96±0.87	0.005
Left main artery, %	0.8	1.9	0.001
Left anterior descending, %	35.6	38.8	0.002
Left circumflex, %	26.1	22.7	<0.001
Right coronary, %	34.7	30.4	<0.001
Saphenous vein graft, %	2.6	5.6	<0.001
Previous restenosis, %	4.4	5.4	0.035
Angiographic success, %	97.9	98.2	0.367
Intravascular ultrasound performed, %	63.0	64.1	0.273
Dissection, %	0.6	0.7	0.770
Type C lesions, %	17.8	20.9	<0.001
Procedure length, min	55.58±42.0	57.44±38.69	0.115
Bivalirudin use, %	71.2	74.6	0.007
Heparin use, %	16.8	14.5	0.026
Glycoprotein IIb/IIIa use, %	11.9	10.1	0.048

On multivariate analysis, clopidogrel cessation, black race, history of diabetes mellitus, history of congestive heart failure, and previous PCI were independent predictors of early ST (<30 days). On further examination, black race emerged as the strongest independent predictor of late ST (>30 days), whereas history of diabetes mellitus was no longer predictive after 30 days (Table 3).

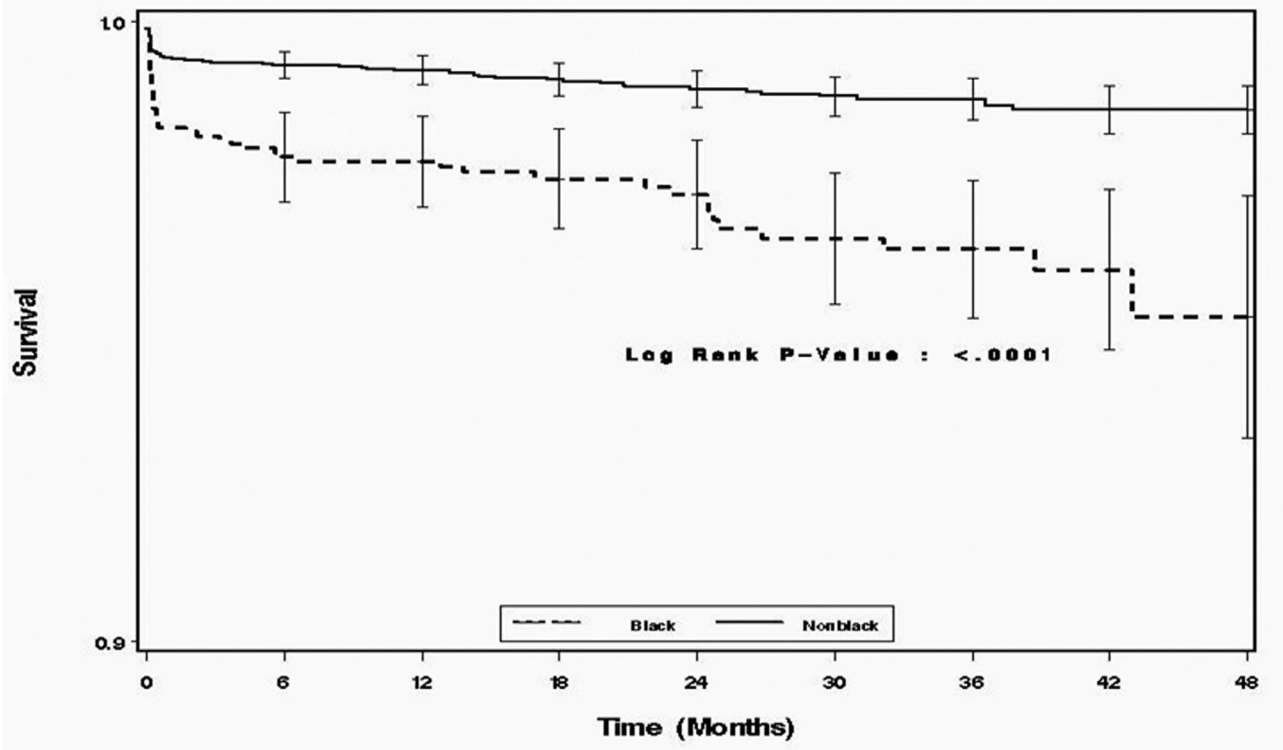
Discussion

The main findings of this large, unrestricted, single-center registry in the United States for all patients who underwent PCI with DES implantation were a 0.85% incidence of early ST at 30 days and rates of late and very late ST of 0.24%/y to 0.36%/y at the 3-year follow-up. These rates were especially higher in the black population, who had a >2-fold

Table 2. Rates of Early, Late and Very Late ST

	At 30 d, %	At 1 y, %	At 2 y, %	At 3 y, %
Overall population	0.83 (0.62–1.04)	1.11 (0.87–1.35)	1.46 (1.16–1.76)	1.76 (1.41–2.11)
Blacks	1.71 (1.06–2.36)	2.25 (1.50–3.00)	2.78 (1.89–3.67)	3.67 (2.53–4.81)
Nonblacks	0.59 (0.39–0.79)	0.79 (0.55–1.03)	1.09 (0.79–1.39)	1.25 (0.91–1.59)

Values in parentheses are 95% confidence intervals.



Events (Patients at Risk)	6 mos.	12 mos.	18 mos.	24 mos.	30 mos.	36 mos.	42 mos.	48 mos.
Black	34 (1595)	1 (1407)	3 (894)	2 (727)	5 (579)	1 (456)	1 (148)	1 (63)
Nonblack	39 (5643)	4 (5154)	6 (3515)	5 (2912)	3 (2421)	1 (1841)	3 (708)	0 (317)

Figure. Kaplan-Meier estimate of definite ST.

increased risk incidence of ST, despite a high rate of compliance with dual antiplatelet therapy. In a multivariate model of ST at 30 days, black race was a strong independent predictor of early ST. In a similar multivariate analysis of ST beyond 30 days, black race persisted as an independent predictor of late ST.

Black race is an independent predictor of ST even when accounting for potential confounders such as socioeconomic status and comorbidities. Socioeconomic status has been associated with worse outcome after coronary revascularization and a greater burden of cardiovascular disease.[11,21–23] Our evaluation used median income to represent socioeco-

Table 3. Multivariable Cox Regression Analysis: Early and Late ST

	Early ST (<30 d) (n=58)			Late ST (>30 d) (n=50)		
	Hazard Ratio	95% CI	*P*	Hazard Ratio	95% CI	*P*
Clopidogrel cessation	29.1	10.1–84.0	<0.0001	2.24	1.16–4.33	0.0161
Black	2.07	1.18–3.63	0.0110	2.60	1.40–4.68	0.0023
Median household income (per $10 000)	0.90	0.78–1.04	0.1585	1.004	0.88–1.15	0.9569
History of chronic renal insufficiency	0.76	0.35–1.61	0.4682	0.97	0.40–2.38	0.9534
History of diabetes mellitus	1.95	1.14–3.33	0.0150	1.54	0.87–2.74	0.1402
Previous PCI	2.11	1.18–3.74	0.0112	0.91	0.72–1.15	0.4104
Age	0.73	0.60–0.88	0.0013	0.85	0.35–2.06	0.7223
History of congestive heart failure	3.25	1.82–5.76	<0.0001	1.58	0.73–3.43	0.2469
Presentation with MI	1.35	0.65–2.81	0.4171	1.84	0.82–4.12	0.1392
History of in-stent restenosis	1.50	0.68–3.28	0.3151	2.24	1.16–4.33	0.0161

CI indicates confidence interval.

nomic status. Consistent with previous studies in a similar patient population, the median income of black patients was lower than that of nonblacks in our study.[15] Although the median income of each group differed, income was not a predictor of ST and therefore cannot account for the increased risk of ST in the black population.

Although differences in socioeconomic status may not explain the increased rate of ST in the black population in this study, discrepancies in access to care have been a concern in studies of racial disparities in health care. Several studies have demonstrated that blacks undergo fewer coronary revascularization procedures than whites,[24,25] even patients with equal access to Medicare benefits.[26,27] Black Medicare beneficiaries have been shown to have higher mortality even after adjustment for confounding variables.[28] Because our entire study population underwent PCI, a discrepancy in access to revascularization procedures is less of an issue. "Access to care" in a broader sense is worth mentioning, however, because it relates to follow-up and medication compliance. Despite a lower median income, more blacks in our study were compliant with clopidogrel therapy at the time of ST, although the difference was not significant (blacks, 87.5% versus nonblacks, 77.8%; $P=0.068$). In addition, previous studies have demonstrated that being financial incapable of complying with clopidogrel therapy is an infrequent reason for clopidogrel cessation.[29] This highlights the fact that socioeconomic disparities in our study population did not seem to affect clopidogrel compliance or the incidence of ST.

Because the traditional socioeconomic factors that plague racial disparities in health care have been accounted for in our study, further mechanisms such as genetic differences by which black race predicts ST must be pursued. Previous studies have demonstrated that carriers of a reduced-function CYP2C19 allele have significantly lower levels of the active metabolite of clopidogrel, diminished platelet inhibition, and an increased rate of cardiovascular events, including ST.[30,31] This polymorphism has been observed in a higher rate of blacks and East Asians compared with whites.[32] A genetic influence on the mechanism of ST in blacks is a possibility and deserves further investigation.

Limitations

This study was a retrospective analysis and is therefore prone to the shortcomings of any prospective study. Any confounding variables not represented in the model could potentially affect outcomes. Another limitation of our study is use of the Academic Research Consortium definitions of definite ST, which require angiographic or pathological confirmation; we did not include probable or possible ST. These factors may result in an underestimation of the true incidence of ST. Furthermore, race was self-reported, which is the preferred method in federal guidelines. Our study, however, reported race in mutually exclusive categories. This does not account for patients who may identify with more than 1 race or ethnicity.

We observed a significant difference in socioeconomic status in the black and nonblack populations. This evaluation used median income by ZIP code to assess socioeconomic status. The use of ZIP code as an aggregate measure of socioeconomic status is controversial because of the large number of residents covered and potential heterogeneity of the population. This heterogeneity may be the explanation for the small to moderate correlation for median income between ZIP code and microlevel data demonstrated in several studies.[33,34] ZIP codes, however, may in fact be a more accurate representation of some populations because smaller aggregate proxies tend to exclude rural residents. In addition, this study did not include data on substance abuse; however, because several studies have reported an association between cocaine use and ST, this issue may warrant further investigation in the future.

In reference to medication compliance, although careful attention was paid to questioning patients on length of treatment, any self-reported medical compliance data are subject to recall bias. The transient cessation of clopidogrel throughout the follow-up duration in this population may be underrepresented; however, all attempts were made to assess the compliance of clopidogrel at the time of ST. This may not account for smaller differences in income in our region with a high population density.

Conclusions

This is the first study to demonstrate black race as an independent predictor of ST after DES implantation. Because our analysis adjusts for traditional variables associated with racial disparities in health care, further mechanisms such as genetic polymorphisms and responsiveness to antiplatelet therapy must be pursued.

Disclosures

None.

References

1. Morice MC, Serruys PW, Sousa JE, Fajadet J, Ban Hayashi E, Perin M, Colombo A, Schuler G, Barragan P, Guagliumi G, Molnàr F, Falotico R, for the RAVEL Study Group, Randomized Study With the Sirolimus-Coated Bx Velocity Balloon-Expandable Stent in the Treatment of Patients With De Novo Native Coronary Artery Lesions. A randomized comparison of a sirolimus-eluting stent with a standard stent for coronary revascularization. *N Engl J Med*. 2002;346:1773–1780.
2. Sousa J. New frontiers in interventional cardiology. *Circulation*. 2005; 111:671–681.
3. Kuntz RE, Baim DS. Defining coronary restenosis: newer clinical and angiographic paradigms. *Circulation*. 1993;88:1310–1323.
4. Vaknin-Assa H, Assali A, Ukabi S, Lev EI, Kornowski R. Stent thrombosis following drug-eluting stent implantation: a single-center experience. *Cardiovasc Revasc Med*. 2007;8:243–247.
5. Ong AT, Hoye A, Aoki J, van Mieghem CA, Rodriguez Granillo GA, Sonnenschein K, Regar E, McFadden EP, Sianos G, van der Giessen WJ, de Jaegere PP, de Feyter P, van Domburg RT, Serruys PW. Thirty-day incidence and six-month clinical outcome of thrombotic stent occlusion after bare-metal, sirolimus, or paclitaxel stent implantation. *J Am Coll Cardiol*. 2005;45:947–953.
6. Iakovou I, Schmidt T, Bonizzoni E, Ge L, Sangiorgi GM, Stankovic G, Airoldi F, Chieffo A, Montorfano M, Carlino M, Michev I, Corvaja N, Briguori C, Gerckens U, Grube E, Colombo A. Incidence, predictors, and outcome of thrombosis after successful implantation of drug-eluting stents. *JAMA*. 2005;293:2126–2130.
7. Maynard C, Fisher L, Passamani E, Pullum T. Blacks in the Coronary Artery Surgery Study: risk factors and coronary artery disease. *Circulation*. 1986;74:64–71.
8. Mensah G. State of disparities in cardiovascular health in the United States. *Circulation*. 2005;111:1233–1241.

9. Haywood L. Issues in the natural history and treatment of coronary heart disease in black populations: medical management. *Am Heart J*. 1984; 108(pt 2):683–687.
10. Brooks M, Jones R, Bach R, Chaitman B, Kern M, Orszulak T, Follmann D, Sopko G, Blackstone E, Califf R. Predictors of mortality and mortality from cardiac causes in the Bypass Angioplasty Revascularization Investigation (BARI) randomized trial and registry. *Circulation*. 2000;101: 2682–2689.
11. Johnson PA, Lee TH, Cook EF, Rouan GW, Goldman L. Effect of race on the presentation and management of patients with acute chest pain. *Ann Intern Med*. 1993;118:593–601.
12. Leborgne L, Cheneau E, Wolfram R, Pinnow EE, Canos DA, Pichard AD, Suddath WO, Satler LF, Lindsay J, Waksman R. Comparison of baseline characteristics and one-year outcomes between African-Americans and Caucasians undergoing percutaneous coronary intervention. *Am J Cardiol*. 2004;93:389–393.
13. Mastoor M, Iqbal U, Pinnow E, Lindsay J Jr. Ethnicity does not affect outcomes of coronary angioplasty. *Clin Cardiol*. 2000;23:379–382.
14. Garg M, Vacek JL, Hallas D. Coronary angioplasty in black and white patients: demographic characteristics and outcomes. *South Med J*. 2000; 93:1187.
15. Gaglia M, Steinberg D, Slottow TP, Roy P, Bonello L, Delabriolle A, Lemesle G, Okabe T, Torguson R, Kaneshige K, Xue Z, Suddath W, Kent K, Satler L, Pichard A, Lindsay J, Waksman R. Racial disparities in outcomes following percutaneous coronary intervention with drug-eluting stents. *Am J Cardiol*. 2009;103:653–658.
16. Smith SC, Feldman TE, Hirshfeld JW, Jacobs AK, Kern MJ, King SB, Morrison DA, O'neill WW, Schaff HV, Whitlow PL, Williams DO, Antman EM, Smith SC, Adams CD, Anderson JL, Faxon DP, Fuster V, Halperin JL, Hiratzka LF, Hunt SA, Jacobs AK, Nishimura R, Ornato JP, Page RL, Riegel B, for the American College of Cardiology/American Heart Association Task Force on Practice Guidelines, ACC/AHA/SCAI Writing Committee to Update the 2001 Guidelines for Percutaneous Coronary Intervention. ACC/AHA/SCAI 2005 guideline update for percutaneous coronary intervention-summary article: a report of the American College of Cardiology/American Heart Association Task Force on Practice Guidelines (ACC/AHA/SCAI Writing Committee to Update the 2001 Guidelines for Percutaneous Coronary Intervention). *J Am Coll Cardiol*. 2006;47:216–235.
17. US Census Bureau. Available at: www.census.gov. Accessed February 14, 2008.
18. Wenaweser P, Daemen J, Zwahlen M, Vandomburg R, Juni P, Vaina S, Hellige G, Tsuchida K, Morger C, Boersma E. Incidence and correlates of drug-eluting stent thrombosis in routine clinical practice: 4-year results from a large 2-institutional cohort study. *J Am Coll Cardiol*. 2008;52: 1134–1140.
19. Pinto Slottow T, Steinberg D, Roy P, Buch A, Okabe T, Xue Z, Kaneshige K, Torguson R, Lindsay J, Pichard A. Observations and outcomes of definite and probable drug-eluting stent thrombosis seen at a single hospital in a four-year period. *Am J Cardiol*. 2008;102:298–303.
20. Kuchulakanti PK, Chu WW, Torguson R, Ohlmann P, Rha SW, Clavijo LC, Kim SW, Bui A, Gevorkian N, Xue Z, Smith K, Fournadjieva J, Suddath WO, Satler LF, Pichard AD, Kent KM, Waksman R. Correlates and long-term outcomes of angiographically proven stent thrombosis with sirolimus- and paclitaxel-eluting stents. *Circulation*. 2006;113: 1108–1113.
21. Daumit GL, Hermann JA, Coresh J, Powe NR. Use of cardiovascular procedures among black persons and white persons: a 7-year nationwide study in patients with renal disease. *Ann Intern Med*. 1999;130:173–182.
22. Lutsey PL, Diez Roux AV, Jacobs DR, Burke GL, Harman J, Shea S, Folsom AR. Associations of acculturation and socioeconomic status with subclinical cardiovascular disease in the multi-ethnic study of atherosclerosis. *Am J Public Health*. 2008;98:1963–1970.
23. Kanjilal S, Gregg EW, Cheng YJ, Zhang P, Nelson DE, Mensah G, Beckles GL. Socioeconomic status and trends in disparities in 4 major risk factors for cardiovascular disease among US adults, 1971–2002. *Arch Intern Med*. 2006;166:2348–2355.
24. Ford E. Coronary arteriography and coronary bypass survey among whites and other racial groups relative to hospital-based incidence rates for coronary artery disease: findings from NHDS. *Am J Public Health*. 1989;79:437–440.
25. Peterson E, Shaw L, DeLong E, Pryor D, Califf R, Mark D. Racial variation in the use of coronary-revascularization procedures: are the differences real? Do They Matter? *N Engl J Med*. 1997;336:480–486.
26. McBean AM, Warren JL, Babish JD. Continuing differences in the rates of percutaneous transluminal coronary angioplasty and coronary artery bypass graft surgery between elderly black and white Medicare beneficiaries. *Am Heart J*. 1994;127:287–295.
27. Whittle J, Conigliaro J, Good CB, Lofgren RP. Racial differences in the use of invasive cardiovascular procedures in the Department of Veterans Affairs medical system. *N Engl J Med*. 1993;329:621–627.
28. Gornick M, Eggers P, Reilly T, Mentnech R, Fitterman L, Kucken L, Vladeck B. Effects of race and income on mortality and use of services among Medicare beneficiaries. *N Engl J Med*. 1996;335:791–799.
29. Lemesle G, De Labriolle A, Ben-Dor I, Maluenda G, Collins SD, Syed AI, Torguson R, Kaneshige K, Xue Z, Suddath WO, Satler LF, Kent KM, Lindsay J, Pichard AD, Waksman R. Is there a rebound effect after clopidogrel cessation in patients undergoing percutaneous coronary intervention and drug-eluting stent implantation? *J Am Coll Cardiol*. 2009; 53:A1–A99.
30. Mega JL, Close SL, Wiviott SD, Shen L, Hockett RD, Brandt JT, Walker JR, Antman EM, Macias W, Braunwald E, Sabatine MS. Cytochrome p-450 polymorphisms and response to clopidogrel. *N Engl J Med*. 2009; 360:354–362.
31. Brandt JT, Close SL, Iturria SJ, Payne CD, Farid NA, Ernest CS, Lachno DR, Salazar D, Winters KJ. Common polymorphisms of CYP2C19 and CYP2C9 affect the pharmacokinetic and pharmacodynamic response to clopidogrel but not prasugrel. *J Thromb Haemost*. 2007;5:2429–2436.
32. Desta Z, Zhao X, Shin JG, Flockhart DA. Clinical significance of the cytochrome P450 2C19 genetic polymorphism. *Clin Pharmacokinet*. 2002;41:913–958.
33. Geronimus AT, Bound J. Use of census-based aggregate variables to proxy for socioeconomic group: evidence from national samples. *Am J Epidemiol*. 1998;148:475–486.
34. Danesh J, Gault S, Semmence J, Appleby P, Peto R. Postcodes as useful markers of social class: population based study in 26 000 British households. *BMJ*. 1999;318:843–844.

CLINICAL PERSPECTIVE

Stent thrombosis is a potentially devastating condition that puts all patients undergoing stent implantation at risk. Variability in the presentation and timing of stent thrombosis can make it an unpredictable and challenging issue to address. Our study demonstrates that black race is an independent predictor of stent thrombosis even when accounting for comorbid confounders and socioeconomic status. These findings suggest that particular populations warrant careful attention with regard to the selection of stent type and antiplatelet therapy. The advent of bedside antiplatelet responsiveness testing may help address this concern. In light of these hypothesis-generating results, further pathogenic studies of genomic and environmental influences should be pursued.

Does Black Ethnicity Influence the Development of Stent Thrombosis in the Drug-Eluting Stent Era?

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