Explaining racial disparities in mortality after abdominal aortic aneurysm repair

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Background: **Black patients have a higher mortality rate than nonblacks after abdominal aortic aneurysm repair. We sought to understand the factors responsible for this racial disparity in the mortality rate after aneurysm repair.**

Methods: **The Medicare database (2001-2006) was used to identify 160,785 patients undergoing open and endovascular abdominal aortic aneurysm repairs. We used risk-adjusted mortality as our primary measure of quality and logistic regression to determine the relationship between race and mortality, sequentially adding contributing factors including patient characteristics, the type of repair (endovascular vs open repair), socioeconomic status, and hospital quality. From these sequential regression models, we estimated the proportion of the disparity that can be explained by each factor.**

Results: **Black patients had a 36% higher risk-adjusted mortality after aneurysm repair than nonblack patients (odds ratio [OR], 1.36; 95% confidence interval [CI], 1.20-1.53). Even after accounting for the type of repair, a significant difference in mortality remained (OR, 1.33; 95% CI, 1.18-1.50). Mortality rates were higher in hospitals treating a higher proportion of black patients. Adjusting for these differences in hospital quality, this disparity was no longer significant (OR, 1.07; 95% CI, 0.93-1.25). We estimate that 29% of the observed disparity in mortality is caused by patient comorbidities, 6% from the use of endovascular repairs, 26% due to socioeconomic factors, and 25% because black patients receive care in lower-quality hospitals.**

Conclusions: **Although many factors contribute, a large proportion of observed disparities in outcomes are attributable to black patients receiving care in lower-quality hospitals. Efforts aimed at improving disparities must focus on improved access to high-quality hospitals and improved resources at the hospitals that treat higher proportions of black patients. (J Vasc Surg 2009;50:709-13.)**

Racial disparities in the outcomes of vascular disease are increasingly apparent.[1] Black patients have worse outcomes across a wide range of vascular surgical procedures, including carotid endarterectomy, peripheral artery bypass grafting, and abdominal aortic aneurysm repair.[2-8] In particular, black patients have a significantly higher mortality rate after abdominal aortic aneurysm (AAA) repair compared with white patients.[8] Although several studies have highlighted the disparities in the treatment of vascular disease, little effort has focused on understanding the mechanisms of these disparities.

These differences in outcomes may be due to three separate mechanisms:

First, black patients may receive care in hospitals with worse outcomes (ie, segregation). This suggests that patients treated in hospitals that care for predominantly black patients will have worse outcomes than patients in hospitals that treat more white patients. Recent studies have suggested that black patients may receive care at hospitals with fewer resources available to provide high-quality care.[9,10] Similarly, black patients may receive care from lower-volume or lower-quality surgeons. Given the lower incidence in aneurysmal disease, a surgeon treating predominantly black patients may have lower volume than other surgeons with a more heterogenous practice. Previous research by Birkmeyer et al[11] has demonstrated that surgeon volume is an important mediator of the relationship between hospital volume and death.

Second, black patients may have worse outcomes when receiving care within the same hospitals as white patients. These differences in the treatment of black patients within the same hospitals could represent discrimination.

Third, these disparities in outcomes could be due to differences in the biology and disease severity in black versus white patients.

It is important to understand the mechanisms responsible for the existing disparities in vascular disease so that we will be better equipped to intervene and make policy decisions that could improve the care of all pa-

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tients. We sought to understand the factors that are responsible for this racial disparity in the mortality rate after AAA repair. To determine which factors are driving this racial variation in the mortality rate, we analyzed Medicare claims data of patients who underwent AAA repair from 2001-2006.

METHODS

Data source and population. We identified all nonruptured AAA repairs performed among Medicare beneficiaries aged ≥65 years between January 2001 and December 2006 using the Medicare Provider Analysis and Review (MEDPAR) claims data-file. All AAA repairs were identified using International Classification of Diseases, Ninth Edition, Clinical Modification (ICD-9-CM) diagnostic code for AAA and the procedure code for open or endovascular AAA repair. Ruptured AAA repairs were excluded using the appropriate ICD-9-CM diagnostic code. Race and ethnicity were dichotomized as black or nonblack. Procedures were classified as elective if the patients identified had an elective code for admission status. The primary outcome measure was death, defined as 30-day or in-hospital death.

Data analysis. Patient comorbidities and characteristics were compared between black and nonblack patients using χ^2 analyses for categoric variables and analysis of variance for continuous variables. We compared the risk-adjusted mortality rates after AAA repair between black and nonblack patients using multivariate logistic regression, controlling for patient risk factors including the interactions of age, sex, and race, acuity of admission, comorbidities (using methods described by Elixhauser et al[12]), year of admission, and type of repair (open vs endovascular). The Elixhauser Index is a widely accepted method of adjusting for patient comorbidities in administrative data that has previously been validated in patients admitted with congestive heart failure, diabetes mellitus, chronic renal failure, stroke, and patients undergoing coronary artery bypass grafting.[13]

We repeated this analysis to adjust for socioeconomic status using a composite measure of neighborhood socioeconomic status based on the 2000 U.S. Census, as previously described by Birkmeyer et al.[14] This composite measure includes three measures of wealth/income (median household income, median value of housing units, and proportion of households with interest, dividend, or rental income), two measures of education (proportion of adult residents completing high school and proportion of adult residents completing college), and one measure of occupation/employment (proportion of employed residents with management, professional, and related occupations).[14]

We used two methods to determine whether black patients receiving care at lower-quality hospitals can explain the observed disparities in outcomes. First, we grouped hospitals by the proportion of black patients treated for an AAA, creating five equally sized groups (quintiles). The first quintile contained zero black patients and was omitted from the subsequent stratified analysis. We then determined the risk-adjusted mortality rates using logistic regression for blacks and nonblacks within each of the remaining four quintiles.

Table I. Patient characteristics and comorbidities by race

Characteristic	*Black*	*Nonblack*	P
Male, %	56.21	74.43	<.001
Mean age (range)	74.21 (65-98)	75.32 (65-99)	<.001
Emergency/urgent surgery, %	31.19	18.33	<.001
Endovascular repair, %	23.62	42.88	<.001
Congestive heart failure, %	1	0.55	<.001
COPD, %	26.85	35.89	<.001
Hypertension, %	66.95	58.91	<.001
Peripheral vascular disease, %	41.1	34.86	<.001
Diabetes, %			
Uncomplicated	15.74	12.05	<.001
Complicated	2.31	0.97	<.001
Chronic renal failure, %	8.11	5.36	<.001
Obesity, %	1.6	2.91	<.001
Coagulopathy, %	7.34	5.47	<.001
Weight loss, %	2.77	1.91	<.001
Comorbidity >2, %	72.46	64.57	<.001

COPD, Chronic obstructive pulmonary disease.

Second, we used fixed-effects regression models, using hospital identifier variables, to adjust for the hospital in which patients received their care. Fixed-effects hierarchical modeling adjusts for hospital-level factors that affect mortality of all patients, isolating the racial differences in mortality within hospitals.[15] We used fixed-effects hierarchical modeling to assess the relationship between race and risk-adjusted mortality after aneurysm surgery, adjusting for the patient level factors and type of repair. If the racial disparity in mortality is no longer significant after accounting for this hospital-level variation, then the differences in mortality can be assumed to arise from differences between hospitals.

To further understand the relative contribution of patient-level factors, socioeconomic status, type of repair, and hospital quality (between-hospital differences), we assessed the degree to which each additional factor added to the models affected the relationship between race and mortality. This effect can be estimated by the relative change in the odds ratio (OR) between the base model and subsequent model, defined as $[(OR_1 - OR_2)/(OR_1 - 1)]$, where OR_1 is the OR of risk-adjusted mortality for a patient of black race and OR_2 is the OR for a patient of black race after taking the between-hospital differences.[16]

We conducted all statistical analyses using Stata 10 software (StataCorp LP, College Station, Tex). Significance was established at $P < .05$.

RESULTS

AAA repairs were done in 68,494 patients (42%), of which 6988 were black (4.3%). Black patients were slightly younger and had significantly more comorbidities compared with nonblack patients (Table I). Black patients were significantly less likely to undergo an endovascular repair

Table II. Mortality of black patients relative to nonblack patients [a]

Model	*OR (95% CI)*	*Proportion of disparity explained, %*
Unadjusted	1.51 (1.37-1.66)	...
Adjusted for		...
Patient factors	1.36 (1.20-1.53)	29
Endovascular repair	1.33 (1.18-1.50)	6
Socioeconomic status	1.21 (1.06-1.37)	26
Hospital quality	1.07 (0.93-1.25)	25

CI, Confidence interval; *OR,* odds ratio.
[a]Data derived from the National Inpatient Sample, 2001-2006.

compared with nonblack patients (23.6% vs 42.9%, $P < .001$) and were more likely to undergo an emergency repair than nonblack patients (31% vs 18%, $P < .001$).

The overall mortality rate for all patients was 4.6%. Black patients had a 51% higher risk of death after AAA repair than nonblack patients in the unadjusted analysis (OR, 1.51; 95% confidence interval [CI], 1.37-1.66). After controlling for patient comorbidities, black patients continued to be 36% more likely to die after an AAA repair (OR, 1.36; 95% CI, 1.20-1.53). Adjusting for the effect of the type of repair (endovascular vs open) had a relatively minor effect on this mortality rate: black patients continued to remain 33% more likely to die (OR, 1.33; 95% CI, 1.18-1.50). Controlling for neighborhood socioeconomic status, black patients continued to have a significantly higher mortality, with a 21% higher risk of dying (OR, 1.21; 95% CI, 1.06-1.37). We estimate that 29% of the disparity in mortality can be explained by patient comorbidities, 6% of the disparity is due to endovascular repairs, and 26% is due to the effect of neighborhood socioeconomic status (Table II).

When hospitals are stratified by the proportion of black patients treated, there is significant segregation of black patients. The proportion of black patients treated in hospitals varied from as low as 0% in the lowest quintile to 64% in the highest quintile (Fig 1). The lowest quintile was not included in the stratified analysis. Figure 2 demonstrates the mortality rates for black and nonblack patients in hospitals stratified by the proportion of black patients treated. Among all hospitals, nonblack patients had similar mortality rates. In contrast, black patients treated in hospitals with a higher proportion of black patients had higher mortality rates than black patients treated in hospitals with a lower proportion of black patients. Differences in mortality between black and nonblack patients within hospitals also appeared to increase as the proportion of black patients increased. In the hospitals treating the highest proportion of black patients, black patients had a 19% higher chance of death compared with nonblack patients (OR, 1.19; 95% CI, 1.01-1.40).

After adjusting for the differences in hospital quality, the effect of race on mortality was no longer statistically significant (OR, 1.07; 95% CI, 0.93-1.25). We estimate

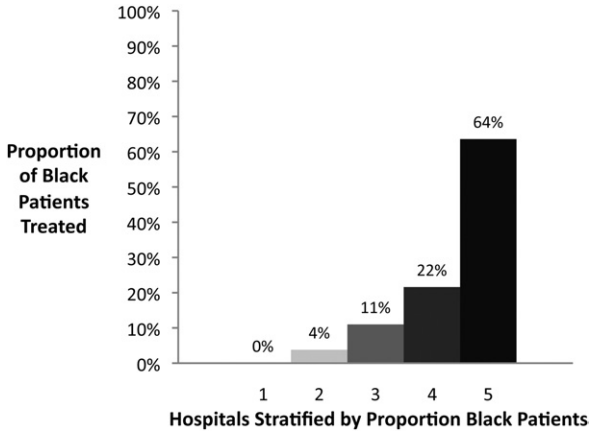

Fig 1. Hospitals stratified by the proportion of black patients treated (2001-2006).

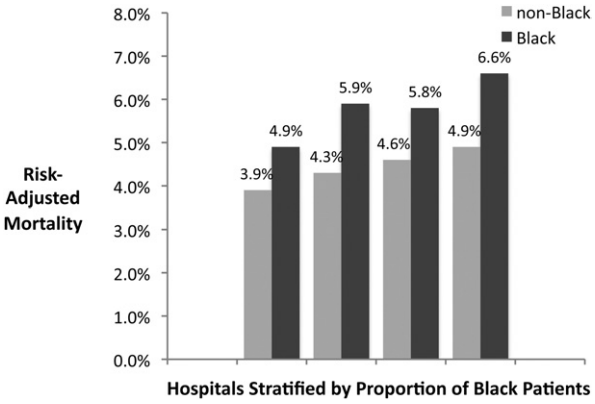

Fig 2. Risk-adjusted 30-day mortality among nonblack and black patients in hospitals stratified by the proportion of black patients (2001-2006).

that 25% of the observed black/nonblack disparity in mortality is due to black patients receiving care in hospitals with higher mortality (Table II).

DISCUSSION

Black patients have a significantly higher mortality rate after repair of an AAA. These racial disparities can be partially explained by differences in comorbidities, the use of endovascular techniques, and socioeconomic status. However, racial differences in mortality are also driven by decreased access to low-mortality, high-quality hospitals. Differences in access to care can explain 25% of the observed disparities between black and nonblack patients.

Previous studies have addressed minority access to high-quality surgical care. Lucas et al[8] demonstrated that black patients requiring high-risk surgical care, including AAA repairs, sought care in hospitals with higher mortality, independent of hospital volume. Black patients are also more likely to receive care in a relatively small number of lower-quality centers, are less likely to be treated by board-

certified physicians or specialists, and have impaired access to medical technology.[9] Similarly, Birkmeyer et al[11] demonstrated that surgeon volume may account for as much as 57% of the differences in mortality after AAA repairs between low- and high-volume hospitals.

These findings suggest that the racial disparities in AAA postoperative mortality may be driven by suboptimal health care delivery in under-performing systems of care. These systems of care may include differences in hospital infrastructure, processes of care, use of endovascular technology, surgeon volume, and nursing/patient ratios. Our study adds to this body of work by exploring the relative contributions of different factors to this disparity in outcome. Our analysis demonstrates that 29% of the disparity in mortality is due to differences in comorbidities, 26% to differences in socioeconomic status, and 25% is explained by black patients receiving care in worse hospitals.

There are two potential methods for addressing this disparity in access to high-quality hospitals. First, selective referral of patients with AAA to centers of excellence could potentially improve outcomes for black patients; however, these benefits must be weighed against the potential barriers to black patients. Selective referral may not be a feasible option due to geography and socioeconomics. Selective referral could potentially exacerbate these disparities should black patients have decreased access to these higher-quality facilities.

Second, quality improvement initiatives targeting low-quality centers, such as disseminating best practices in vascular surgery, may improve racial/ethnic disparities in postoperative mortality. Because most black patients receive care in a relatively small number of hospitals,[17] targeting these hospitals for quality improvement may be the most efficient method of improving the care of black patients.

Although the disparity in mortality can be partially explained by differences in access to high-quality hospitals, black patients may also receive worse care within the same hospitals. This study demonstrated a trend toward worse outcomes among black patients treated in the same hospitals as nonblack patients, raising the concern that patients may be treated differently within hospitals.

Still unexplained are 14% of the differences in mortality between black and nonblack patients. This residual variation in mortality could be due to unmeasured factors, including differences in the care of black patients within hospitals. These differences could be due to unmeasured differences in patient comorbidities and biology or severity of the AAA. Although we have controlled for differences in measured comorbidities, no data are available to account for differences in anatomy or severity of disease. Medicare claims data do not include any information on radiographic characteristics of aneurysms or suprarenal or pararenal clamping. Unfortunately, there is no potential data source available that would meet these requirements. Because we have no data to suggest that black patients present with more suprarenal aneurysms, this confounding would simply bias the overall results toward the null hypothesis.

These differences could also be due to differential treatment of black and nonblack patients within hospitals. Remarkably, black patients were profoundly less likely to receive an endovascular repair in this analysis, which has been shown elsewhere.[18] However, this difference in the utilization of endovascular repairs only accounted for 6% of the observed mortality differences between black and nonblack patients. Other unmeasured differences in the care of black patients may be moderating this disparity. Qualitative methods of research, such as surveys, focus groups, and mixed-methods, may further elucidate the mechanisms of these disparities. Using focus groups, researchers have shown that black patients have misconceptions about cancer care and mistrust of the health care system that may contribute to worse outcomes after cancer diagnosis.[19] Similar methods may be instrumental in understanding and addressing disparities in the diagnosis and treatment of abdominal aneurysms.

This study has several important limitations. This analysis relies on Medicare claims data, which provides adequate power to explore the relationship between patient race, mortality, and the hospital, but only accounts for patients with end-stage renal disease or those aged >65 years. This age range, however, represents most patients undergoing an AAA repair, accounting for 70% of all AAA repairs.[10]

The Medicare database also provides limited clinical detail about patient comorbidities and other prognostic factors. We were able to control for several patient-level factors, including age, gender, race, comorbidities, and acuity of surgery (urgent or emergency). More robust clinical data would improve risk-adjustment and may improve the explanatory power of patient-level factors. Although several large prospective databases with robust clinical data are being collected, including the National Surgical Quality Improvement Program, none have adequate sample size for the present analyses.

An additional limitation of the analysis is the lack of patient-level socioeconomic data. Our analysis relies on the patient ZIP-code level data to estimate the effect of socioeconomic status. However, this is acceptable because the use of ZIP-code level analyses provides important insight into the effect of neighborhoods on the acquisition of health care.

One final limitation is our reliance on perioperative death as the outcome measure. Other factors, such as the reintervention rate, are important components of quality of care but are not available in the Medicare Part A database. Despite this limitation, it seems conclusive that black patients have a worse mortality rate after AAA repair.

CONCLUSION

Black patients are more likely to die after an AAA repair. These differences can be partially explained by differences in comorbidities, differences in the rate of endovascular repair, and the socioeconomic status of the neighborhood. However, this analysis indicates that racial disparities in the outcomes of AAA repair are also driven by decreased access

to high-quality hospitals with a low mortality rate. The two implications of this study are that efforts aimed at improving these disparities could target improving the existing hospitals in which black patients receive their care, and that further efforts would be necessary to improve the referral of black patients to higher-quality hospitals.

AUTHOR CONTRIBUTIONS

Conception and design: NO, JD
Analysis and interpretation: NO, GU, JD
Data collection: NO, JD
Writing the article: NO, GU, AM, JD
Critical revision of the article: NO, GU, AM, JD
Final approval of the article: NO, GU, AM, JD
Statistical analysis: NO, JD
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Overall responsibility: NO

REFERENCES

1. Smedley BD, Stith AY, Nelson AR, Institute of Medicine (U.S.). Committee on Understanding and Eliminating Racial and Ethnic Disparities in Health Care. Unequal treatment: confronting racial and ethnic disparities in health care. Washington, DC: National Academy Press; 2003.
2. Feinglass J, Abadin S, Thompson J, Pearce WH. A census-based analysis of racial disparities in lower extremity amputation rates in Northern Illinois, 1987-2004. J Vasc Surg 2008;47:1001-7; discussion 1007.
3. Feinglass J, Pearce WH, Martin GJ, Gibbs J, Cowper D, Sorensen M, et al. Postoperative and amputation-free survival outcomes after femorodistal bypass grafting surgery: findings from the Department of Veterans Affairs National Surgical Quality Improvement Program. J Vasc Surg 2001;34:283-90.
4. Huber TS, Wang JG, Wheeler KG, Cuddeback JK, Dame DA, Ozaki CK, et al. Impact of race on the treatment for peripheral arterial occlusive disease. J Vasc Surg 1999;30:417-25.
5. Rucker-Whitaker C, Feinglass J, Pearce WH. Explaining racial variation in lower extremity amputation: a 5-year retrospective claims data and medical record review at an urban teaching hospital. Arch Surg 2003;138:1347-51.
6. Stansbury JP, Jia H, Williams LS, Vogel WB, Duncan PW. Ethnic disparities in stroke: epidemiology, acute care, and postacute outcomes. Stroke 2005;36:374-86.
7. Tunis SR, Bass EB, Klag MJ, Steinberg EP. Variation in utilization of procedures for treatment of peripheral arterial disease. A look at patient characteristics. Arch Intern Med 1993;153:991-8.
8. Lucas FL, Stukel TA, Morris AM, Siewers AE, Birkmeyer JD. Race and surgical mortality in the United States. Ann Surg 2006;243:281-6.
9. Bach PB, Pham HH, Schrag D, Tate RC, Hargraves JL. Primary care physicians who treat blacks and whites. N Engl J Med 2004;351:575-84.
10. Birkmeyer JD, Siewers AE, Finlayson EV, Stukel TA, Lucas FL, Batista I, et al. Hospital volume and surgical mortality in the United States. N Engl J Med 2002;346:1128-37.
11. Birkmeyer JD, Stukel TA, Siewers AE, Goodney PP, Wennberg DE, Lucas FL. Surgeon volume and operative mortality in the United States. N Engl J Med 2003;349:2117-27.
12. Elixhauser A, Steiner C, Harris DR, Coffey RM. Comorbidity measures for use with administrative data. Med Care 1998;36:8-27.
13. Li B, Evans D, Faris P, Dean S, Quan H. Risk adjustment performance of Charlson and Elixhauser comorbidities in ICD-9 and ICD-10 administrative databases. BMC Health Serv Res 2008;8:12.
14. Birkmeyer NJ, Gu N, Baser O, Morris AM, Birkmeyer JD. Socioeconomic status and surgical mortality in the elderly. Med Care 2008;46:893-9.
15. Localio AR, Berlin JA, Ten Have TR, Kimmel SE. Adjustments for center in multicenter studies: an overview. Ann Intern Med 2001;135:112-23.
16. Finlayson EV, Goodney PP, Birkmeyer JD. Hospital volume and operative mortality in cancer surgery: a national study. Arch Surg 2003;138:721-5; discussion 726.
17. Jha AK, Orav EJ, Li Z, Epstein AM. Concentration and quality of hospitals that care for elderly black patients. Arch Intern Med 2007;167:1177-82.
18. Dimick JB, Upchurch GR Jr. Endovascular technology, hospital volume, and mortality with abdominal aortic aneurysm surgery. J Vasc Surg 2008;47:1150-4.
19. Shankar S, Selvin E, Alberg AJ. Perceptions of cancer in an African-American community: a focus group report. Ethn Dis 2002;12:276-83.

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