Original Investigation

Influence of Race on the Management of Lower Extremity Ischemia
Revascularization vs Amputation

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IMPORTANCE Among patients presenting with critical lower extremity ischemia, it has been previously documented that white individuals are more likely to undergo revascularization than nonwhite individuals, with the disparity largely attributed to differences in resources and access to care.

OBJECTIVE To investigate the amputation disparity between white and nonwhite patients with critical lower extremity ischemia in more detail using a larger data set than previous studies, with a focus on the role of confounding factors such as access and hospital resources.

DESIGN, SETTING, AND PATIENTS All hospital discharge records from the Nationwide Inpatient Sample of adult patients with the primary diagnosis of critical lower extremity ischemia from 2002-2008 were examined in detail using multiple logistic regression (n = 774 399).

MAIN OUTCOMES AND MEASURES Rates of amputation and revascularization for peripheral vascular disease across race/ethnicity.

RESULTS Controlling for confounding factors, black patients were found to have 1.77 times the odds of receiving an amputation compared with white patients (95% CI, 1.72-1.84; $P < .001$). Further analysis revealed the black to white odds ratio paradoxically increased with increasing revascularization capacity of the presenting hospital, from a low of 1.43 (95% CI, 1.23-1.65) to a high of 1.98 (95% CI, 1.83-2.24). The amputation disparity also paradoxically increased for patients living in wealthier zip codes.

CONCLUSIONS AND RELEVANCE Black patients have greater odds of undergoing amputation than white patients, even after correcting for an array of confounding parameters. Contrary to current beliefs that the disparity is mainly secondary to differences in access, this study found that the disparity was magnified in settings where resources were greatest. Whether the explanation lies primarily in patient-specific, physician-specific, or institutional-specific factors remains to be determined but is critical to better understanding our health care system and maintaining approaches that are consistently fair and equitable.

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Ethnic/racial disparities in health care are well described, existing across the full spectrum of medical and surgical conditions.[1-5] One compelling example of this disparity can be found in institution-based or population-based studies of lower extremity amputation. For patients presenting with critical lower limb ischemia, the primary treatment options are revascularization or amputation. It is well documented that white patients are more likely to undergo an attempt at limb salvage by revascularization, while nonwhite patients are more likely to undergo amputations.[2,6-11] Major lower extremity amputation (above or below the knee) is widely viewed by patients as highly undesirable, resulting in lifelong disability, often accompanied by significant emotional burden.[12,13] Possible explanations for this disparity can be broadly categorized into institutional-level, patient-level, and health care provider–level factors. As with many other ethnic/racial health care disparities, the differences in amputation rates between white and nonwhite patients have been largely attributed to differences in access to care leading to differences in the severity of disease at the time of presentation.

The purpose of this study, using a large data set, was to investigate factors that might contribute to this racial disparity. In addition to assessing the independent influence of race, we focused on several questions: (1) Are there significant differences, characterized by the capacity to perform advanced vascular procedures, in the type of hospital at which white and nonwhite patients with lower extremity ischemia receive care? (2) Do differences in hospital capacity have an independent impact on the racial disparity in treatment? (3) Do local resources (as assessed by the wealth of the zip codes in which the patients resided) have an independent impact on the racial disparity in treatment?

Methods

Classification of Race

While the concept of biological race has been disproven,[14-16] this study acknowledges the social construct of race and categorizes patients based on their assignment by the data source. Categories used by the data source included white, black, and Hispanic.

Data Source

Data were obtained from the Nationwide Inpatient Sample (NIS) from 2002-2008 (inclusive). The NIS is the largest all-payer inpatient care database available in the United States, containing data on 100% of hospital discharges from more than 1 000 participating hospitals. Overall, the data represent approximately 20% of total nonfederal hospital discharges in the United States, stratified by geographic region, hospital size, urban or rural location, teaching status, and ownership status.[17]

Analysis

All analyses were performed using SAS version 9.2 (SAS Institute). All hospital discharge records meeting the following inclusion criteria were retrieved from the data source and analyzed: (1) patient admitted with primary *International Classification of Diseases, Ninth Revision, Clinical Modification* (*ICD-9-CM*) code indicating either peripheral vascular disease (443.9), atherosclerosis of native arteries of the extremities (440.20-24), or atherosclerosis of bypass graft of extremities (440.30-32); (2) patient received surgical treatment of either lower extremity amputation (*ICD-9-CM* procedure codes 84.1, 84.10, and 84.15-19) or lower extremity revascularization (*ICD-9-CM* codes 39.25 and 29.29) during hospital admission; and (3) patient's race/ethnicity recorded as either white, black, or Hispanic. Patients receiving both amputation and revascularization at index admission were excluded, as were those whose procedure involved revision of a previous amputation. Those with no race/ethnicity specified on record and those specified as Asian, Native American, or other were also excluded from the study.

Records meeting the inclusion criteria were subsequently grouped according to race. All statistical calculations were adjusted according to probability weights to reflect survey sampling characteristics. Probability weights were provided for each NIS record, allowing national estimates reflecting all nonfederal hospitals in the United States to be extrapolated from the stratified random sample of hospitals. Using the χ^2 statistic, univariate analysis was performed to compare factors such as severity of ischemia at the time of presentation, insurance status, comorbidities, and socioeconomic status among the patient groups. The mean income for the patients' zip code of residence was used as a proxy for socioeconomic status. Frequency of amputation was compared in an identical manner. The difference in the mean age among the groups was assessed using the *t* test.

A variable depicting each hospital's revascularization capacity was calculated by determining the number of patients who presented to the particular hospital with critical lower leg ischemia between 2002 and 2008 and dividing into this value the number who received a revascularization procedure between 2002 and 2008. These values were then merged with the patient discharge records, allowing each discharge record to have an indicator of the given hospital's relative capacity to perform revascularization.

Multiple logistic regression of all significant variables was then performed, allowing the independent contribution of each variable on surgical treatment to be ascertained. Further analysis using multiple logistic regression on subgroups of data (eg, subgrouped based on type of hospital at which the patients were treated) was also carried out to further characterize any racial disparity and look for particular trends among the variables.

Results

In all, 774 399 records were obtained describing patients who presented with the primary diagnosis of critical lower extremity ischemia from 2002-2008 (inclusive). Of these, 350 992 underwent either amputation (37.5%) or revascularization (62.5%).

There were 5 major findings. First, differences existed among ethnic groups in patient characteristics at the time of presentation. **Table 1** summarizes the characteristics of each patient group presenting with lower leg ischemia. In terms of comorbidities, black and Hispanic patients were more likely to have diabetes mellitus ($P < .001$) and chronic renal failure

Table 1. Characteristics of Patient Populations Presenting With Lower Leg Ischemia Treated With Amputation or Revascularization

Characteristic	Group, %		
	White	Black[a]	Hispanic[a]
Average age, y	71.9	70.2[b]	69.9[b]
Female	43.3	52.8[b]	43.6
Comorbidities			
Diabetes mellitus	42.6	50.7[b]	66.0[b]
Hypertension	53.0	52.1[b]	47.4[b]
CRF	5.6	9.9[b]	11.9[b]
CHD	45.5	33.7[b]	42.8[c]
COPD	25.2	13.9[b]	13.7[b]
Presentation			
Gangrene	41.1	59.2[b]	55.4[b]
Ulceration	18.3	9.8[b]	13.6[b]
Rest pain	15.9	11.2[b]	10.4[b]
Prior revascularization on same extremity	5.0	3.3[b]	3.2[b]
Insurance type			
Medicare	77.7	76.6[b]	72.8[d]
Medicaid	4.0	9.0[b]	12.4[b]
Private	16.0	11.4[b]	11.3[b]
Income by zip code			
<37 000	24.7	55.1[b]	52.0[b]
37 000-45 999	27.3	21.4[b]	20.9[b]
46 000-60 999	25.7	14.5[b]	17.2[b]
>61 000	22.4	9.1[b]	10.0[b]
Hospital type			
Teaching	48.9	58.7[b]	41.6[b]
Nonteaching	51.1	41.3[b]	58.4[b]
Surgical decision, % receiving amputation	34.5	56.4[b]	48.2[b]

Abbreviations: CHD, chronic heart disease; COPD, chronic obstructive pulmonary disease; CRF, chronic renal failure.

[a] Statistical tests were performed in comparison to the white cohort.

[b] $P < .001$.

[c] $P < .01$.

[d] $P < .05$.

($P < .001$), while white patients were more likely to have hypertension ($P < .001$), congestive heart failure ($P < .001$), and chronic obstructive pulmonary disease ($P < .001$). In terms of the severity of arterial compromise at presentation, black and Hispanic patients were more likely to present with gangrene ($P < .001$), while white patients were more likely to present with ulcers ($P < .001$) or rest pain ($P < .001$). White patients were also more likely to have private health insurance ($P < .001$), while black and Hispanic patients were more likely to be insured under Medicaid ($P < .001$). Black and Hispanic patients were also more likely to reside in zip codes where the mean income fell below the 25th percentile ($P < .001$).

Second, black and Hispanic patients presenting with critical lower extremity ischemia were significantly more likely to undergo an amputation as opposed to revascularization in comparison with white patients ($P < .001$). Black patients were also significantly more likely to undergo an amputation in comparison with Hispanic individuals ($P < .001$). More black patients (56.4%) underwent an amputation compared with Hispanic (48.2%) and white (34.5%) patients.

Third, race independently influenced the treatment decision more than insurance or socioeconomic status. Multiple logistic regression analysis on all statistically significant variables, denoted in Table 1, was performed, allowing the determination of the independent contribution of each on the surgical decision (amputation vs revascularization) (**Table 2**). This analysis revealed that being black alone, independent of all other variables, increased the odds of receiving an amputation by 78% (odds ratio [OR], 1.78; 95% CI, 1.72-1.84). The only variables with more independent influence on the decision to amputate were an initial presentation of gangrene (OR, 11.22; 95% CI, 10.89-11.56) and a prior attempt at revascularization (OR, 2.63; 95% CI, 2.47-2.81). Medicaid or Medicare insurance, chronic renal failure, and diabetes mellitus were also found to increase the odds of undergoing an amputation, but all to a lesser degree than being black. Being white; having private insurance; living in the wealthiest zip codes; having chronic obstructive pulmonary disease, chronic heart disease, or hypertension; and being cared for at a teaching hospital all independently increased the odds of revascularization.

Fourth, racial disparity between black and white patients was highest within hospitals with the greatest capacity to perform revascularization. Because access is not fully described by insurance status, we also investigated the influence on racial disparity of a hospital's capacity to perform revascularizations. We found that 38.8% of the hospitals in the study did not perform a single revascularization procedure between 2002 and 2008. For the purposes of this analysis, these hospitals were designated as not having the capacity to perform revascularization. The remaining 61.2% of hospitals were divided into

Table 2. Independent Influence of Variables on Surgical Decision For Amputation vs Revascularization[a]

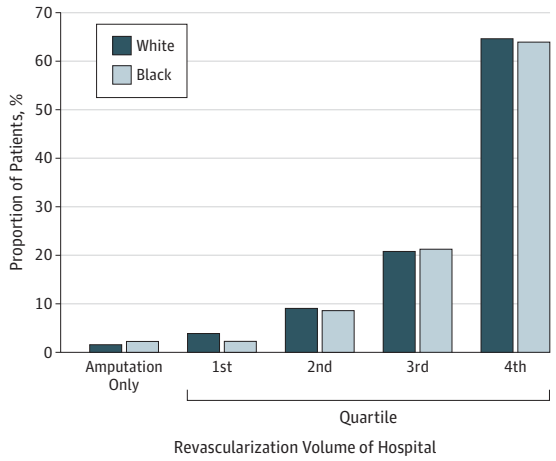
Variable	Odds Ratio (95% CI)[b]
Gangrene	11.22 (10.89-11.56)
Redo of previous revascularization	2.63 (2.47-2.81)
Black	1.77 (1.72-1.84)
Medicaid	1.73 (1.62-1.85)
Residence in poorest 25% of zip codes	1.63 (1.56-1.70)
Medicare	1.62 (1.55-1.69)
Chronic renal failure	1.27 (1.21-1.33)
Hispanic	1.09 (1.03-1.15)
Diabetes mellitus	1.07 (1.04-1.10)
Female	1.04 (1.01-1.07)
Teaching hospital	0.93 (0.90-0.96)
COPD	0.89 (0.86-0.93)
CHD	0.83 (0.81-0.93)
Hypertension	0.72 (0.70-0.74)

Abbreviations: CHD, chronic heart disease; COPD, chronic obstructive pulmonary disease.

[a] Obtained from multiple logistic regression analysis.

[b] Odds ratio indicates the odds of amputation vs revascularization in patients with the specified variable present, independent of confounding variables.

Figure 1. Proportion of Patients With Critical Lower Extremity Ischemia Presenting to Hospitals of Different Revascularization Capacities



No statistical differences existed between hospital types to which black and white patients presented. Categories on the x-axis reflect the capacity of the hospital for performing lower extremity revascularization. Amputation-only hospitals did not perform a revascularization procedure during the study period. Hospitals in quartiles 1-4 performed an increasing volume of revascularizations.

quartiles based on volume of revascularizations performed. There were no statistically significant differences between the percentages of black and white patients presenting to the hospitals in any of the revascularization categories (**Figure 1**). Very few patients with critical lower extremity ischemia were treated at hospitals with no capacity to perform revascularization (1.6% of white and 2.3% of black patients). Most patients from both groups presented to hospitals with the highest capacity (64.6% of white and 63.9% of black patients). Investigating all patients treated at each quartile separately, the odds of receiving a revascularization procedure, independent of all other variables, were greatest at hospitals with a high capacity to perform revascularization (**Figure 2**). However, while both black and white patients at these hospitals were more likely to undergo revascularization, this option occurred disproportionately among white patients, resulting in a higher black to white OR for amputation in the hospitals with the greatest capacity to perform revascularizations (Figure 2).

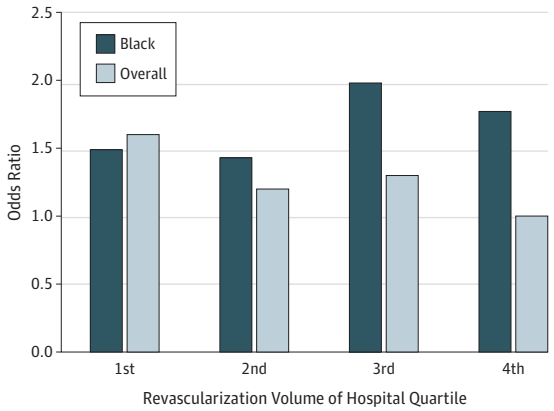
And finally, racial disparity was greatest among those living in wealthier zip codes (**Figure 3**). The overall odds of being treated with a revascularization procedure, independent of other variables, increased as the mean income of the patient's residing zip code increased. However, this increase was noted more among white than black patients, resulting in an increased disparity between black and white individuals in the higher wealth zip codes. The black to white OR of amputation was 2.04 among those living in the poorest quartile of zip codes (95% CI, 1.95-2.14); the OR increased to 2.45 (95% CI, 2.27-2.65) among black compared with white individuals in the wealthiest quartile of zip codes.

Comment

In this study of patients presenting with advanced limb ischemia, race itself was found to be a significant factor in the surgical treatment a patient received; this was independent of other variables such as severity of presentation, insurance status, socioeconomic status, multiple comorbidities, and the capacity of the hospital to perform revascularization. After correcting for these and other variables, black patients were still found to have significantly greater odds for undergoing an amputation compared with white patients. In contrast, most white patients underwent an attempt at limb salvage by surgical revascularization.

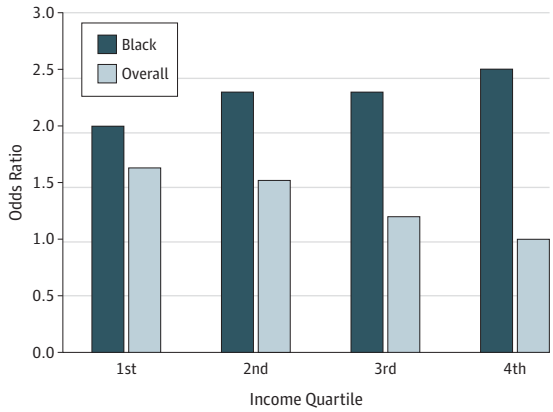
While previous studies have documented a racial disparity in patients receiving amputations, the explanation for this disparity remains incompletely understood. Many studies have attributed this disparity to differences in access.[2,6,7,9,18-26] Some have focused on a hospital-based explanation, with black patients less likely than white patients to undergo an attempt at revascularization prior to amputation.[27] Other studies have suggested that the disparity correlates with socioeconomic status in addition to hospital-specific factors,[28] while others have suggested that this disparity persists across all hospital types.[29] Using a large national database, we hoped to further define this disparity, focusing specifically on the influence of race and attempting to further characterize the nature and role of access. In our study, the black-white disparity existed after correcting for patients' insurance status and the severity of ischemia at the time of presentation. One access-related explanation might be that black patients are more likely to be treated at lower volume facilities with less capacity to perform advanced arterial procedures. By generating a metric to describe each hospital's relative revascularization capacity, we found no statistically significant difference between black and white patients in terms of hospitals with differing revascularization volumes or capaci-

Figure 2. Amputation Odds Ratio vs Revascularization Capacity of Hospitals



The x-axis indicates the capacity of a hospital to perform revascularization. The y-axis indicates the odds ratio of receiving amputation to receiving revascularization. Overall odds for receiving an amputation decreases when presenting to hospitals with greater revascularization capacity. However, the disparity between black and white patients was higher at hospitals with the greatest revascularization capacity, as reflected by the black to white odds ratio for amputation. All odds ratios were calculated using multiple logistic regression, correcting for confounding variables.

Figure 3. Amputation Odds Ratio vs Wealth of Residing Zip Code



The x-axis indicates the mean income of patients' residing zip code, divided into quartiles. The y-axis indicates the odds ratio of receiving amputation to receiving revascularization. Overall odds for receiving an amputation were lower for patients residing in wealthier zip codes. However, the disparity between black and white patients increased as the wealth of zip code increased, as reflected by the black to white odds ratio for amputation. All odds ratios were calculated using multiple logistic regression, correcting for confounding variables.

ties. In fact, we found that while all patients were more likely to undergo a revascularization at those hospitals with a greater revascularization capacity, this was disproportionally true for white patients, independent of all other variables. The greatest disparity in amputations between black and white patients was found at the hospitals with the highest revascularization volumes (and, presumably, the greatest capacity and expertise). These findings suggest that (1) the well-documented racial disparities in the treatment of lower extremity ischemia cannot be explained solely on the basis of differences in access to care, and (2) other factors that contribute to the racial disparity, not corrected for and listed in Table 2, are magnified in situations where revascularization procedures are most readily available.

A similar trend was found when subgrouping patients based on the mean income in the zip codes in which they resided. As the wealth of the zip code increased, there was an increase in the likelihood of receiving a revascularization procedure for all patients residing in that zip code. However, this likelihood disproportionally affected white patients, leading to an increase in the racial disparity.

Explanations generally invoked to explain racial disparities in health care can be divided into 3 categories: (1) institutional factors, such as financing and access; (2) patient-level factors, such as noncompliance, reluctance to seek care, and biological differences; and (3) provider-level factors, such as prior experience and expertise, as well as stereotyping and biases, both conscious and subconscious.[30-32] The predominant institutional factors, insurance status and access to adequate facilities in the vicinity, were accounted for in our regression model. A combination of patient-level and provider-level factors may affect the course of a patient's treatment prior to presentation at the hospital (eg, a patient delaying treatment or a physician delaying screening); however, because the degree of ischemia at the time of presentation was accounted for in our regression model, treatment differences prior to hospitalization became irrelevant in this study. Therefore, the results of the multiple regression analysis suggest that race-specific factors that exist following hospital admission may play a significant role in the treatment and outcomes of patients presenting with critical lower extremity ischemia.

The role of unintentional or unconscious bias in medical decision making has been well described[32-34] and cannot be ruled out as contributing to the disparity. Stereotyping in general has been recognized as a widely used mechanism to aid in the processing of the vast amounts of information encountered daily.[35,36] It is possible that the limited timeline in which surgical decisions must often be made may further increase the influence of stereotyping and unconscious bias.

Biological differences between groups may contribute to the disparity in vascular disease; however, given that race is a socially defined category and more genetic variability has been found to occur among races than between them,[37-39] this explanation may be overused. Historically, theories placing predominant emphasis on biological differences among races to explain health care disparities have not stood up to well-designed scientific studies.[40] Furthermore, while biological differences may impact an individual's predisposition and course of disease, this impact would be reflected by their severity at the time of presentation, a parameter accounted for in our regression model.

Limitations of this retrospective study included the possibility that confounding factors outside those used in our regression model played a role. For instance, while the data available from the NIS allowed the severity of presentation to be accounted for, a greater degree of detail regarding presentation may have revealed more subtle differences among racial groups. In addition, while NIS variables allowed us to distinguish secondary vs primary amputation, it provided little information in regard to distinguishing primary from repeat am-

putation; we were only able to exclude patients whose procedure involved revision of a previous amputation. These and other cofounding variables could potentially be addressed with prospective studies; however, this would be at the expense of the statistical power afforded by the retrospective analysis of a large database such as that used in the current study.

The amputation rate of Hispanic patients in this study was found to be intermediate, higher than white patients but lower than black patients. It should be noted that the term Hispanic encompasses people of vastly different cultures and backgrounds, ranging from white individuals of European descent (Spain) to Puerto Ricans of African descent. Limitations in the data's specificity precluded analysis of these subgroups. Differences exist among these groups in skin color, socioeconomic status, residential segregation, geographic location, and other factors.[41-44] Further study using more detailed ethnicity data on Hispanic patients could prove useful.

While the large numbers available in the national database used in this study provide statistical power, dissecting out the variable factors that underlie the differences in presentation, intervention, and outcome is a significant challenge, and one must be cautious in applying firm conclusions. Despite this limitation, it does appear that race alone is a significant factor that influences the treatment received by patients presenting with lower limb ischemia. Whether the explanation lies primarily in patient-specific, physician-specific, or institutional-specific factors remains to be determined. However, it is a determination that is critical to better understanding our health care system and maintaining approaches that are consistently fair and equitable.

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Invited Commentary

Why Do Nonwhite Patients Undergo Amputation More Commonly Than White Patients?

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There is a compelling amount of data showing that amputation and revascularization rates between white and nonwhite patients are different. What accounts for this? The current analysis suggests that access to care, socioeconomic status, and clinical category of disease at presentation do not account for such differences.[1] In their discussion, the authors suggest 3 general factors to consider: (1) differing access to care, (2) patient factors such as noncompliance, and (3) physician factors including bias and prejudice; however, they ultimately cite reasonably good arguments against most. Nowhere do they claim that health care provider bias is the reason, but this seems to be the only factor that cannot be excluded.

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There is a fourth possible explanation, especially as the others do not seem to be causative: genetic differences in the behavior of peripheral vascular disease between groups. While the authors pointed out that dividing people into separate categories (race) is a social construct, there are clearly biological differences between any 2 broadly defined groups (eg, resistance to malaria, response to alcohol, behavior of breast cancer, and response to certain drugs, in addition to the amount of melanin in the skin). What if there were differences in the behavior, composition, or anatomic patterns of atherosclerosis itself? In other words, 2 people may have the same access to care, socioeconomic status, and compliance, but (even within the same clinical class at presentation) one has disease that is more often amenable to bypass when symptomatic, while the other has a greater chance of presenting with anatomically nonreconstructable occlusion—all because of genetic factors.

It is politically dangerous to raise the issue of consistent biologic variability between groups, but such variability unequivocally exists for certain genetically determined entities. If we ignore this issue, we run the risk of doing just what we are trying to avoid—giving one group of patients inferior care because we have not recognized the true cause of the problem. Durazzo and colleagues[1] have shown that it is not access to care or economic factors that account for the (real) differences in amputation rates—thus, we are left with either health care provider bias or genetic differences in the disease process itself. It may be the former, but we must investigate the latter to provide the best possible care for all our patients.

ARTICLE INFORMATION

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