Peripheral Bypass Surgery and Amputation

Northern Illinois Demographics, 1993 to 1997

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Hypothesis: This study tests whether age, sex, income, and racial differences predict rates of aortoiliac and femorodistal bypass surgery and above- and below-knee amputation for residents of northern Illinois from 1993 to 1997.

Design: A hospital discharge survey study describing standardized procedure rates and the odds of undergoing amputation vs bypass procedures for specified sociodemographic populations. Multiple logistic regression was used to compare the odds of undergoing major amputation vs bypass surgery controlling for the prevalence of diabetes, gangrene, high-risk comorbid conditions, and treatment at major area teaching hospitals.

Results: Between 1993 and 1997, 19,250 study procedures were performed during 18,603 admissions at 105 Illinois hospitals. The mean annual major amputation rate per 100,000 was 20.77; femorodistal and aortoiliac bypass rates were 24.26 and 4.70, respectively. Significantly higher odds (between 1.14 and 1.36) of undergoing amputation were found for low-income areas and ZIP codes with large and medium African American populations. Severe comorbidity, diabetes, and especially gangrene (odds ratio, 12.9) predicted amputation, while treatment at a major teaching hospital and male sex predicted a higher odds of undergoing bypass procedures.

Conclusions: Results are consistent with unmeasured racial and income differences in the severity of atherosclerosis (or related risk factors such as smoking, diet, and exercise), barriers to timely primary care, or selective referral of lower-income and African American patients to hospitals with less vascular surgery capacity. These findings imply a particular need to identify and review the quality of care for patients undergoing primary lower-extremity amputations.

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Despite reductions in the prevalence of cardiovascular risk factors, such as smoking, hypertension, and ischemic heart disease, the rate of nontraumatic major lower-extremity amputation has not fallen in the United States. In part, this lack of progress is related to the steady population prevalence of diabetes. Although accounting for between 40% and 60% of all thigh, calf, and foot amputations, patients with diabetes have 20 times the relative risk of undergoing amputation as patients without diabetes. There have been a number of studies documenting the often dramatic reduction in amputation rates that can be achieved through improved access to preventive primary care and limb-preserving arterial bypass or angioplasty procedures. Thus, from a public health standpoint, recent reports documenting continuing differences in per capita rates of amputation for patients with and without diabetes by race, income, and sex raise potentially disturbing questions about health care access and effectiveness.

This study of selected lower-extremity amputation and bypass surgery procedures attempts to shed further light on the extent of sociodemographic differences in treatment. Data are presented for patients who were hospitalized for above- or below-knee amputation or for aortoiliac or femorodistal bypass procedures at Illinois hospitals from 1993 to 1997 in a 9-county area of northern Illinois (population, 7.73 million). The study was conducted to describe differences in the absolute risk of bypass surgery and amputation as a function of age, sex, and ZIP code–based income and racial characteristics; to determine differences between sociodemographic groups in the odds of undergoing amputation vs bypass procedures for the cohort of northern Illinois residents hospitalized for these procedures;
MATERIALS AND METHODS

COMPUTATION OF POPULATION-BASED PROCEDURE RATES

Data for 1993 through 1997 nonfederal hospital discharges were obtained from Illinois Hospital and Health Systems Comdata files. These files contain publicly mandated information on all hospital discharges of residents of the 9 Chicago-area counties of northern Illinois. Any of 5 International Classification of Diseases, Ninth Revision, Clinical Modification, procedure codes for each discharge was used to calculate overall rates per 100 000 area residents for 4 procedures: above-knee amputation (84.17), below-knee amputation (84.15), aortoiliac bypass (39.25), and femorodistal bypass (39.29). For primary study analyses, all procedures were counted, and the sensitivity of results was compared with sensitivity when counting only the more proximal or most severe procedure when multiple procedures occurred for the same patient within the same hospitalization. Other available data included up to 9 secondary diagnosis codes, patient age, hospital discharge status, and ZIP code. Demographic data for 323 northern Illinois ZIP codes were derived from Claritas demographics software as extrapolated from the 1990 census.18

Because access to hospitals offering lower-extremity angioplasty closely reflects bypass surgery access in Illinois, angioplasty procedures were not included in this analysis. This avoids controversy about the role of lower-extremity angioplasty as a primary treatment for limb salvage and associated difficulties in distinguishing International Classification of Diseases, Ninth Revision, Clinical Modification, codes for angioplasty vs other vessel repairs for dialysis access.19 To confine the analysis to patients whose primary treatment reflects lower-extremity vascular disease, hospital discharges of patients treated for trauma, lower-extremity neoplasms, coronary artery surgery, or abdominal aortic aneurysm repair and patients younger than 25 years were excluded from the analysis. The resulting patient population thus includes a small number of individuals with diabetic neuropathy or infection but intact arterial circulation, a small group of patients undergoing bypass surgery procedures for disabling intermittent claudication, and a much larger group of patients with diffuse and usually multilevel arterial stenoses related to ischemic rest pain, gangrene, and ulceration.

Annual procedure rates per 100 000 population were calculated for each procedure. Four age groups were used to directly standardize 1993 through 1997 rates for each procedure to the 1995 northern Illinois population. The crude rate is presented for patients 65 years or older. Separate age-adjusted procedure rates were then calculated for 7 study populations: men and women; residents of ZIP codes with small (<10%; 1995 population, 4.93 million), medium (10%-49%; 1995 population, 1.62 million), and large (>50%; 1995 population, 1.18 million) proportions of African American population; and residents in ZIP codes with low to median household income (<$30 000; 1995 population, 1.56 million). Approximately 63% of low-income areas had a large African American population.

ANALYSIS OF POPULATION DIFFERENCES AMONG HOSPITALIZED PATIENTS

To further analyze the use of limb-preserving surgery for each study population, differences in procedure rates were calculated for the 1993 through 1997 cohort of northern Illinois patients hospitalized for major amputation or bypass procedures. These differences might simply reflect underlying differences in severity of vascular disease or the presence of high-risk comorbid conditions that might

and to estimate adjusted odds of undergoing major amputation vs bypass surgery for each study population after controlling for the prevalence of diabetes, gangrene, high-risk comorbid conditions, and treatment at major Chicago-area teaching hospitals using multiple logistic regression. Results provide insight into the continuing challenge of reducing amputation rates for vulnerable, high-risk patient populations.

RESULTS

POPULATION DIFFERENCES IN THE ABSOLUTE RISK OF LOWER-EXTREMITY PROCEDURES

From 1993 through 1997, there were 18 603 admissions of northern Illinois residents involving study procedures at 105 nonfederal Illinois hospitals. There were 19 230 study procedures, with 647 admissions involving more than 1 study procedure during the stay. Procedures included 3716 above-knee amputations, 4323 below-knee amputations, 1819 aortoiliac bypass procedures, and 9392 femorodistal bypass procedures.

Table 1 presents the mean annual procedure rates per 100 000 residents of each of the 7 study populations. The northern Illinois mean annual combined major amputation rate per 100 000 residents was 20.77; overall femorodistal bypass and aortoiliac bypass rates were 24.26 and 4.70 per 100 000, respectively. As compared with residents in ZIP codes with small (<10%) African American populations, residents in ZIP codes with both large (>50%) and medium (10%-49%) African American populations had much higher rates of amputation (14.5, 41.3, and 27.6, respectively). The racial discrepancy in absolute risk seems to be greatest for above-knee amputation (19.81 for ZIP codes with large vs only 6.37 for those with small African American populations). ZIP codes with large and medium African American populations also had higher peripheral bypass surgery rates, which is consistent with a higher overall burden of vascular disease and diabetes for these populations. However, racial differences in bypass surgery rates were substantially smaller than racial differences in amputation rates. The femorodistal bypass rates for ZIP codes with large, medium, and small African American populations were 34.39, 26.77, and 21.39, respectively.

Results were similar when comparing the 1.5 million residents of low-income ZIP codes with other northern Illinois residents. Lower-income residents had almost double the amputation rate and approximately one third higher bypass surgery rates than the area popula-
preclude limb-preserving vascular surgery. In addition, differences in bypass surgery rates may reflect selective referral of some high-risk patients (or lower-risk patients with disabling claudication) to major teaching institutions, which would be most likely to have significant vascular surgery capacity. Several clinical and hospital variables were therefore defined as control variables for such potentially important differences in illness severity and teaching hospital referral patterns.

Diagnosis codes in hospital claims data do not have sufficient clinical detail to determine the precise indications for a procedure or often to differentiate preoperative or iatrogenic complications from severity of illness at admission. However, for this study, patients with diagnosis codes for chronic renal failure, congestive heart failure, or preexisting cerebrovascular disease were empirically classified as having high-risk comorbid conditions. Unlike patients with codes for coronary artery disease or hypertension, the selected high-risk secondary diagnosis codes were associated with a doubling of inpatient death rates for this patient population (from 5.3% overall to 10.1%; P < .001) across all procedures. Gangrene codes were used to provide one measure of peripheral vascular disease severity at the time of operation. In particular, for patients undergoing bypass procedures, a gangrene code is likely to differentiate procedures undertaken for limb-threatening ischemia as opposed to less severe disabling claudication. Any listed diabetes codes were used to determine the proportion of patients with diabetes undergoing each procedure. Finally, 5 Chicago-area hospitals (accounting for 13% of all study discharges) were designated as major teaching hospitals by virtue of their major medical school affiliations.

**STATISTICAL ANALYSIS**

Data are first presented on lower-extremity procedure rates per 100,000 northern Illinois residents, standardized to 1995 for 7 populations: men, women, patients older than 64 years, and residents of areas with low income and areas with large, medium, and small African American populations. These rates describe the variation in the absolute risk of each population of being hospitalized for a lower-extremity procedure. Next, clinical and sociodemographic variables were used to describe the comparative risks of amputation vs bypass procedures within the cohort of hospitalized patients. Differences in the proportion of patients from each study population actually undergoing any of the 4 study procedures were compared using a χ² test. Finally, multiple logistic regression was used to estimate risk-adjusted odds ratios (ORs) of undergoing a major lower-extremity amputation procedure vs a bypass surgery procedure. Odds ratios are defined as the odds that a member of a given study population (eg, an individual from a low-income ZIP code) will undergo an amputation divided by the odds that this same individual will undergo bypass surgery. Odds ratios thus reflect the increased (>1.0) or decreased (<1.0) risk that a patient of a given age, sex, and racial or income ZIP code population underwent major amputation as compared with bypass surgery.

The multiple logistic regression analysis controls (ie, adjusts risk across each study population) for the prevalence of diabetes, gangrene, severe comorbidity, and treatment in a major teaching hospital. Regression-adjusted ORs thus provide the best measure of the strength of sociodemographic effects on amputation rates, independent of these selected measures of patients’ severity of illness or referral to a teaching institution. For multiple regression, admissions rather than total procedures were analyzed; thus, a patient undergoing both a bypass and amputation procedure in the same admission was classified as an amputation.

**COMPARATIVE RISK OF AMPUTATION VS BYPASS SURGERY PROCEDURES FOR HOSPITALIZED PATIENTS**

**Table 2** presents the prevalence among specified clinical and sociodemographic patient populations undergoing each study procedure. Forty-five percent (P < .001) of all above-knee amputations but 55.7% of below-knee amputations (P = .08) were performed for male patients. Conversely, a significantly greater proportion of bypass procedures were performed for male than female patients (P < .001). Residents in areas with medium and large African American populations or low income were at significantly higher risk for amputation and had significantly fewer bypass procedures than nonpoor, largely white populations (representing almost two thirds of the total northern Illinois population but accounting for less than 50% of amputation procedures). Thus, despite a higher absolute rate of bypass procedures for minority and poor populations (Table 1), poor and African American patients hospitalized in this cohort had a greater likelihood of limb loss and especially higher odds of above-knee amputation. As expected, the largest age-related differences were for above-knee amputation, with older patients (11.5% of the area population) accounting for 81.3% of above-knee amputations. There was a nonsignificant age group difference in the odds of undergoing femorodistal bypass procedures.

Diabetes was coded most often (66.8%) for patients undergoing below-knee amputation; patients with diabetes had more than 3 times the chance of undergoing below-knee amputation as other study procedures. High (>82%) proportions of patients who underwent amputation had gangrene codes. Severe comorbidity was also associated with amputation vs bypass, as expected, and teaching hospital treatment was associated with a greater likelihood of bypass vs amputation, as expected.

**MULTIPLE LOGISTIC REGRESSION**

**Table 3** presents multiple logistic regression results for all clinical and sociodemographic variables considered jointly as predictors of major amputation vs bypass. The
The results for study populations were all significant and reveal higher odds (between 1.14 and 1.36) of undergoing amputation for patients in low-income areas and areas with large and medium African American populations (as compared with higher-income areas with small African American populations). Patients 65 years and older had a modest but significantly increased risk of amputation and, as expected, patients with severe comorbidity, diabetes, and especially gangrene (multivariate OR, 12.9) had higher odds of amputation. Treatment at a major teaching hospital and male sex were protective (predicted higher odds of undergoing a bypass procedure).

This study of 1993 through 1997 northern Illinois hospital data revealed little recent progress in reducing an-
nual age-adjusted amputation rates, which remain highest for low-income and African American populations. Significant differences in the odds of undergoing major amputation procedures as compared with lower-extremity bypass procedures were found when data were stratified by race, sex, and income characteristics, even after controlling for some underlying measures of illness severity and referral. These results are consistent with a significant body of previous research.

Population-based studies of the older Medicare population (65 years and older) have found that the overall age-adjusted rate of all lower-extremity amputation procedures, including foot and toe amputation, is more than 3 times higher for African Americans. In previous cohort studies of patients with peripheral vascular disease hospitalized for lower-extremity procedures, odds of undergoing thigh, calf, and foot amputation rather than bypass surgery or angioplasty were between 1.5 and 3.0 times greater for African American patients. Higher rates of amputation have also been found within races for lower-income Medicare patients. Sex bias may also exist in the proportion of patients undergoing bypass procedures for both disabling intermittent claudication and limb salvage. California and Maryland hospital discharge studies have found that female patients undergo fewer lower-extremity bypass procedures and have higher age-adjusted surgical mortality rates than men.

Differences in the severity of atherosclerosis and related risk factors, such as diabetes and hypertension control, smoking, exercise, and diet, may explain some or perhaps most of the sociodemographic differences described herein. However, these population differences may themselves be related to barriers to timely primary care. Nevertheless, lower-extremity revascularization procedures are associated with increasingly successful arterial patency rates, referral patterns to state-of-the-art vascular surgery facilities may represent an important access issue.

Among older Medicare patients hospitalized for peripheral vascular disease, treatment at a teaching hospital has been associated with a lower probability of amputation. However, it remains unclear to what extent this effect is a result of the availability of experienced vascular surgeons, ancillary hospital staff, and state-of-the-art facilities, or simply a result of more favorable patient selection at teaching institutions (eg, a greater proportion of bypass procedures performed for disabling intermittent claudication).

Like all previous hospital claims data studies, this study suffers from the inability to identify and link individual patients across multiple admissions. More detailed clinical data are required to determine the proportion of patients with vascular disease undergoing primary amputation or amputation without any prior revascularization procedures. It is thus unknown whether hospitals with high amputation but low revascularization rates are treating sicker patients (including patients with multiple amputations) or have insufficient vascular surgery capacity and are performing a high rate of primary amputation procedures. While the overall rate of primary amputation remains unknown, it is likely to be very high. About 60% of amputations over the last 2 decades for residents of Olmstead County, Minnesota, were primary procedures, and this occurred in an area where per capita major amputation rates are lower and bypass surgery rates are 3 times higher than the rates described above for northern Illinois residents.

Because most patients in this sample were 65 years and older and thus Medicare eligible (67.3%) and only a small number of patients who underwent either amputation (7.9%) or bypass (5.8%) had Medicaid coverage, insurance restrictions are unlikely to have been a major direct cause of relative differences in procedure rates. However, lack of timely primary care, intensive diabetes education, and foot care may be very important issues for poor and minority populations and those with low medical literacy regardless of insurance status. Recent approaches to intensive diabetes treatment reflect the possibility of reducing diabetic amputation rates by 40%, the explicit national health objective for the year 2000.

Rates of major lower-extremity amputation reflect the complex interaction between vascular disease prevalence, medical and patient self-treatment practices, and physician and patient perceptions about the appropriate timing and effectiveness of invasive limb-preserving surgical or endovascular procedures. While the vascular surgery literature reports increasingly effective patency rates for distal bypass and angioplasty, most major amputation procedures may continue to be performed as primary procedures. Efforts to reduce amputation rates for vulnerable populations should focus on reviewing access to timely medical, surgical, and rehabilitation alternatives.

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REFERENCES