Care of patients undergoing vascular surgery at safety net public hospitals is associated with higher cost but similar mortality to nonsafety net hospitals

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Objective: **This study compared in-hospital mortality and resource utilization among vascular surgical patients at safety net public hospitals (SNPHs) with those at nonsafety net public hospitals (nSNPHs).**
Methods: **The National Inpatient Sample (2003-2011) was queried to identify surgical patients with peripheral arterial disease (PAD), carotid stenosis, or nonruptured abdominal aorta aneurysm based on International Classification of Diseases, Ninth Revision, Clinical Modification diagnostic and procedure codes. The cohort was then divided into SNPH and nSNPH groups according to the definition of SNPH used by the National Association of Public Hospitals. Clinical characteristics, length of stay, in-hospital mortality, and hospital charges were compared between groups. Advanced PAD was defined as that associated with rest pain or tissue loss. Statistical methods included bivariate χ^2 tests for categoric variables, *t*-tests for continuous variables, and multivariable linear and logistic regression to adjust for confounding variables (in-hospital mortality).**
Results: **We identified 306,438 patients operated on for PAD, carotid stenosis, and abdominal aortic aneurysm. Patients at SNPHs were younger, the percentage of female and minority patients was higher, and patients had a higher Elixhauser comorbidity index ($P < .001$). Nonelective admissions were more common among SNPH patients who presented with more advanced PAD ($P > .05$) and symptomatic carotid stenosis ($P < .05$). Patients at SNPHs had a significantly longer length of stay, higher hospital charges, and higher in-hospital mortality ($P < .05$ for all variables). Crude odds of mortality at SNPHs were 1.28 higher than at nSNPHs (95% confidence interval, 1.13-1.46; $P < .001$), but adjusted analyses revealed no statistically significant difference between the odds of in-hospital mortality at both hospital groups.**
Conclusions: **Patients undergoing vascular surgery at SNPHs, despite being younger, had higher comorbidities, presented more urgently with more advanced disease, and incurred higher costs than the SNPH cohort despite similar adjusted odds of in-hospital mortality. Delayed presentation and higher comorbidities are most likely related to poor access to routine and preventive health care for the SNPH patients. (J Vasc Surg 2014;60:1627-34.)**

Access to care affects surgical outcomes.[1] In patients with peripheral arterial disease (PAD), many studies have shown a decrease in amputation rates associated with appropriate primary care evaluation and timely referral to a vascular surgeon for aggressive wound care and revascularization.[2,3] Sociodemographic factors, including age, income, race, gender, and insurance payer status adversely affect access to care and have been shown to lead to an increased rate of amputation among patients with PAD.[4] Similar observations have been made in patients with carotid stenosis[5] and abdominal aortic aneurysm (AAA).[6,7] We have demonstrated that Medicaid recipients had a 1.7-fold higher odds of presenting with a ruptured AAA than patients with private insurance.[7] Although specific causation may be difficult to delineate using large population-based studies, lack of appropriate primary care has been hypothesized to lead to delayed diagnosis and adverse outcomes.[8]

Safety net public hospitals (SNPHs) are institutions that have a higher share of sociodemographically challenged patients.[9] These hospitals are have an "open door" policy of offering services to patients regardless of their capability to pay[9] and also have a substantial payer mix of uninsured and Medicaid beneficiaries.[9] Such hospitals by "mission or by mandate" provide disproportionate care to "vulnerable patients."[9] Although the definition of a "vulnerable patient" is not clearly delineated, it includes low-income patients and Medicaid recipients.[9]

Given the association of Medicaid insurance and uninsured status on presentation and outcomes,[7] we set out to assess whether outcomes of patients undergoing vascular surgery procedures are different at SNPHs and non-SNPHs (nSNPHs). As such, we compared clinical presentation, in-hospital mortality, hospital length of stay (LOS), and overall hospital charges for patients treated for intact

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AAA, carotid stenosis, and PAD at these types of institutions.

METHODS

To compare surgical outcomes at SNPHs and nSNPHs, we evaluated the National Inpatient Sample (NIS) for 2003 to 2011. The NIS is the largest database of its kind and includes all payer discharge information from a national survey of 20% of all nonfederal hospitals in the United States. A complete overview and description of the NIS is available on its Web site.[10] The NIS was queried to identify patients undergoing open repair of intact (nonruptured) AAA, carotid endarterectomy (CEA), and lower extremity bypass (LEB) by linking the International Classification of Disease, Ninth Revision, Clinical Modification (ICD-9-CM) procedure codes[11] for all patient discharges associated with a primary diagnosis of intact AAA, carotid stenosis, and PAD. We excluded patients with ruptured AAA.

The Boston University School of Medicine Institutional Review Board approved the use of deidentified data for this study. Given that this is a deidentified database, no patient consent was obtained.

The NIS reports the median income for each patient's postal ZIP code, allowing the use of these data as a proxy for each patient's socioeconomic status. We defined SNPHs as hospitals for which >25% of the patients were derived from the lowest income ZIP codes using one of the definitions used for SNPH[9] (Fig 1). The patient cohort was then divided into patients treated at SNPHs and nSNPHs.

Primary outcomes of interest, including in-hospital mortality, and resources utilization, including hospital charges and LOS, were then compared between the two hospital types. These primary outcomes included in-hospital mortality and resources utilization, which included charges and LOS. Detailed procedure cost information is unavailable in the NIS; therefore, total hospital charges were used as a surrogate for cost information.

The NIS provides a weighting strategy to draw estimates at the national level based on a 20% annual survey of hospitals. Statistical analyses were performed based on these weighted numbers, and therefore, values provided in the Results, unless specified otherwise, are representative of the national values. This use of survey weights to make observations regarding surgical procedures at the national level is a method that has been previously described.[12,13] Data points with missing data for in-hospital mortality were removed from the analysis.

Bivariate comparisons of categoric variables were performed using χ^2 tests, and continuous variables were compared by *t*-tests. LOS and hospital charges were log-transformed for the analysis. Institutional volumes and surgeon case volumes have been shown to be an indicator of mortality in many studies for a variety of different procedures[14,15]; however, a unique surgeon identifier is not available for most NIS states, so surgeon volume was not included in this study.

To evaluate the causes of disparity of crude mortality, in addition to differences in comorbidities, we compared the hospital volume compositions of these two cohorts during each year of our study. We divided each cohort into three volume groups by the number of annual AAA operations performed at each hospital type based on the Leapfrog group recomendations[16] as low (<30 per annum), medium (30-49 per annum), and high (>50 per annum) volume category hospitals.

Multivariable logistic regression, which adjusts for confounding variables, was performed to determine whether the type of hospital was associated with a higher odds ratio (OR) of in-hospital mortality. For covariate-adjusted testing of differences in hospital cost and LOS between the two hospital types, a parametric multivariable regression was used after log-transformation of hospital cost and LOS.

Covariates included in the logistic regression for mortality included patient age, gender, insurance type, and the comorbid conditions of hypertension, diabetes mellitus, chronic lung disease, coronary artery disease, congestive heart failure (CHF), valvular heart disease, obesity, and renal failure. Many studies have shown that these variables affect mortality rates of vascular procedures and are generally agreed to be risk factors for mortality.

Statistical analyses were performed using SAS 9.3 software (SAS Institute Inc, Cary, NC). The Elixhauser comorbidity SAS macro, designed for use with administrative data sets, was used to identify patient comorbidities for the purposes of bivariate and multivariable analyses.[17] Elixhauser software includes the ICD-9-CM codes for the comorbidities of interest. These ICD-9-CM codes are included in the Appendix. A $P < .05$ was considered statistically significant for all tests.

RESULTS

In the NIS during the calendar years 2003 to 2011, we identified 306,438 patients with discharge diagnoses of intact AAA, LEB, and CEA. Most patients were not treated at SNPHs (9.56% vs 90.4% at nSNPHs). This corresponds appropriately with the observation here that <14.0% of hospitals were SNPHs during each year of this study. A significantly higher representation of teaching hospitals was among SNPHs than nSNPHs during each year of this analysis ($P < .05$). SNPHs performed 9.6% of all AAA procedures, 8.8% of all CEA procedures, and 12.04% of LEB procedures. Proportionately higher percentages of SNPH patients were Medicaid beneficiaries. Table I provides a descriptive comparison between patients treated at SNPHs and nSNPHs.

Analysis of patient characteristics, presentations, and type of admission. The national estimates based on SNPH and nSNPH patient groups showed significant dissimilarities in age, gender, and racial composition. The patient population at SNPHs was significantly younger ($P < .001$) and composed of a proportionately higher percentage of women ($P = .044$) and nonwhite ($P < .001$) patients.