Regional variation in the cost of infrainguinal lower extremity bypass surgery in the United States

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ABSTRACT

Background: Lower extremity bypass (LEB) remains the gold standard revascularization procedure in patients with peripheral arterial disease. The cost of LEB substantially varies based on patient's characteristics and comorbidities. The aim of this study was to assess regional variation in infrainguinal LEB cost and to identify the specific health care expenditures per service that are associated with the highest cost in each region.

Methods: We identified adult patients who underwent infrainguinal LEB in the Premier database between June 2009 and March 2015. Generalized linear regression models were used to report differences between regions in total in-hospital cost and service-specific cost adjusting for patient's demographics, clinical characteristics, and hospital factors.

Results: A total of 50,131 patients were identified. The median in-hospital cost was $13,259 (interquartile range, $9308-$19,590). The cost of LEB was significantly higher in West and Northeast regions with a median cost of nearly $16,000. The high cost in the Northeast region was driven by the fixed (indirect) cost, whereas the driver of the high cost in the West region was the variable (direct) cost. The adjusted total in-hospital cost was significantly higher in all regions compared with the South (mean difference, West, $3752 [95% confidence interval (CI), 3477-4027]; Northeast, $2959 [95% CI, 2703-3216]; Midwest, 1586 [95% CI, 1364-1808]).

Conclusions: In this study, we show the marked regional variability in LEB costs. This disparity was independent from patient clinical condition and hospital factors. Cost inequality across the US represents a financial burden on both the patient and the health system. (J Vasc Surg 2018;67:1170-80.)

Infrainguinal lower extremity bypass (LEB) remains the current gold standard for revascularization of limbs affected by peripheral arterial disease (PAD).[1] LEB has been performed for decades in the context of critical limb ischemia (CLI) with good long-term survival and limb salvage rates, as high as 90% in the 10-year follow-up.[2,3] Contemporary outcomes for this open procedure, in a surgical landscape tending toward endovascular techniques, remain consistently positive.[4]

Endovascular interventions are currently more commonly performed than LEB,[5] yet LEB had been suggested to be the more cost-effective option for patients with CLI.[6,7] However, the Bypass vs Angioplasty for Severe Ischaemia of the Leg (BASIL) trial challenged that conclusion by showing that the incremental cost of bypass procedure was associated with minimal improvements in the quality of life.[8] This conflicting evidence about the cost of LEB is of major importance, because the health care costs associated with CLI have been estimated at $3 billion annually in Medicare patients, with most of the cost driven by amputations and endovascular interventions.[9,10] The health care burden of CLI will continue to increase in the coming years, as the population ages and as the incidence of diabetes increases.[11] Thus, it is crucial to understand what contributes to the cost of LEB as the increasing prevalence of CLI continues to necessitate more of these interventions.

The cost of LEB has been shown to depend on many factors, including patient demographics and comorbidities, which impact the complication rate and prolong the duration of stay. Factors that have been associated with increased cost include CLI at presentation, bilateral lesions, presence of coronary artery disease, female sex, and advanced age,[12,13] whereas non-white race, dialysis dependence, and preoperative dependent functional status have been associated with an increased duration of stay.[14,15] Furthermore, geographic and regional variations in vascular care are known to exist and impact spending and the amputation rate.[9] Despite the abundance of research into regional variation in health care spending and management of CLI,[16] to date there has been no study on regional variations in the cost of this high-volume procedure. Understanding and identifying

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Author conflict of interest: none.

Presented at the American College of Surgeons Clinical Congress, Washington, D.C., October 18, 2016.

Additional material for this article may be found online at www.jvascsurg.org.

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The editors and reviewers of this article have no relevant financial relationships to disclose per the JVS policy that requires reviewers to decline review of any manuscript for which they may have a conflict of interest.

0741-5214

https://doi.org/10.1016/j.jvs.2017.08.055

contributors to cost variations could help to mitigate the inefficiencies in spending within the health care system.

The objective of this study, therefore, was to assess regional variations in the cost of LEB using a large national database and identify potential targets for economical interventions to curb the continuously rising cost.

METHODS

Data source. The Premier Healthcare Database was inquired from June 2009 to March 2015, to identify patients who underwent infrainguinal LEB. The Premier database provides deidentified discharge information from approximately 700 hospitals around the United States. Premier uses *International Classification of Diseases, 9th Revesion, Clinical Modification* (ICD-9-CM) codes to capture patient medical conditions and procedures. The Premier database is a prospective database that is compliant with the Health Insurance Portability and Accountability Act. Comprehensive details about billing information and cost are readily available in Premier. Premier collects reimbursement data, which are proprietary information held by the hospitals and payers. Premier normalizes the administrative claims data to reflect actual cost to treat the patient. This figure includes all supplies, labor, depreciation of equipment, and so on. In addition, item-level costs are collected in the Premier database with the date of service it was provided.[17] The Johns Hopkins Institutional Review Board had approved this study. Individual consent was waived owing to the use of deidentified data.

Patient population. Adult patients who had primary or admitting ICD-9-CM procedural codes for infrainguinal LEB (38.18, 39.29) were identified. Patients who lacked a diagnosis for PAD affecting the lower limbs or had a hybrid repair with concomitant endovascular intervention within the same hospitalization were excluded (Supplementary Table I, online only). Age was coded as a continuous variable ranging from 18 to 89, where patients who are 90 years or older were coded as 89 to avoid identification. Race was described in Premier as either white, black, Hispanic, or other. Insurance payers were grouped as either Medicare, Medicaid, private insurance (managed care and commercial plans), and other (self-pay, charity, worker's compensation, other's governmental payers, employer contracts, and others). To differentiate whether a certain medical condition was a comorbid diagnosis or developed during hospitalization as a complication, Premier indicates if the code was present on admission or not. Therefore, we were able to identify the patient's associated comorbidities by assigning binary variables based on the presence or absence of the relevant ICD-9 codes. CLI was defined as the presence of rest pain, ulcer, or gangrene. Hospital-level factors included region, urban or rural setting, and academic status of the hospital (teaching vs nonteaching). The number of beds within a facility was provided as a continuous variable. A three-category variable was generated to correspond with hospital size: small, 346 beds or fewer; medium, 347 to 513 beds; and large, more than 513 beds. Duration of in-hospital stay was reported in days.

ARTICLE HIGHLIGHTS

- **Type of Research:** Retrospective analysis of prospectively collected data of the national Premier Healthcare Database
- **Take Home Message:** Median in-hospital cost of lower extremity bypass in 50,131 patients was $13,259, with significant regional variations, independent of patient or hospital factors. The driver for high cost in the Northeast was indirect cost, whereas in the West it was direct cost.
- **Recommendation:** These data suggest to work on cost inequalities of lower extremity bypass surgery across the United States.

Outcomes. The primary outcome of interest was the total in-hospitalization cost. Secondary outcomes were the various types of cost and in-patient services cost, which were the fixed (indirect) cost, the variable (direct) cost, the operation cost, supply, pharmacy, imaging, and rehabilitation cost (Supplementary Table II, online only). Of note, all costs presented in this study refer to actual costs incurred by hospitals for providing a certain service. The direct cost refers to the fee-for-service cost, the cost of the surgery and the equipment used for the procedure, and the cost for the pharmaceutical materials. The fixed (indirect) or overhead cost is best represented by the administrative fees paid for labor, building space, and maintenance, and they represent the major bulk of hospital cost.[18] To account for the increasing price trajectory in economy, all cost values were adjusted for inflation via the consumer price index calculation provided by the Bureau of Labor Statistics and presented as 2015 $US equivalent.[19]

Statistical analysis. We compared patient- and hospital-related factors among the four national regions: Midwest, Northeast, South, and West. Continuous variables were tested for normality via the skewness and kurtosis normality test and were all determined nonnormal; therefore, median and interquartile ranges (IQRs) were reported for continuous variables. Nonparametric K-sample equality-of-medians test was performed to evaluate the statistical difference between the comparison groups. Pearson's χ^2 test was used to report count and percentages for categorical variables. Outliers of cost values were identified by Tukey's box plot method in