From the Eastern Vascular Society

Unplanned return to operating room after lower extremity arterial bypass is an independent predictor for hospital readmission

Faisal Aziz, MD, FACS,[a] Erik B. Lehman, MS,[b] and Amy B. Reed, MD, FACS,[a] *Hershey, Pa*

Objective: **Hospital readmissions after surgical operations are considered serious complications and have an impact on health care-associated costs. The Centers for Medicare and Medicaid Services strongly encourage identification and ramification of factors associated with hospital readmissions after operations. Despite advances in endovascular surgery, lower extremity arterial bypass remains the "gold standard" treatment for severe, symptomatic peripheral arterial disease. The purpose of this study was to retrospectively review the factors associated with hospital readmission after lower extremity bypass surgery.**

Methods: **The 2013 lower extremity revascularization-targeted American College of Surgeons National Surgical Quality Improvement Program (NSQIP) database and generalized 2013 general and vascular surgery NSQIP Participant Use Data File were used for this study. Patient, diagnosis, and procedure characteristics of patients undergoing lower extremity bypass surgery were assessed. Multivariate logistic regression analysis was used to determine independent risk factors for hospital readmission within 30 days after surgery.**

Results: **A total of 2646 patients (65% male, 35% female) were identified in the NSQIP database who underwent lower extremity open revascularization during the year 2013. Indications for operations included tissue loss (39%), rest pain (32%), and severe claudication (25%). Preoperative ankle-brachial indices were 0.4 to 0.9 (32%) and <0.4 (16.5%). A total of 425 patients (16%) were readmitted within 30 days of index operation. Risk factors associated with readmission included wound complication (odds ratio [OR], 8.54; 95% confidence interval [CI], 6.68-10.92; $P < .001$), need for reoperation (OR, 5.95; 95% CI, 4.45-7.97; $P < .001$), postoperative myocardial infarction (OR, 2.19; 95% CI, 1.25-3.83; $P = .006$), wound dehiscence (OR, 8.45; 95% CI, 4.54-15.71; $P < .001$), organ or space surgical site infection (OR, 7.62; 95% CI, 2.89-20.14; $P < .001$), postoperative pneumonia (OR, 2.66; 95% CI, 1.28-5.52; $P = .009$), progressive renal insufficiency (OR, 4.12; 95% CI, 1.52-11.11; $P = .005$), superficial surgical site infection (OR, 7.37; 95% CI, 5.31-10.23; $P < .001$), urinary tract infection (OR, 2.67; 95% CI, 1.42-5.01; $P = .002$), and deep wound infection (OR, 14.0; 95% CI, 7.62-24.80; $P < .001$).**

Conclusions: **Readmission after lower extremity bypass surgery is a serious complication. Various factors put a patient at high risk for readmission. Return to the operating room, wound infection, amputation, deep venous thrombosis, and major reintervention on bypass are independent risk factors for hospital readmission. Return to the operating room is associated with a 5.95-fold increase in hospital readmission. (J Vasc Surg 2016;63:678-87.)**

With decreasing lengths of hospital stay, the incidence of early readmissions to hospitals has been increasing.[1] Section 3025 of the Patient Protection and Affordable Care Act[2] puts a greater responsibility on the hospitals for early readmissions. The majority of the surgical readmissions are related to postoperative complications.[3] Since the public release of a report by the Institute of Medicine in 1999[4] on medical errors, there has been an increasing public focus[5] on recognizing and preventing potentially preventable adverse events. It is estimated that 48% to 66% of all hospital adverse events are related to surgery, and more than half are deemed preventable.[6-9] Unlike other postoperative complications, unplanned reoperations can be considered nondiscretionary and major events. Any unplanned return to the operating room is tracked by administrative databases and by the American College of Surgeons National Surgical Quality Improvement Program (ACS NSQIP). Peripheral arterial disease (PAD) represents the most severe form of atherosclerotic disease, and hospital readmission after lower extremity open revascularization can be multifactorial. In an era of increasing health care scrutiny, it is crucial to identify potentially preventable causes of readmission. The purpose of this study was to identify the risk factors associated with increased risk of hospital readmission and to analyze which of these factors can be considered preventable. This has

From the Division of Vascular Surgery, Penn State Heart and Vascular Institute,[a] and Department of Public Health Sciences,[b] Pennsylvania State University College of Medicine.

Author conflict of interest: none.

A portion of the project described was supported by the National Center for Research Resources and the National Center for Advancing Translational Sciences, National Institutes of Health (NIH), through Grant UL1 TR000127. The content is solely the responsibility of the authors and does not necessarily represent the official views of the NIH.

Presented at the Twenty-ninth Annual Meeting of the Eastern Vascular Society, Baltimore, Md, September 24-26, 2015.

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

Correspondence: Faisal Aziz, MD, FACS, Penn State Milton S. Hershey Medical Center, 500 University Dr, Mail Code H053, Rm C4632, Hershey, PA 17033 (e-mail: faziz@hmc.psu.edu).

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

http://dx.doi.org/10.1016/j.jvs.2015.09.015

implications for patient care quality and financial reimbursements in the future.

METHODS

Data set. The ACS NSQIP Participant Use Data File[10] is a de-identified data set generated and operated by the ACS. The data set is compliant with the Health Insurance Portability and Accountability Act. It has more than 250 participant academic and community U.S. hospitals. Methods used to extract data from the NSQIP database have been described previously.[11-15] Data are collected by using a systematic sampling method. Surgical operations are divided into 8-day cycles. At each NSQIP site, the first 40 operations performed within each 8-day cycle that meet program inclusion criteria are entered in the database. The NSQIP program limits the number of cases per cycle for certain higher volume and lower risk surgeries to ensure heterogeneity. At each ACS NSQIP site, a trained clinical nurse is assigned to data collection. Outcomes have been shown to be highly reliable, with <1.5% variable disagreements during annual audits.[13] To ensure complete follow-up, patients with incomplete 30-day outcomes are excluded from the database. Because there are no patient identifiers in the NSQIP database, no Institutional Review Board approval or consent of patients was required.

Patients. All patients who underwent any lower extremity open revascularization procedure during the year 2013 were identified using the Procedure-Targeted Participant Use Data File[10] from the NSQIP database. Using unique case identification numbers, this file was merged to the main ACS NSQIP adult Participant Use Data File. Any patient who presented with revascularization of bilateral limbs in the same calendar year was deleted from the data set.

Outcomes. Primary outcome was readmission within 30 days after surgery. Basic demographic data, including age, gender, race, age range, and body mass index range, were analyzed. Several perioperative variables were analyzed: operative times, length of hospital stay, type of operation, symptoms, high-risk physiologic factors, high-risk anatomic factors, preoperative use of aspirin, preoperative use of beta blockers, preoperative use of statins, need for amputation, significant postoperative bleeding, postoperative myocardial infarction, postoperative stroke, untreated loss of patency, wound infection, preoperative albumin level, number of days from hospital admission to operation, type of anesthetic, American Society of Anesthesiologists (ASA) classification, diabetes mellitus, end-stage renal disease, emergency operation, congestive heart failure, chronic obstructive pulmonary disease, hypertension, postoperative renal failure, need for reoperation, history of smoking, surgeon's specialty, need for blood transfusion, transfer status, urinary tract infection, wound classification, cardiac arrest, wound disruption, superficial and deep wound infection, pneumonia, and need for reintubation (Table I).

Definition. Only unplanned readmissions were included in this study. Unplanned readmission is defined as any unplanned readmission (to the same or another hospital) for a postoperative occurrence likely related to the principal surgical procedure within 30 days of the procedure. Reoperation is defined as "an unplanned return to the operating room for a surgical procedure related to either the index or concurrent procedure performed." This return must be within the 30-day postoperative period. The return to the operating room may occur at any hospital or surgical facility (ie, index hospital or an outside hospital). This definition is not meant to capture patients who go back to the operating room within 30 days for a follow-up procedure based on the pathologic results from the index or concurrent procedure. (NSQIP definitions are provided in the Appendix, online only.)

Statistical analysis. All variables were initially summarized with frequencies and percentages or means, medians, and standard deviations. Logistic regression was used to determine any bivariate associations of independent variables with 30-day readmission. Odds ratios (ORs) were used to quantify the magnitude and direction of any significant associations. The significant ($P < .05$) independent variables from the bivariate analysis were then used in a process of stepwise selection to find the group of variables collectively that were most significantly associated with 30-day readmission in a multivariable logistic regression model. With so many variables and a large sample size, a more stringent entry criterion of $P < .05$ and a stay criterion of $P < .05$ were used for the stepwise process of variable selection to be more conservative. Forward and backward selection methods were also employed to check for other potential models, but the three approaches resulted in similar reduced models. The fit of the final model was checked using the Hosmer and Lemeshow goodness-of-fit test ($P = .1140$). The C statistic (C = .820) was used to estimate the prediction strength of the final model. All analyses were performed using SAS version 9.4 (SAS Institute, Cary, NC).

RESULTS

Demographics and preoperative comorbidities. A total of 2646 patients (65% male, 35% female) underwent lower extremity revascularization operations in the year 2013. The mean age was 67.7 (± 11.3) years. Among these patients, 425 (16%) were readmitted to the hospital within 30 days after surgery. About 40% of all readmissions were within 2 weeks after the discharge (Fig).

Comparing variables between no readmission and readmission groups. Patients were divided into two groups: no readmission (n = 2221) and readmission (n = 425) groups. The following factors were found to have no significant difference between these two groups: gender, age range, body mass index range, type of operation, high-risk anatomic factors, preoperative use of aspirin or beta blockers or statins, preoperative albumin level, type of anesthetic, preoperative dialysis dependency, emergency operation, history of chronic obstructive pulmonary disease, postoperative renal failure, smoking, need for blood transfusions, transfer status, preoperative urinary