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Unplanned reoperations after vascular surgery

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Objective: **Existing literature on unplanned reoperation (UR) after vascular surgery is limited. The frequency of 30-day UR and its association with other adverse outcomes was analyzed.**

Methods: **Patients who underwent vascular procedures in the American College of Surgeons National Surgical Quality Improvement Program (2012) were abstracted. UR, captured by a distinct variable now available in the data set, and its association with complications, readmissions, mortality, and failure to rescue (FTR) were analyzed using bivariate and multivariate methods.**

Results: **Among 35,106 patients, 3545 URs were performed on 2874 patients. The overall UR rate was 10.1%. Among patients who underwent URs, approximately 80.4%, 15.8%, and 3.8% had one, two, and three or more reoperations, respectively; 39.4% of URs occurred after initial discharge. Median time to UR was 7 days but varied by procedure. Procedures with the highest UR rates were embolectomy (18.2%), abdominal bypass (14.4%), and open procedures for peripheral vascular disease (13.8%). Common indications for UR were hemorrhage, graft failure or infection, thromboembolic events, and wound complications. Patients with URs had higher rates of subsequent complications (49.9% vs 19.9%; $P < .001$), readmission (41.8% vs 7.0%; $P < .001$), and mortality (8.0% vs 2.5%; $P < .001$) than those not undergoing URs. FTR was more likely among patients who had a UR (13.6% vs 9.3%; $P < .001$); this varied within procedure groups. After multivariate adjustment, UR was independently associated with mortality in an incremental fashion (for one UR: adjusted odds ratio, 2.0; 95% confidence interval, 1.7-2.5; for two or more URs: adjusted odds ratio, 3.1; 95% confidence interval, 2.2-4.2).**

Conclusions: **URs within 30 days are frequent among patients undergoing vascular surgery and are associated with worse outcomes, including mortality and FTR. (J Vasc Surg 2016;63:730-6.)**

The number and complexity of vascular procedures performed in the United States have increased.[1,2] For some vascular procedures, reinterventions and reoperations may be necessary. Although some such reoperations may be necessary and planned, others may be unplanned and potentially avoidable or predictable. The implications of an unplanned reoperation (UR) could be serious, considering that most vascular procedures are performed on elderly patients with complex comorbidities and compromised physiologic reserve. Understanding of the factors driving URs and delineating high-risk groups and procedures for URs could help focus future resources, staged interventions, and informed consent.

A comprehensive, procedure-specific analysis of UR rates after vascular surgery in the United States and their association with complications, readmissions, mortality, and failure to rescue (FTR) has not been done. The objective of this study was to characterize 30-day URs after vascular surgery. We examine URs stratified by procedure among patients who underwent 11 groups of vascular operations. We hypothesize that a procedure-dependent differential risk of UR exists among patients undergoing vascular procedures and that overall, UR is significantly associated with other adverse events, such as mortality and FTR.

METHODS

Data. Data were collected from 374 U.S. hospitals participating in the American College of Surgeons National Surgical Quality Improvement Program (ACS NSQIP) that were included in the Participant Use Data File (2012). Through record review and patient follow-up, trained surgical clinical reviewers prospectively collect data about preoperative and operative characteristics as well as 30-day postoperative outcomes of surgical patients captured in the database, irrespective of whether the patient is an inpatient, has been discharged home or to another facility, or has been readmitted to another hospital. A description of the structure of the ACS NSQIP program and detailed definitions of all variables used in this study are available from the ACS NSQIP Participant Use Data File user guide.[3] Starting in 2012, ACS NSQIP introduced a new variable that captures URs, which was used in this study. In the data set, UR 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

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The American College of Surgeons National Surgical Quality Improvement Program (ACS NSQIP) and the hospitals participating in the ACS NSQIP are the source of the data used herein; they have not verified and are not responsible for the statistical validity of the data analysis or the conclusions derived by the authors.

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postoperative period. The return to the OR may occur at any hospital or surgical facility."

Inclusion criteria. This study was restricted to adult patients (aged ≥18 years) who underwent one of 11 groups of vascular procedures specified as the principal operation and denoted by the Current Procedural Terminology (CPT) code in NSQIP: (1) open abdominal aortic aneurysm (AAA) repair (CPT codes: 33877, 35091, 35092, 35081, 35082, 35102, 35103, 35131, 35141, 35142, 35151); (2) carotid surgery (CPT codes: 35301, 35606, 35001, 37215); (3) abdominal bypass (CPT codes: 35531, 35631, 35560, 35537, 35538, 35647, 35539, 35540, 35646, 35647, 35565, 35665); (4) open operations for peripheral vascular disease (PVD; CPT codes: 35583, 35556, 35583, 35656, 35566, 35585, 35666, 35661, 35571, 35587, 35371, 35302, 35351, 35355); (5) dialysis access (CPT codes: 36818, 36819, 36821, 36830, 49324, 49421); (6) embolectomy (CPT codes: 34101, 34111, 34201, 34203); (7) lower extremity amputations (CPT codes: 27590, 27880, 27682); (8) endovascular abdominal aortic repair (CPT codes: 34800, 34802, 34803, 34804, 34805, 0078T, 0079T); (9) thoracic endovascular aortic repair (CPT codes: 33880, 33881, 33883); (10) endovascular iliac operations (CPT code: 34900); and (11) endovascular procedures for PVD (CPT codes: 37220, 37221, 37224, 37225, 37226, 37227, 37228, 37229, 37230, 37231).

Baseline characteristics of patients. Demographic characteristics included age, sex, race, residence, and functional status before surgery. Pre-existing comorbidities included hypertension requiring medication; diabetes mellitus; history of chronic obstructive pulmonary disease; cardiac comorbidities, including newly diagnosed or worsening congestive heart failure within 30 days before surgery, myocardial infarction 6 months before surgery, and a history of cardiac surgery; PVD, including revascularization, rest pain, or gangrene; dialysis dependence within 2 weeks before surgery; history of paralysis (hemiplegia, paraplegia, or quadriplegia); presence of an open wound before surgery; preoperative sepsis; and bleeding disorder. Operative characteristics included emergent vs nonemergent surgery, elective vs nonelective surgery, American Society of Anesthesiologists classification, and operation time. Operation time was defined as prolonged if it was greater than the calculated 75th percentile for the specific procedure.

Outcomes. Occurrence of a UR ≤30 days of index surgery was the primary outcome of interest; the occurrence of multiple URs was also assessed. Using CPT and International Classification of Diseases, Ninth Revision codes, indications for URs as provided in the data set were investigated.

The association of a UR with all complications (occurrence and timing), readmissions, and mortality within 30 days of surgery was examined. All 21 types of complications captured in the ACS NSQIP Participant Use Data File were included. The NSQIP-defined complications were superficial, deep, and organ space surgical site infections; wound dehiscence; pneumonia; urinary tract infection; severe sepsis or shock; pulmonary embolism; deep venous thrombosis or thrombophlebitis; reintubation; prolonged ventilator use >48 hours or failure to wean; acute renal insufficiency or failure; myocardial infarction; cardiac arrest; stroke; bleeding requiring ≥5 units of blood; flap, graft, or prosthesis failure; peripheral neuropathy; and coma. Because NSQIP uses predefined variables for complications, not all complications experienced by a patient are included in the database. Patients who experienced postoperative complications for whom data regarding timing of the complication were missing (n = 113) were excluded from the study.

Because all (100%) URs are contingent on a complication, the post-UR complication rate as captured by NSQIP was calculated. Therefore, all complication rates provided for patients who had UR are for complications that occurred after UR. This allowed determination of whether patients who had a UR were at disproportionate risk of experiencing subsequent complications. We then used post-hospital discharge complication data to determine whether complications that occur after UR were more likely in the inpatient setting vs after hospital discharge. A postdischarge complication was defined as one for which the interval between operation and occurrence of the complication was greater than the interval between operation and hospital discharge. Readmission data included in the data set were used to delineate finer detail about the relationship between URs and complications. Finally, the FTR rate, defined as the 30-day mortality rate in patients who experience one or more postoperative complications, was compared between patients who had UR and those who did not.

Statistical analysis. Bivariate analyses were performed using Fisher exact and two-tailed χ^2 test for categorical variables and *t*-test for continuous variables. Multivariate logistic regression models were created to determine whether the occurrence of a UR was independently associated with mortality. Independent variables with $P < .05$ on bivariate analyses were included in the initial multivariable model; a stepwise backward elimination technique was used to derive the final multivariate model. Adjusted odds ratios with 95% confidence intervals were computed. $P < .05$ was considered statistically significant for all analyses.

Data analyses and management were performed using SPSS for Windows version 19.0 statistical software (IBM Corp, Armonk, NY). The ACS NSQIP Participant Use Data File is a public database with de-identified data; therefore, informed consent could not be obtained. This study was deemed exempt from the Stanford University Institutional Review Board as it is based on data received by the study authors in a de-identified form and thus does not constitute "human subjects research."

RESULTS

Baseline characteristics. There were 35,106 patients in the study. The mean age of the study sample was 68.9 years (median, 70 years; interquartile range, 62-76 years). Most patients were male (62.8%), white (79.0%), admitted from home (89.1%), and of independent