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Hospital Readmissions after Elective Lower Extremity Vascular Procedures

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Abstract

Background—This study evaluated risk factors associated with 30-day readmission after open and endovascular lower extremity (LE) revascularization.

Methods—Patients admitted with peripheral artery disease and LE procedures were selected from national electronic medical record data, Cerner Health Facts[®] (2008–2014). 30-day readmission was determined. Logistic regression models identified characteristics independently associated with readmission.

Results—There were 2,781 open and 2,611 endovascular procedures. Readmission was 10.9% (9.6% open vs. 12.3% endovascular, $p < .0001$). Greater disease severity was associated with readmission for both groups. Readmission factors for LE bypass: blood transfusions (OR 2.25, 95% CI 1.62–3.13), hyponatremia (OR 1.72, 95% CI 1.15–2.57), heart failure (OR 1.57, 95% CI 1.07–2.29), bronchodilators (OR 1.50, 95% CI 1.13–2.00), black race (OR 1.43, 95% CI 1.03–1.99), and hypokalemia (OR 0.43, 95% CI 0.20–0.95). Readmission factors for endovascular procedures: vasodilators (OR 1.63, 95% CI 1.22–2.16), end stage renal disease (OR 1.43, 95% CI 1.02–2.01), fluid and electrolyte disorders (OR 1.44, 95% CI 1.00–2.06), hypertension (OR 1.33, 95% CI 0.99–1.76), coronary artery disease (OR 1.31, 95% CI 1.02–1.67), and diuretics (OR 1.30, 95% CI 1.01–1.70).

Conclusions—Readmission after LE revascularization is associated with disease severity for both procedures. Factors associated with readmission following LE bypass included heart failure, transfusions, hyponatremia, black race, and bronchodilator use. Risk factors for endovascular readmissions were often chronic conditions including coronary artery disease, kidney disease, hypertension, and hypertensive medications. Awareness of risk factors may help providers identify high-risk patients who may benefit from increased surveillance and programs to lower readmission.

Keywords

Peripheral vascular disease; health outcomes; patient readmission; risk factor

Introduction

It has been estimated that that unplanned rehospitalizations cost Medicare \$17.4 billion or more annually.¹ The increasing cost of hospital readmissions has driven national efforts to reduce these events, including decreased reimbursements for institutions with higher readmission rates. As well, lowering 30-day readmission rates after vascular interventions offers potential to improve healthcare quality.² Specific risk factors associated with readmission following lower extremity vascular procedures remains poorly defined, warranting further investigation.^{1, 3, 4}

Despite increased utilization of minimally invasive procedures, there is little information on causes for readmission and readmission rates after endovascular procedures. Readmission is a multifactorial problem that varies with characteristics of patients and treatment received during the index admission. Thus, there is a knowledge gap regarding utilizing index stay information to predict future readmissions.⁵

Improved opportunities to reduce unplanned readmissions are essential. Strategies to reduce readmission will include assessing patients to identify those at highest risk for readmission. Understanding the diagnoses, medications, and laboratory values associated with readmission after revascularization for peripheral artery disease (PAD) may offer potential targets for reducing readmission and associated costs.

This analysis evaluates the readmission rates after lower extremity (LE) interventions using a national electronic medical record data set, compares rates between open bypass and endovascular procedures for PAD, and evaluates detailed clinical factors associated with readmission for each procedure type. In addition to risk factors typically present in administrative databases, our national dataset also had detailed information on medications and laboratory studies. The objective of this analysis is to describe characteristics of the index admission that are associated with readmission and to define the diagnoses present on readmission after lower extremity procedures.

Methods

Overall

We conducted a retrospective cohort study of adults admitted for PAD who underwent LE procedures. Patients admitted between September 2008 and March 2014 was selected from the Cerner Health Facts[®] database using International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM) diagnosis and procedure codes (index admission). We used the Agency for Healthcare Research and Quality's (AHRQ) Clinical Classifications Software to group diagnosis codes into clinically relevant groups. The study was approved by the Health Sciences Institutional Review Board at the University of Missouri. Informed patient consent was not needed as the Cerner Health Facts[®] database is completely de-identified using methods that are compliant with the Health Insurance Portability and Accountability Act (HIPAA).

Data source

Health Facts is a proprietary database comprised of electronic medical records from hospitals and hospital systems that use Cerner Corporation's electronic health record and that elect to participate. Hospitals choose what types of data to contribute. For example, hospitals may not contribute billing data for any of their patients. Categories of data hospitals may contribute potentially include billing data, diagnoses and procedures, encounter data, medication orders, and diagnostic test results. All data were collected as part of providing medical care in participating facilities. Cerner de-identifies and standardizes the data before including them in Health Facts. Rigorous validity checks are applied to the data.

Study Population

We included elective inpatient admissions during which an LE procedure was performed (open: 38.08, 38.18, 38.38, 38.48, 38.88, 39.29, 39.56, 39.57, 39.58; endovascular: 39.50, 39.90) and the patient had a diagnosis of PAD (gangrene, 440.24; ulceration, 440.23; rest pain, 440.22, claudication, 440.21; or unspecified severity, 440.20, 440.29, 440.4 or 443.9). Where multiple diagnosis codes were used, PAD severity was designated as the most severe diagnosis code associated with the encounter.

We excluded: 1) admissions for patients less than 21 years old at admission; 2) admissions during which both endovascular and open procedures were performed; 3) hospital stays longer than 30 days; 4) admissions flagged as emergent or urgent; 5) patients who died in the hospital or were discharged to hospice; 6) encounters with an adjacent encounter within 3 hours of admission or discharge; and 7) admissions with no reported laboratory or medication data. We identified patients readmitted within 30 days of their discharge from the index admission.

Statistical Analysis

We used SAS for Windows, version 9.4, for all analyses (SAS Institute, Cary, NC). We used chi-square analysis or independent t-tests (for categorical or continuous variables, respectively) to compare the characteristics of patients who received open or endovascular procedures and to determine characteristics of the index admission associated with readmission. Relative risks (RR) and 95% confidence intervals (CI) were calculated. We also examined patients' diagnoses recorded during the readmission stay and determined if they were associated with the type of procedure received during the index admission.

To account for nonrandom assignment of procedure type, a propensity score was used to adjust for the probability of receiving an open procedure. We allowed age, race, gender, marital status, PAD severity, hospital bed-size, teaching facility, index diagnoses, Charlson index,⁶ and pre-operative medications to enter a stepwise logistic model (entry and exit p-value = .10). The estimated probability of having an open procedure was used as a covariate in the overall readmission model.

Associations of index admission diagnoses, post-operative medications, and laboratory results with 30-day readmission were then modeled using three separate logistic regression models – one for all patients and separate models for open and endovascular procedures. We

initially created a base model that included the propensity score, procedure type (open vs. endovascular), patient characteristics (age, sex, race/ethnicity, and disease severity), hospital characteristics (bed size and teaching facility), and length of stay. The procedure-specific base models excluded the propensity score and procedure type. Comorbid diagnoses, post-operative medications, laboratory values, and encounter characteristics were allowed to enter into each base model using stepwise selection (entry and exit p-value = .10). Backwards elimination models were also run to determine whether the same variables were retained in the final models. Odds ratios and 95% CIs were calculated. Model discrimination was assessed with the c-statistic, where 1 indicates perfect fit and .5 is no better than a coin toss. Model calibration was assessed with the Hosmer-Lemeshow goodness-of-fit test, where p>.05 indicates adequate fit over the range of predicted readmission.

Results

Overall

We identified 5,392 patients who underwent elective LE procedures (Figure 1). The mean age of patients was 67.5 years (95% CI of the mean 67.2–67.8); almost half (44.0%) of patients were age 70 years or older (Table 1). Over half (59.7%) of patients were men. Most patients (73.7%) were White and 21.6% were African American. Most patients (77.4%) were discharged to home, 10.5% went to an intermediate care or skilled nursing facility (ICF/SNF), and 3.2% were discharged to a rehabilitation facility. Readmission differed by discharge location; 71.0% of readmitted patients had been discharged to home compared with 78.2% of patients who were not readmitted (Table 1). In contrast, 14.5% of readmitted patients were discharged to an ICF/SNF compared with 10.0% of patients who were not readmitted (p=.0008). There were 71 hospitals represented in the sample. All were located in urban areas. Most encounters (73.3%) took place in hospitals that had 300 beds or more or were teaching facilities (77.8%).

Overall 30-day readmission was 10.9%. Several diagnoses and conditions were associated with increased readmission following any LE procedure (Table 2), including end stage renal disease (RR 1.77, 95% CI 1.43–2.20), chronic kidney disease (RR 1.57, 95% CI 1.33–1.86), fluid and electrolyte disorders (RR 1.53, 95% CI 1.24–1.89), posthemorrhagic anemia (RR 1.44, 95% CI 1.10–1.88), heart failure (RR 1.45, 95% CI 1.18–1.78), chronic anemia (RR 1.41, 95% CI 1.17–1.70), lower extremity cellulitis (RR 1.38, 95% CI 1.05–1.80), and atrial fibrillation (RR 1.31, 95% CI 1.05–1.64). Notably, several diagnoses were not associated with readmission, including embolism and thrombosis, depression, and disorders of lipid metabolism.

Post-operative medications associated with readmission following any LE procedure (Table 3) included steroids (RR 1.50, 95% CI 1.16–1.95), vasodilators (RR 1.37, 95% CI 1.13–1.66), non-cardio selective beta blockers (RR 1.30, 95% CI 1.10–1.53), bronchodilators (RR 1.25, 95% CI 1.05–1.49), calcium channel blockers (RR 1.21, 95% CI 1.02–1.42), and insulin for diabetes I (RR 1.22, 95% CI 1.04–1.43). Medications for type II diabetes and vasopressors were not associated with readmission. Post-operative laboratory results associated with readmission following any LE procedure included (Table 3): estimated glomerular filtration rate (eGFR) <30 mL/min (RR 1.67, 95% CI 1.33–2.09), platelet count

> 400,000/ μ L (RR 1.80, 95% CI 1.35–2.39), blood urea nitrogen (BUN) > 20 mg/dL (RR 1.28, 95% CI 1.09–1.51), and white blood cell count > 11,000/ μ L (RR 1.18, 95% CI 1.00–1.40).

There were 2,781 open (51.6%) and 2,611 endovascular (48.6%) procedures (Table I in the Data Supplement). Older patients were more likely to receive endovascular procedures, as were patients with higher disease severity, women, African-Americans, patients in smaller hospitals, and patients in non-teaching hospitals (all $p < .0001$). Of patients who had an open procedure, 266 were readmitted (9.6%), compared with 320 (12.3%) patients who had endovascular procedures ($p < .0001$). When stratified by procedure type, different covariates were associated with readmission. Compared to patients who had open procedures who were not readmitted, those who were readmitted were more likely to have had (Table II in the Data Supplement) heart failure (RR 1.75, 95% CI 1.28–2.38), end stage renal disease (RR 1.62, 95% CI 1.01–2.57), chronic kidney disease (RR 1.51, 95% CI 1.13–2.01), or depressive disorders (RR 1.50, 95% CI 1.01–2.22). Patients who had an open procedure who were readmitted within 30 days were more likely than those not readmitted to be on the following post-operative medications (Table III in the Data Supplement): steroids (RR 1.61, 95% CI 1.05–2.45), bronchodilators (RR 1.41, 95% CI 1.11–1.79), diuretics (RR 1.38, 95% CI 1.09–1.74), or non-cardio selective beta blockers (RR 1.33, 95% CI 1.04–1.70). Additionally, open procedure patients that were readmitted within 30 days were more likely to have post-operative laboratory results that included: blood urea nitrogen (BUN) > 20 mg/dL (RR 1.33, 95% CI 1.03–1.71), elevated platelet count (RR 2.19, 95% CI 1.46–3.28), low eGFR (RR 1.59, 95% CI 1.06–2.39), low hemoglobin (RR 1.47, 95% CI 1.04–2.08), low hemoglobin (RR 1.47, 95% CI 1.04–2.08), or low serum sodium (RR 1.48, 95% CI 1.05–2.08).

Diagnoses and conditions associated with readmission within 30 days after an endovascular procedure (Table IV in the Data Supplement) included end stage renal disease (RR 1.69, 95% CI 1.32–2.18), fluid and electrolyte disorders (RR 1.61, 95% CI 1.22–2.13), anemia (RR 1.55, 95% CI 1.23–1.95), chronic kidney disease (RR 1.51, 95% CI 1.22–1.86), diabetes (RR 1.42, 95% CI 1.15–1.74), hypertension (RR 1.41, 95% CI 1.11–1.81), and lower extremity cellulitis (RR 1.41, 95% CI 1.02–1.94). Patients who had an endovascular procedure and who were readmitted within 30 days were more likely to be on the following post-operative medications than patients who were not readmitted (Table V in the Data Supplement): vasodilators (RR 1.45, 95% CI 1.14–1.83), steroids (RR 1.38, 95% CI 0.99–1.93), insulin for type I diabetes (RR 1.31, 95% CI 1.06–1.62), or non-cardio selective beta blockers (RR 1.30, 95% CI 1.03–1.63). Compared with patients who were not readmitted, endovascular procedure patients that were readmitted within 30 days were more likely to have post-operative laboratory results that included low eGFR (RR 1.59, 95% CI 1.20–2.10) and an elevated platelet count (RR 1.50, 95% CI 1.00–2.25).

Considering the diagnoses present at the time of readmission (Table 4), chronic problems (e.g., chronic kidney disease, chronic heart disease, end-stage renal disease, diabetes, anemia, and hypertension) and lower extremity cellulitis were more likely to be associated with having had an endovascular procedure during the index stay. Readmission patients with

posthemorrhagic anemia were more likely to have had an open procedure during their index encounter.

Models

The propensity model had a c-statistic of 0.71 and a non-significant goodness-of-fit statistic ($\chi^2 = 9.01$, $p = .34$). Odds ratios and 95% CIs for multivariable analysis of readmission are shown in Table 5. Forward selection and backwards elimination selected the same variables for all models. In all models, age and gender were unrelated to readmission and increased disease severity was associated with greater odds of readmission. In the propensity-adjusted model, having an open procedure was associated with lower odds of readmission (OR 0.77, 95% CI 0.63–0.93).

For readmission following either type of procedure, the following variables were retained in the base model (beyond those we automatically included): having had a transfusion (OR 1.65, 95% CI 1.28–2.13), low post-operative serum sodium (OR 1.41, 95% CI 1.04–1.88), chronic kidney disease (OR 1.37, 95% CI 1.08–1.74), vasodilator receipt (OR 1.37, 95% CI 1.08–1.74), coronary artery disease (OR 1.29, 95% CI 1.08–1.54), and receipt of bronchodilators (OR 1.25, 95% CI 1.01–1.55) or non-cardio selective beta blockers (OR 1.24, 95% CI 1.01–1.51). Model fit was adequate ($p = .46$) and discrimination was modest (c-statistic = .66).

For readmission following an open bypass, the following variables were retained in the model: having had a transfusion (OR 2.25, 95% CI 1.62–3.13), low post-operative serum sodium (OR 1.72, 95% CI 1.15–2.57), heart failure (OR 1.57, 95% CI 1.07–2.29), bronchodilator use (OR 1.50, 95% CI 1.13–2.00), and low post-operative serum potassium (OR 0.43, 95% CI 0.20–0.95). Model discrimination was moderate (c-statistic = .69) and calibration ($p = .30$) was adequate.

For readmission following an endovascular procedure, the following variables were retained in the model: vasodilator use (OR 1.63, 95% CI 1.22–2.16), end stage renal disease (OR 1.43, 95% CI 1.02–2.01), fluid and electrolyte disorders (OR 1.44, 95% CI 1.00–2.06), hypertension (OR 1.33, 95% CI 0.99–1.76), coronary artery disease (OR 1.31, 95% CI 1.02–1.67), and diuretic use (OR 1.30, 95% CI 1.01–1.70). Calibration was adequate ($p = .63$) and discrimination was modest (c = .64).

Discussion

Overall, this analysis has demonstrated that disease severity, receiving a transfusion, hyponatremia, use of steroids, chronic kidney disease, coronary artery disease, and receiving vasodilators or bronchodilators were associated with greater odds of readmission for both open and endovascular LE procedures. For open lower extremity bypass, receiving a blood transfusion, heart failure, use of bronchodilators, hyponatremia, hypokalemia, and black race were significant risk factors for 30-day readmission. Risk factors specific for readmission after an endovascular lower extremity procedure included coronary artery disease, use of vasodilators, use of diuretics, hypertension, end stage renal disease, and fluid and electrolyte disorders.

The factor most strongly associated with readmission after any lower extremity procedure was severity of disease. Patients with gangrene had 2.5 times the odds of readmission, and those with ulceration had 1.6 times greater odds. The higher odds of readmission among patients with more severe disease are likely related to overall health status, need for secondary procedures, or worsening status. Previous analyses corroborate that disease severity is associated with readmission.^{7, 8}

Overall, the most important medications associated with readmission were the use of steroids, vasodilators, and bronchodilators. The odds of 30-day readmission were 39% higher for patients taking steroid medications. Previous studies in other surgical specialties have found similar results with steroid utilization, mortality and serious postoperative complications. This analysis reports the association of steroids to readmission, which has been previously described for other surgical procedures.⁹

For open LE bypass procedures, a diagnosis of heart failure during the index hospitalization was highly associated with 30-day readmission after controlling for other risk factors. This may represent an acute event at the index admission or may be an exacerbation of preexisting congestive heart failure. McPhee et al. evaluated 1,516 lower extremity bypasses from a prospective institutional registry and examined patients who had an unplanned readmission. Using multivariable analysis, they found that preoperative factors associated with unplanned readmission included dialysis dependence, tissue loss indication, and history of congestive heart failure.^{10, 11}

For bypass surgery, patients receiving a blood transfusion during the index admission had 2.25 times the odds of readmission. When evaluating general surgery patients, events leading to increased risk of 30-day readmission were blood transfusions and vascular complications.¹² Reasons for this association are unclear, but may represent a bleeding complication during the index visit or transfusion-related morbidity¹³ and subsequent readmission. As well, patients utilizing bronchodilators had 1.5 the odds of readmission after open bypass. This may be associated with underlying pulmonary dysfunction and COPD. It has been well established that medical patients with a primary disease diagnosis of CHF and COPD are at increased risk of readmission.¹⁴

Furthermore, patients with fluid and electrolyte disorders, particularly hyponatremia (sodium <135 mEq/L) were more likely to be readmitted. Other investigators have reported predictors of readmissions within 30 days of hospital discharge for diabetic Medicare home healthcare with fluid and electrolyte diseases and depression and/or anxiety.¹⁵ We also found that depressive disorders were associated with readmission after open bypass surgery. Odonkor et al. have suggested that depressive symptom severity moderated the association of sociodemographic, social support and physical function indicators with 30-day readmissions.¹⁶ Finally, race was associated with increased readmission after lower extremity bypass as the odds of 30-day readmission were 43% higher for blacks compared to whites. Racial disparities have been described for many surgical procedures^{17, 18} and race is likely a surrogate for sociodemographic disparities and other factors which lead to the development of inferior outcomes.^{19, 20}

Patients who underwent endovascular procedures were more likely to be readmitted than patients who underwent open procedures. Other authors have reported that readmission after endovascular treatment is relatively common, especially in patients with critical limb ischemia.²¹ Chronic conditions including end stage renal disease, fluid and electrolyte disorders, and coronary artery disease during the index admission were associated with increased readmission at 30-days. As well, the use of vasodilators and diuretics were associated with readmission after endovascular procedures, consistent with the finding that hypertension is associated with increased readmission. Other authors have found chronic conditions associated with readmission after infrainguinal endovascular procedures including diabetes, congestive heart failure, renal insufficiency, and preoperative dialysis.²¹ Curran et al. evaluated risk factors for readmission and post-discharge adverse events and suggested that optimization of medical comorbidities may play a role in decreasing readmission and post-discharge adverse events.²² This phenomenon has been previously described—regardless of payer or age group—readmission within 30 days following non-surgical hospitalizations for chronic conditions was higher than the readmission rate for acute conditions.²³

Therefore, as we preform endovascular procedures on more patients with multiple chronic conditions using lower thresholds for intervention, we may continue to see substantial rates of readmission in the vascular population if chronic conditions cannot be better managed in the post-procedure setting. This also suggests that penalties for elevated readmission rates in the presence of existing patient conditions may be ineffective for reducing readmissions.

A secondary evaluation of the diagnosis codes recorded at the time of readmission demonstrated that patients with posthemorrhagic anemia had more often received open lower extremity bypass during the index admission, suggesting a complication secondary to surgery, whereas chronic conditions were more commonly documented upon readmission following endovascular procedures. Chronic conditions most often seen in the post-endovascular readmission group included chronic kidney disease, end-stage renal disease, chronic anemia, and diabetes.

This study has limitations secondary to relying on ICD-9 codes, as coding may vary between institutions. Because procedure type was not randomly assigned, confounding could explain the differences between groups, and this was addressed with a propensity score analysis. As well, all of the procedures were performed during inpatient admissions as no outpatient facilities contributed data. As Cerner Corporations' Health Facts is a proprietary database comprised of electronic clinical records from hospitals and hospital systems that use Cerner's electronic health record, the ethnicity and patient mix may not represent the entire US population. It is also possible that hospitals that do not contribute certain types of data (e.g., laboratory or medication data), might differ from hospitals that do contribute these data. Proportions by ethnicity, however, are comparable to previously published evaluations of LE procedures utilizing Medicare data, which is considered a representative sample of the elderly US population. Patients of smaller and rural hospitals are underrepresented.

Overall, readmission after LE vascular procedures is a complex and multifactorial problem that is difficult to predict. Previous authors have stated that determining the risk of

readmission after surgery is difficult to predict at the time of discharge, and that of information available at that time, preoperative factors are the most important.⁵ We have demonstrated that disease severity is highly predictive of readmission for both open and endovascular procedures. Chronic conditions, including coronary artery disease, renal disease, hypertension, and hypertensive medications were associated with increased readmission after endovascular procedures, suggesting that more intense medical management in the outpatient setting may reduce future hospital readmission. For patients undergoing lower extremity bypass, receiving blood transfusions, having heart failure, using bronchodilators, and hyponatremia were associated with readmission. Recognition of these risk factors could help providers identify high-risk patients who may benefit from increased surveillance and improved outpatient medical management, and may serve as markers for future discharge programs supporting patients after lower extremity vascular procedures.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Figure 1.

*More than one exclusion reason can apply to an admission, therefore the sum of the individual exclusions exceeds the total admissions excluded.

Table 1

Patient and encounter characteristics for patients with peripheral artery disease who had lower extremity revascularization, by readmission status [Frequency (Column percentage) unless otherwise indicated].

	Total (N= 5392)		Readmitted (N=586)		Not readmitted (N=4806)		p-value*
<i>Patient characteristics</i>							
Age							.16
21–59	1374	(25.5)	136	(23.2)	1238	(25.8)	
60–69	1644	(30.5)	201	(34.3)	1443	(30.0)	
70–79	1478	(27.4)	159	(27.1)	1319	(27.4)	
80 or older	896	(16.6)	90	(15.4)	806	(16.8)	
Marital status							.36
Married, life partner	2264	(42.0)	249	(42.5)	2015	(41.9)	
Divorced, separated	639	(11.9)	72	(12.3)	567	(11.8)	
Single, widowed	1746	(32.4)	198	(33.8)	1548	(32.2)	
Unknown	743	(13.8)	67	(11.4)	676	(14.1)	
Peripheral artery disease severity							<.0001
Gangrene	678	(12.6)	125	(21.3)	553	(11.5)	
Rest pain	785	(14.6)	91	(15.5)	694	(14.4)	
Ulceration	751	(13.9)	88	(15.0)	663	(13.8)	
Claudication	1574	(29.2)	111	(18.9)	1463	(30.4)	
Unknown	1604	(29.8)	171	(29.2)	1433	(29.8)	
Sex							.41
Female	2173	(40.3)	227	(38.7)	1946	(40.5)	
Male	3219	(59.7)	359	(61.3)	2860	(59.5)	
Race/ethnicity							.009
African American	1162	(21.6)	157	(26.8)	1005	(20.9)	
Caucasian	3974	(73.7)	404	(68.9)	3570	(74.3)	
Other	152	(2.8)	17	(2.9)	135	(2.8)	
Unknown	104	(1.9)	8	(1.4)	96	(2.0)	
Discharge destination							<.0001
Home	4172	(77.4)	416	(71.0)	3756	(78.2)	
Hospital	71	(1.3)	3	(0.5)	68	(1.4)	
ICF/SNF	564	(10.5)	85	(14.5)	479	(10.0)	
Rehabilitation facility	171	(3.2)	29	(5.0)	142	(3.0)	
Unknown	414	(7.7)	53	(9.0)	361	(7.5)	
<i>Hospital characteristics</i>							
Bed size							.44
<200	446	(8.3)	44	(7.5)	402	(8.4)	
200–299	994	(18.4)	120	(20.5)	874	(18.2)	
300–499	1514	(28.1)	169	(28.8)	1345	(28.0)	
500 or more	2438	(45.2)	253	(43.2)	2185	(45.5)	
Teaching facility							.59

	Total (N= 5392)		Readmitted (N=586)		Not readmitted (N=4806)		p-value *
No	1197	(22.2)	125	(21.3)	1072	(22.3)	
Yes	4195	(77.8)	461	(78.7)	3734	(77.7)	
<i>Stay characteristics</i>							
Length of stay, mean (sd)	4.9	(4.7)	6.0	(5.6)	4.7	(4.6)	<.0001
Charlson index, mean (sd)	2.6	(1.6)	2.9	(1.8)	2.6	(1.6)	<.0001

ICF: intermediate care facility; SNF: skilled nursing facility

* Chi-square comparison (t-test for continuous variables) of readmission versus no readmission.

Table 2

Association of selected diagnoses and conditions during the index hospital admission for patients with peripheral artery disease, by readmission status [Frequency (Column percentage)].

	Readmitted (N=586)		Not Readmitted (N=4806)		Relative risk (95% confidence interval)	p-value*
<i>Acute problems</i>						
Arterial embolism/thrombosis	82	(14.0)	642	(13.4)	1.05 (0.84 – 1.31)	.67
Cardiac/MI	16	(2.7)	117	(2.4)	1.11 (0.70 – 1.77)	.66
Fluid and electrolyte disorders	84	(14.3)	448	(9.3)	1.53 (1.24 – 1.89)	<.0001
Renal failure	41	(7.0)	269	(5.6)	1.23 (0.92 – 1.66)	.16
Respiratory failure	37	(6.3)	233	(4.9)	1.28 (0.94 – 1.74)	.12
Venous embolism/thrombosis	28	(4.8)	231	(4.8)	0.99 (0.69 – 1.42)	.97
<i>Chronic problems</i>						
Atrial fibrillation	79	(13.5)	493	(10.3)	1.31 (1.05 – 1.64)	.01
Anemia	117	(20.0)	695	(14.5)	1.41 (1.17 – 1.70)	<.001
Chronic heart failure	93	(15.9)	528	(11.0)	1.44 (1.18 – 1.77)	<.001
Chronic kidney disease	163	(27.8)	900	(18.7)	1.57 (1.33 – 1.86)	<.0001
Chronic obstructive pulmonary disease	126	(21.5)	842	(17.5)	1.25 (1.04 – 1.51)	.01
Conduction disorders	35	(6.0)	227	(4.7)	1.24 (0.90 – 1.71)	.18
Coronary artery disease	310	(52.9)	2220	(46.2)	1.27 (1.09 – 1.48)	.002
Depressive disorders	37	(6.3)	281	(5.9)	1.08 (0.79 – 1.47)	.65
Diabetes	285	(48.6)	2047	(42.6)	1.24 (1.07 – 1.45)	.005
Disorders of lipid metabolism	278	(47.4)	2262	(47.1)	1.01 (0.87 – 1.18)	.86
End stage renal disease	79	(13.5)	357	(7.4)	1.77 (1.43 – 2.20)	<.0001
Heart failure	93	(15.9)	528	(11.0)	1.45 (1.18 – 1.78)	<.001
Hypertension	426	(72.7)	3224	(67.1)	1.27 (1.07 – 1.51)	.006
Occlusion/stenosis of pre-cerebral arteries	36	(6.1)	322	(6.7)	0.92 (0.67 – 1.27)	.60
Osteoarthritis	30	(5.1)	269	(5.6)	0.92 (0.65 – 1.30)	.63
Thyroid disorders	35	(6.0)	348	(7.2)	0.83 (0.60 – 1.15)	.25
<i>Infections</i>						
Lower extremity cellulitis	50	(8.5)	292	(6.1)	1.38 (1.05 – 1.80)	.02
Other infection	36	(6.1)	226	(4.7)	1.28 (0.94 – 1.75)	.12
Pneumonia	10	(1.7)	68	(1.4)	1.18 (0.66 – 2.12)	.57
Sepsis	7	(1.2)	53	(1.1)	1.07 (0.53 – 2.16)	.84
Surgical site infection	7	(1.2)	96	(2.0)	0.62 (0.30 – 1.27)	.18
Urinary tract infection	18	(3.1)	115	(2.4)	1.25 (0.81 – 1.94)	.31
<i>Complications</i>						
Complications of procedure	92	(15.7)	682	(14.2)	1.11 (0.90 – 1.37)	.32
Hemorrhage or hematoma	21	(3.6)	191	(4.0)	0.91 (0.60 – 1.37)	.64
Posthemorrhagic anemia	51	(8.7)	284	(5.9)	1.44 (1.10 – 1.88)	.008

MI: myocardial infarction

* Chi-square comparison of readmission versus no readmission.

Table 3

Association of post-operative medications and laboratory results for patients with peripheral artery disease, by readmission status (Column percentage)].

	Readmitted (N=586)		Not Readmitted (N=4806)		Relative risk (95% confidence interval)	p-value [*]
<i>Post-operative medications</i>						
ACE inhibitors	191	(32.6)	1532	(31.9)	1.03 (0.87 – 1.21)	.72
Angiotensin II receptor antagonists	55	(9.4)	488	(10.2)	0.93 (0.71 – 1.20)	.55
Antiplatelet agents, non-aspirin	286	(48.8)	2444	(50.9)	0.93 (0.80 – 1.08)	.34
Aspirin and aspirin combinations	328	(56.0)	2916	(60.7)	0.84 (0.72 – 0.98)	.02
Beta blockers, cardio selective	225	(38.4)	1866	(38.8)	0.98 (0.84 – 1.15)	.84
Beta blockers, non-cardio selective	167	(28.5)	1100	(22.9)	1.30 (1.10 – 1.53)	.002
Bronchodilator	146	(24.9)	985	(20.5)	1.25 (1.05 – 1.49)	.01
Calcium channel blockers	186	(31.7)	1314	(27.3)	1.21 (1.02 – 1.42)	.02
Diabetes Type I (insulin)	216	(36.9)	1532	(31.9)	1.22 (1.04 – 1.43)	.01
Diabetes Type II	78	(13.3)	625	(13.0)	1.02 (0.82 – 1.28)	.83
Diuretics	221	(37.7)	1535	(31.9)	1.25 (1.07 – 1.47)	.002
H2 blockers	139	(23.7)	1021	(21.2)	1.13 (0.95 – 1.36)	.16
HMG-CoA reductase inhibitors	249	(42.5)	2212	(46.0)	0.88 (0.75 – 1.03)	.10
Nitroglycerin (sublingual)	46	(7.9)	351	(7.3)	1.07 (0.81 – 1.42)	.63
Proton pump inhibitors	171	(29.2)	1317	(27.4)	1.08 (0.91 – 1.28)	.36
Steroids	52	(8.9)	276	(5.7)	1.50 (1.16 – 1.95)	.002
Vasopressors	103	(17.6)	809	(16.8)	1.05 (0.86 – 1.28)	.65
Vasodilators	109	(18.6)	663	(13.8)	1.37 (1.13 – 1.66)	.004
<i>Post-operative laboratory results^{**}</i>						
Blood urea nitrogen (mg/dL)						
Low (men < 8; women < 6)	17	(2.9)	165	(3.4)	0.92 (0.58 – 1.46)	.73
Normal (men 8–20; women 6–20)	380	(64.9)	3377	(70.3)	reference	
High (> 20)	189	(32.3)	1264	(26.3)	1.28 (1.09 – 1.51)	.002
Estimated GFR (mL/min)						
>= 90 (normal)	258	(44.0)	2281	(47.5)	reference	
60–89 (mild reduction)	136	(23.2)	1195	(24.9)	1.00 (0.82 – 1.22)	.95
30–59 (moderate reduction)	109	(18.6)	924	(19.2)	1.03 (0.84 – 1.28)	.72
<30 (severe reduction/failure)	83	(14.2)	406	(8.5)	1.67 (1.33 – 2.09)	<.0001
Hemoglobin < 8 gm/dL	48	(8.2)	315	(6.6)	1.24 (0.94 – 1.63)	.13
Platelet count (1000/μl)						
Low (< 150)	65	(11.1)	607	(12.6)	0.90 (0.71 – 1.16)	.44
Normal (150–400)	479	(81.7)	4022	(83.7)	reference	
High (> 400)	42	(7.2)	177	(3.7)	1.80 (1.35 – 2.39)	<.0001
Serum glucose (mg/dL)						
Low (< 80)	14	(2.4)	78	(1.6)	1.41 (0.86 – 2.31)	.17
Optimal (80–180)	488	(83.3)	4058	(84.4)	reference	

	Readmitted (N=586)		Not Readmitted (N=4806)		Relative risk (95% confidence interval)	p-value *
High (> 180)	84	(14.3)	670	(13.9)	1.03 (0.83 – 1.29)	.73
Serum potassium (mEq/L)						
Low (< 3.7)	29	(5.0)	326	(6.8)	0.75 (0.52 – 1.07)	.10
Normal (3.7–5.2)	524	(89.4)	4287	(89.2)	reference	
High (> 5.2)	33	(5.6)	193	(4.0)	1.34 (0.96 – 1.85)	.08
Serum sodium (mEq/L)						
Low (< 135)	60	(10.2)	385	(8.0)	1.26 (0.98 – 1.62)	.06
Normal (135–145)	521	(88.9)	4378	(91.1)	reference	
High (> 145)	5	(0.9)	43	(0.9)	0.97 (0.42 – 2.25)	.96
White blood cell count (1000/ μ l)						
Low (< 4.5)	6	(1.0)	62	(1.3)	0.84 (0.39 – 1.82)	.67
Normal (4.5–11.0)	417	(71.2)	3589	(74.7)	reference	
High (> 11.0)	163	(27.8)	1155	(24.0)	1.18 (1.00 – 1.40)	.04

ACE: angiotensin converting enzyme; GFR: glomerular filtration rate

* Chi-square comparison of readmission versus no readmission.

** Lab results use 'normal' values as the reference.

Table 4

Frequency of selected diagnoses and conditions during the readmission stay with type of procedure received during the index stay for patients with peripheral artery disease who had lower extremity revascularization [Frequency (Percentage)].

	Endovascular procedure (N=320)		Open procedure (N=266)		p-value*
Acute problems					
Arterial embolism/thrombosis	37	(11.6)	45	(16.9)	.06
Fluid and electrolyte disorders	49	(15.3)	35	(13.2)	.45
Renal failure	22	(6.9)	19	(7.1)	.89
Venous embolism/thrombosis	17	(5.3)	11	(4.1)	.50
Chronic problems					
Alcohol-related disorder	4	(1.3)	4	(1.5)	.79
Anemia	80	(25.0)	37	(13.9)	<.0001
Atrial fibrillation	49	(15.3)	30	(11.3)	.15
Chronic heart disease	177	(55.3)	133	(50.0)	.19
Chronic kidney disease	113	(35.3)	50	(18.8)	<.0001
Chronic obstructive pulmonary disease	60	(18.8)	66	(24.8)	.07
Conduction disorders	20	(6.3)	15	(5.6)	.75
Connective tissue disease	45	(14.1)	42	(15.8)	.55
Depressive disorders	13	(4.1)	24	(9.0)	.01
Diabetes	179	(55.9)	106	(39.9)	<.0001
Disorders of lipid metabolism	158	(49.4)	120	(45.1)	.30
Disorders of peripheral nervous system	49	(15.3)	30	(11.3)	.15
End stage renal disease	63	(19.7)	16	(6.0)	<.0001
Esophageal disorders	37	(11.6)	29	(10.9)	.80
Heart failure	52	(16.3)	41	(15.4)	.78
Hypertension	245	(76.6)	181	(68.1)	.02
Lower extremity ulcer	77	(24.1)	64	(24.1)	.99
Occlusion/stenosis pre-cerebral arteries	18	(5.6)	18	(6.8)	.56
Thyroid disorders	20	(6.3)	15	(5.6)	.75
Infections					
Lower extremity cellulitis	36	(11.3)	14	(5.3)	.009
Other Infection	25	(7.8)	11	(4.1)	.06
Pneumonia	5	(1.6)	5	(1.9)	.77
Surgical site infection	4	(1.3)	3	(1.1)	.89
Urinary tract infection	10	(3.1)	8	(3.0)	.93
Complications					
Complications of implant or graft	38	(11.9)	41	(15.4)	.21
Complications of procedure	48	(15.0)	44	(16.5)	.60
Hemorrhage or hematoma	11	(3.4)	10	(3.8)	.83
Posthemorrhagic anemia	18	(5.6)	33	(12.4)	.003

* Chi-square comparison of index procedure type.

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Table 5

Multivariable logistic regression of risk factors for 30-day readmission, overall and by procedure type

	Overall (N = 5392)			Open (N = 2781)			Endovascular (N = 2611)		
	Odds Ratio (95% CI)		p-value	Odds Ratio (95% CI)		p-value	Odds Ratio (95% CI)		p-value
<i>Propensity score</i>	1.61	(0.80 – 3.22)	.11						
<i>LE Procedure - Open</i>	0.77	(0.63 – 0.93)	.007						
<i>Age (years)</i>	1.00	(0.99 – 1.01)	.56	1.00	(0.99 – 1.02)	.70	1.00	(0.99 – 1.01)	.56
<i>Race (reference= White)</i>									
Black	1.21	(0.97 – 1.50)	.09	1.43	(1.03 – 1.99)	.03	1.13	(0.85 – 1.50)	.40
Other/unknown	0.89	(0.56 – 1.38)	.61	1.11	(0.60 – 2.03)	.74	0.85	(0.45 – 1.60)	.62
<i>Gender (Male)</i>	1.10	(0.90 – 1.34)	.34	1.15	(0.86 – 1.52)	.34	1.18	(0.91 – 1.52)	.20
<i>Severity (reference=Claudication)</i>									
Gangrene	2.48	(1.82 – 3.38)	<.0001	3.19	(2.11 – 4.84)	<.0001	1.96	(1.28 – 3.00)	.002
Rest pain	1.58	(1.16 – 2.16)	.004	1.54	(1.03 – 2.30)	.03	2.07	(1.32 – 3.25)	.001
Ulceration	1.58	(1.16 – 2.16)	.004	1.63	(1.05 – 2.54)	.03	1.47	(0.96 – 2.24)	.07
Length of stay (days)	1.02	(1.00 – 1.04)	.02				1.03	(1.01 – 1.06)	.01
<i>Diagnoses and conditions</i>									
Anemia				0.70	(0.47 – 1.04)	.07			
Chronic kidney disease	1.37	(1.08 – 1.74)	.006						
Coronary artery disease	1.29	(1.08 – 1.54)	.005				1.31	(1.02 – 1.67)	.03
Depressive disorders				1.58	(0.98 – 2.54)	.05			
End stage renal disease							1.43	(1.02 – 2.01)	.03
Fluid/electrolyte disorders							1.44	(1.00 – 2.06)	.04
Heart failure				1.57	(1.07 – 2.29)	.02			
Hypertension							1.33	(0.99 – 1.76)	.05
Surgical site infection	0.46	(0.21 – 1.01)	.05						
<i>Post-op medications/procedures</i>									
Any transfusion	1.65	(1.28 – 2.13)	<.0001	2.25	(1.62 – 3.13)	<.0001			
Bronchodilators	1.25	(1.01 – 1.55)	.04	1.50	(1.13 – 2.00)	.004			
Calcium channel blockers	1.19	(0.98 – 1.45)	.08	1.32	(0.99 – 1.77)	.05			
Diuretics							1.30	(1.01 – 1.70)	.04
Non-cardio selective beta blockers	1.24	(1.01 – 1.51)	.03						
Steroids	1.39	(1.00 – 1.92)	.05						
Vasodilators	1.37	(1.08 – 1.74)	.008				1.63	(1.22 – 2.16)	<.001
<i>Post-operative labs (reference = normal)</i>									
Sodium, high (>145 mEq/L)	0.56	(0.21 – 1.48)	.23	1.36	(0.50 – 3.68)	.54			
Sodium, low (<135 mEq/L)	1.41	(1.04 – 1.88)	.02	1.72	(1.15 – 2.57)	.008			
Potassium, high (>5.2 mEq/L)				0.97	(0.53 – 1.76)	.91			
Potassium, low (<3.7 mEq/L)				0.43	(0.20 – 0.95)	.03			

CI: confidence interval