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Risk Factors for Thirty-Day Readmissions after Lower-Extremity Amputation in Patients with Vascular Disease

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Abstract

Background—Understanding risk factors associated with readmission after lower extremity amputation may indicate targets for reducing readmission.

Objective—This study evaluated factors associated with all-cause 30-day readmission after lower extremity amputation procedures.

Design—Retrospective cohort study.

Setting—Inpatient

Patients—A total of 2,480 patients who had lower extremity amputations between 2008 and 2014 were selected from national electronic medical record database, Cerner Health Facts®.

Methods—Univariate analysis of demographics, diagnoses, post-operative medications and laboratory results were examined. Multivariate logistic regression models were used to identify characteristics independently associated with readmission overall and by amputation location - above the knee (AKA) or below the knee (BKA).

Main Outcome Measurement—Readmission within 30 days of discharge.

Results—Over half of patients (1403, 57%) underwent BKA and 1077 (43%) underwent AKA. Readmission within 30 days was 22% (24.1% BKA vs. 19.4% AKA, $p = .005$). In multivariable logistic regression, factors associated with 30-day readmission after any amputation included: BKA (odds ratio [OR] 1.41, 95% confidence interval [CI] 1.15-1.74, $p = .001$), hypertension (OR 1.70, 95% CI 1.33-2.16), surgical site infections (OR 1.44, 95% CI 1.02-2.04), heart failure (OR 1.39, 95% CI 1.10-1.75), discharge to a skilled nursing facility (OR 1.88, 95% CI 1.41-2.51), and emergency/urgent procedures (OR 1.32, 95% CI 1.04-1.67). At readmission, 13.3% of patients with a BKA required an AKA revision and 21.3% had a diagnosis of surgical site infection.

Conclusion—Risk factors for readmission after any amputation included cardiac comorbidities, associated post-operative medications, and discharge to a skilled nursing facility. The finding that acute arterial embolism or thrombosis and a BKA during the index admission was highly

associated with readmission, combined with the high rates of 30-day conversion to an AKA when readmitted, suggests these patients more often develop stump complications or may be undertreated during the initial hospitalization.

Level of Evidence—III

Keywords

lower extremity amputation; below knee amputation; above knee amputation; readmission

Introduction

The escalating cost of hospital readmission has prompted recent nationwide efforts aimed at reducing the incidence of this important quality measure.[1,2] Within the Medicare population, the 30-day readmission rate after vascular surgical procedures is almost 24%, significantly higher than the average rate of 15.6% for other surgical procedures.[3] Because patients undergoing vascular surgery account for a significant proportion of readmissions, surgeons may face reduced reimbursements in the near future if these trends continue. However, risk factors associated with readmission remain poorly defined, and further research is needed to identify interventions that will prevent readmission following lower extremity amputation.

It has been estimated that readmissions cost Medicare \$17.4 billion or more annually.[3] One goal of the Patient Protection and Affordable Care Act is to reduce hospital readmissions, with financial penalties applied for excessive rates of unplanned readmissions within 30 days among Medicare beneficiaries. Readmission after an amputation is a multifactorial problem that varies with characteristics of patients, treatments received during the initial hospitalization and after discharge, and complications in the hospital and after discharge.[1] There currently exists a large knowledge gap regarding information to predict future readmissions.[4] Lowering 30-day readmission rates after amputation offers potential to improve healthcare quality and reduce cost.

Data on readmission after lower extremity amputation are limited. Strategies to reduce readmission includes identifying patients at highest risk for readmission. Understanding the diagnoses, complications, medications, and laboratory values associated with readmission after lower extremity amputation may provide targets for reducing readmission and associated costs. This analysis evaluated the readmission rates after lower extremity (LE) amputation using a national electronic medical record data set to analyze multiple clinical factors associated with readmission after major amputation.

Methods

Data

This retrospective study included adult patients with a diagnosis of peripheral artery disease who underwent lower extremity amputations (above or below the knee). Using ICD-9-CM diagnosis and procedure codes, data were extracted for patients admitted between September 2008 and March 2014 who met inclusion criteria from a national electronic medical record

database, the Cerner Health Facts® database. Hospital systems in the Cerner Health Facts® database choose whether to participate and what data elements to include (e.g., patient demographics, diagnosis and procedures, encounter data, diagnostic test results, medications, and billing data). The Cerner Health Facts® database is compliant with the Health Insurance Portability and Accountability Act (HIPAA). Using Agency for Healthcare Research and Quality's (AHRQ) Clinical Classifications Software[5], diagnosis codes were used to group clinically relevant conditions. The study was exempted by the Health Sciences Institutional Review Board at the University of Missouri. Informed patient consent was not required as the Cerner Health Facts® database is completely de-identified.

Study Population

The study population (N = 2480) included patients who had a diagnosis of peripheral artery disease (ICD-9-CM diagnosis codes: rest pain, 440.22; gangrene, 440.24; claudication, 440.21; ulceration, 440.23; or unspecified severity, 440.20, 440.29, 440.4 or 443.9) and who underwent a major lower extremity amputation (above the knee: 84.17; below the knee: 84.15). Patients were excluded from the sample if they: had both an below the knee and above the knee amputation performed during the stay, had a hospital stay of 30 days or more, had a stay with another stay within 3 hours of discharge or admission, died while in the hospital, or had no post-operative laboratory or medication data in the Cerner Health Facts® database.

Patients' demographic characteristics (age, gender, and race) were extracted along with hospital characteristics (size, whether or not it was a teaching facility) and acute/chronic problems (chronic heart failure, COPD, hypertension, respiratory problems, etc.). We also included the Charlson Comorbidity Index (CCI), a measure that estimates one-year mortality based on patients' comorbidities.[6] The CCI uses ICD-9-CM diagnosis codes to identify 17 categories of comorbidities. Categories are weighted and summed to derive a single comorbidity index that ranges from 0 for patients who have none of the comorbidities to 25 for patients who have all of them. Categorical variables were also created for amputation procedure type (above the knee [AKA] vs. below the knee [BKA]). The highest post-operative laboratory result following a lower extremity amputation were examined and included: hemoglobin, blood urea nitrogen (BUN), glucose, serum potassium and sodium, white blood cell and platelet counts. Orders for select post-operative medications was also examined, including: angiotensin converting enzyme inhibitors, angiotensin II receptor antagonists, antiplatelet agents (non-aspirin), aspirin and aspirin combinations, selective and non-cardio selective beta blockers, bronchodilators, calcium channel blockers, diuretics, histamine H2-receptor antagonists, HMG-CoA reductase inhibitors, insulin, other diabetes medications, nitroglycerin (sublingual), proton pump inhibitors, steroids, vasodilators, and vasopressors. Our study outcome examined whether patients were readmitted within 30 days of their discharge from the index admission.

Statistical Analysis

All analyses were performed in SAS version 9.4 (SAS Institute, Cary, NC). Using chi-square analysis or independent t-tests (for categorical or continuous variables, respectively) we compared the characteristics of patients who underwent either an AKA or BKA to determine

characteristics of the index admission associated with 30-day readmission. We used relative risks (RR) and 95% confidence intervals (CI) to examine associations of index admission diagnoses, post-operative medications, and laboratory results with 30-day readmission. We then modeled 30-day readmission using three separate logistic regression models – one for all patients undergoing a lower extremity amputation and separate models for AKA and BKA procedures. All models included patient and hospital characteristics as well as admission and discharge type; the overall model also included procedure type (AKA vs. BKA). Comorbid diagnoses, post-operative medications and laboratory values, and encounter characteristics were also allowed to enter into each 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 estimated readmission risk.

Results

Overall

Overall, 2480 patients underwent lower extremity amputation – 1403 (57%) BKA and 1077 (43%) AKA (Table 1). The mean age of patients was 68.4 years; almost half (47%) of patients were age 70 years or older. A majority of patients were white (57%) and 36% were African American. Over half (61%) of patients who underwent LE amputation were men. Most encounters (72%) took place in hospitals that had 300 beds or more or were teaching facilities (83%). There were 547 patients (22%) who were readmitted within 30 days. Older patients were more likely have an AKA, as were women and patients in larger hospitals (both $p < .001$). Of patients who had a BKA, 338 were readmitted (24%), compared with 209 (19%) patients who had an AKA ($p < .001$). At readmission, 13.3% of patients with a BKA required an AKA revision and 21.3% had a diagnosis of surgical site infection.

Several diagnoses and conditions were associated with increased readmission following any LE amputation procedure (Table 2), including: hypertension (RR 1.58, 95% CI 1.31-1.91), surgical site infections (RR 1.34, 95% CI 1.06-1.70), end stage renal disease (RR 1.33, 95% CI 1.13-1.58), chronic heart failure (RR 1.29, 95% CI 1.10-1.51), coronary artery disease (RR 1.27, 95% CI 1.09-1.47), chronic kidney disease (RR 1.26, 95% CI 1.09-1.46), disorders of lipid metabolism (RR 1.25, 95% CI 1.07-1.45), and chronic anemia (RR 1.23, 95% CI 1.06-1.43).

Post-operative medications associated with readmission following any LE amputation (Table 3) included: vasodilators (RR 2.10, 95% CI 1.35-3.26), H2 blockers (RR 1.31, 95% CI 1.12–1.54), and cardio-selective beta blockers (RR 1.18, 95% CI 1.01-1.38). Post-operative laboratory results associated with readmission following any LE amputation included: estimated glomerular filtration rate (eGFR) < 30 mL/min (RR 1.33, 95% CI 1.11-1.61).

Models

Odds ratios and 95% CIs for multivariable analysis of 30-day readmission are shown in Table 4. Forward selection and backwards elimination selected the same variables for all models. In the overall model, having a below knee amputation was associated with greater odds of readmission (OR 1.41, 95% CI 1.15-1.74). The following variables were associated with readmission following either type of procedure: transfer to a skilled nursing facility at discharge (OR 1.88, 95% CI 1.41-2.51), hypertension (OR 1.70, 95% CI 1.33-2.16), receipt of H2 blockers (OR 1.47, 95% CI 1.17-1.84), surgical site infection (OR 1.44, 95% CI 1.02-2.04), chronic heart failure (OR 1.39, 95% CI 1.10-1.75), having the procedure done at a teaching facility (OR 1.38, 95% CI 1.03-1.87), and emergency or urgent admission (OR 1.32, 95% CI 1.04-1.67). Model fit was adequate ($p = .67$) and discrimination was modest (c -statistic = .66).

For readmission following an AKA, the following variables were significantly associated with readmission: hypertension (OR 2.28, 95% CI 1.53-3.39), transfer to a skilled nursing facility at discharge (OR 2.07, 95% CI 1.29-3.31), and being African American (OR 1.42, 95% CI 1.03-1.97). Model discrimination was moderate and calibration was adequate (c -statistic = .66, $p = .81$). The following variables were significantly associated with readmission following a BKA: vasodilator use (OR 4.25, 95% CI 1.48-12.20), arterial embolism or thrombosis (OR 1.85, 95% CI 1.14-3.01), transfer to a skilled nursing facility at discharge (OR 1.65, 95% CI 1.15-2.38), receipt of H2 blockers (OR 1.59, 95% CI 1.19-2.13), hypertension (OR 1.42, 95% CI 1.05-1.91), chronic heart failure (OR 1.37, 95% CI 1.02-1.85), and or coronary artery disease (OR 1.31, 95% CI 1.00-1.70). Receipt of Angiotensin II receptor antagonists was associated with lower odds of readmission after BKA (OR .47, 95% CI .24-.95). Calibration was adequate ($p = .92$) and discrimination was moderate ($c = .65$).

Discussion

We found that all-cause readmission after lower extremity amputations was high at 22%, which is consistent with previously published reports utilizing Medicare data.[7] After controlling for patient, facility, and illness-related factors in a multivariable model, the risk of readmission was significantly higher for patients undergoing BKA than for those who had AKA. Adjusting for comorbidities, age, race, and procedure type, factors associated with 30-day readmission after any amputation included discharge to a skilled nursing facility, hypertension, receipt of H2 blockers, surgical site infection, heart failure, surgery in a teaching facility, and having an emergent or urgent admission. The most common factors associated with readmission after AKA included Black race, and hypertension. For BKA, risk factors included receipt of vasodilators or H2 blockers; a diagnosis of an arterial embolism, heart failure, coronary artery disease, or hypertension; and discharge to a skilled nursing facility.

The level of amputation was associated with 30-day readmission. The odds of 30-day readmission were 41% higher after a BKA compared to an AKA. When evaluating BKA, patients with acute thrombosis had higher likelihood of readmission. In addition to the association between acute arterial embolism or thrombosis and a BKA at the index

admission with readmission, we also noted high rates of conversion to an AKA for readmitted patients. This suggests that patients may be undertreated during the initial hospitalization. As well, this may also suggest that patients undergoing BKA are more likely to develop stump complications requiring readmission and revision to an above the knee amputation. Previous authors have reported that stump complications accounted for 13% and 10% of early and late readmissions, respectively, and that stump revision surgery was performed frequently.[8] We are not suggesting that patients with extensive comorbidity should induce physicians to undertake amputation at a higher level initially to minimize the risk of readmission as has been previously described,[9] but practitioners need to be cognizant of the significant risk for readmission for patients who have had an emergent admission associated with an acute arterial embolic event and receive a below the knee amputation.

We have also demonstrated that readmission after LE amputation was associated with urgent or emergency admission. Previous authors have reported that 30-day readmission is frequent after urgent operative interventions to treat peripheral artery disease.[10] Authors have also demonstrated an increased rate of readmission associated with emergency vascular surgery. [11] Engelbert et al. found that patients urgently admitted were more likely to be readmitted (16.2%) than those that were electively admitted (9.1%; $p < .01$).[7] Reasons for these disparities remain unclear, but it may be due to the severity of disease, the fact the patient may be in extremis, or the types of procedures that are performed in an emergency situation.

This analysis also evaluated the patient's chronic conditions and comorbidities. A history of heart failure or hypertension were associated with increased readmission after lower extremity amputations. Previous studies evaluating chronic conditions have shown that readmission after a hospitalization for congestive heart failure is common among Medicare beneficiaries, with almost half of patients readmitted within 6 months.[12] As well, other studies have reported that readmission following lower extremity revascularization is associated with chronic conditions including coronary artery disease, kidney disease, hypertension, and hypertensive medications.[13] We also evaluated the medications associated with readmission after amputation and found that the use of postoperative vasodilators were highly associated with readmission after BKA, corroborating the finding of hypertension as a significant risk factor. These findings suggest that patients undergoing amputation have multiple medical problems associated with subsequent readmission.

Patients with a history of surgical site infection during the index admission for any amputation were more likely to be readmitted. Previous studies in vascular surgery have shown that wound-related complications are highly associated with readmission. Curran et al. reported that wound-related complications accounted for 49% of readmissions after LE amputation.[11] Other studies have shown that infectious complications have also been associated with more than one-third of all readmissions after LE revascularization procedures.[14] It has been suggested that risk factors for readmission after general surgery procedures are multifactorial, and that postoperative complications appear to drive readmissions in surgical patients.[15]

Black patients had a significantly higher rate of readmission after AKA compared to whites. Racial disparities have been reported for many surgical outcomes. Black patients are significantly more likely to be readmitted to the hospital after major surgery compared to white patients.[16] Higher rates of readmission after vascular surgery for patients of Black race has also been previously described.[17] As well, racial and socioeconomic differences were observed in both the receipt of surgery and surgical outcomes among hospitalized patients with cancer in the US.[18,19] Previous authors have also reported that minority patients, those with lower socioeconomic status, and patients with Medicaid are more likely receive amputation for critical limb ischemia further delineating a disparity.[20]

Finally, this analysis has demonstrated that discharge destination after amputation is associated with readmission. Patients discharged to a skilled nursing facility after amputation were more likely to be remitted than those discharged elsewhere for both above and below the knee amputations. Previous studies have shown that for vascular surgery patients, discharge destination was also a strong risk factor for readmission.[7] Reasons for this association are unclear. Kayssi et al. reported that markers of patient dependence (long hospitalization, discharge to long-term care facility) were associated with late readmission (from 31 to 365 days following discharge from the index stay).[8] While we examined readmission within 30 days, we did find that discharge to a skilled nursing facility following amputation was associated with readmission. Previous authors have reported that efforts will be required in discharge planning and bridging transitions to discharge.[21]

This study has limitations secondary to the use of ICD-9-CM codes, the variability that occurs between institutions and coding, and the variability of coders. Because procedure type was not randomly assigned, confounding by indication may explain the differences between groups. Health Facts is a proprietary database comprised of electronic clinical records from hospitals and hospital systems that use Cerner's electronic health record, and the patient mix may not represent the entire US population. 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 may be underrepresented. Readmissions to other health systems cannot be identified in Health Facts, which likely led to under-estimation of readmission. However, approximately 75% of patients discharged from hospitals with at least 1000 Medicare discharges are readmitted to the same hospital.[3]

Conclusion

To reduce readmission rates, institutions will need to identify high-risk patients. To lower post-amputation readmission rates, efforts should focus on subgroups such as patients with BKA with an emergency admission, patients with a diagnosis of acute arterial thrombosis, those who develop surgical site infections, patients with comorbidities such as heart failure, and those discharged to a nursing home. Closer follow-up of these high-risk patients, optimization of medical comorbidities, improved communication with skilled nursing facilities, and aggressive management of wound infection may play a role in decreasing readmission and other post-discharge adverse events. Awareness of risk factors may assist

providers to identify high-risk patients who may benefit from increased surveillance and other programs to lower readmission after lower extremity amputations.

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Table 1

Patient and encounter characteristics for patients who underwent major amputation, by readmission status and amputation type [Frequency (Column percentage)].

Characteristic	N	%	N	%	N	%	N	%	p-value*	N	%	N	%	p-value*
Age in years, mean (sd)	68.4	(12.9)	68.4	(13.1)	68.2	(12.2)	.70	66.4	(12.8)	71.0	(12.6)	<.001		
21-59	641	(25.9)	497	(25.7)	144	(26.3)	.41	440	(31.4)	201	(18.7)	<.001		
60-69	676	(27.3)	524	(27.1)	152	(27.8)		402	(28.7)	274	(25.4)			
70-79	587	(23.7)	449	(23.2)	138	(25.2)		305	(21.7)	282	(26.2)			
80 or older	576	(23.2)	463	(24.0)	113	(20.7)		256	(18.3)	320	(29.7)			
Gender							.70					<.001		
Female	957	(38.6)	750	(38.8)	207	(37.8)		473	(33.7)	484	(44.9)			
Male	1521	(61.3)	1182	(61.2)	339	(62.0)		928	(66.1)	593	(55.1)			
Unknown	2	(0.1)	1	(0.1)	1	(0.2)		2	(0.1)	–	–			
Race							.04					.04		
Caucasian	1406	(56.7)	1116	(57.7)	290	(53.0)		820	(58.5)	586	(54.4)			
African American	882	(35.6)	663	(34.3)	219	(40.0)		469	(33.4)	413	(38.4)			
Other or unknown	192	(7.7)	154	(8.0)	38	(7.0)		114	(8.1)	78	(7.2)			
Marital status							.03					<.001		
Married, life partner	881	(35.5)	681	(35.2)	200	(36.6)		556	(39.6)	325	(30.2)			
Divorced, separated	351	(14.2)	276	(14.3)	75	(13.7)		201	(14.3)	150	(13.9)			
Single, widowed	1029	(41.5)	789	(40.8)	240	(43.9)		529	(37.7)	500	(46.4)			
Unknown	219	(8.8)	187	(9.7)	32	(5.9)		117	(8.3)	102	(9.5)			
Admission source							.003					<.001		
Emergent or urgent	979	(39.5)	729	(37.7)	250	(45.7)		544	(38.8)	435	(40.4)			
Elective	826	(33.3)	659	(34.1)	167	(30.5)		522	(37.2)	304	(28.2)			
Unknown	675	(27.2)	545	(28.2)	130	(23.8)		337	(24.0)	338	(31.4)			
Discharge location							<.001					<.001		
Home	428	(17.3)	361	(18.7)	67	(12.3)		250	(17.8)	178	(16.5)			
Other	320	(12.9)	244	(12.6)	76	(13.9)		132	(9.4)	188	(17.5)			

Characteristic	Patient readmitted within 30 days						Amputation type					
	Total (n = 2480)			Not Readmitted (n = 1933)			Readmitted (n = 547)			Below Knee (n = 1403)		
	N	%		N	%		N	%		N	%	p-value*
SNF or Rehabilitation	1591	(64.2)		1204	(62.3)		387	(70.8)		937	(66.8)	(60.7)
Unknown	141	(5.7)		124	(6.4)		17	(3.1)		84	(6.0)	(5.3)
Hospital size												
< 200	226	(9.1)		193	(10.0)		33	(6.0)		133	(9.5)	(8.6)
200-299	461	(18.6)		350	(18.1)		111	(20.3)		283	(20.2)	(16.5)
300-499	694	(28.0)		523	(27.1)		171	(31.3)		440	(31.4)	(23.6)
500 or more	1099	(44.3)		867	(44.9)		232	(42.4)		547	(39.0)	(51.3)
Teaching facility	2057	(82.9)		1578	(81.6)		479	(87.6)		1162	(82.8)	(83.1)
Readmission within 30 days	547	(22.1)		–	–		547	(100)		338	(24.1)	(19.4)
Length of stay, mean (sd)	12.7	(12.5)		12.6	(12.9)		13.1	(11.2)		12.8	(13.3)	(11.4)
Charlson Index, mean (sd)	3.9	(2.9)		3.8	(2.1)		4.0	(2.1)		4.1	(2.1)	(2.1)
												<.001

SNF = skilled nursing facility

* Chi-square comparison (t-test for continuous variables).

Association of selected diagnoses and conditions during the index hospital admission for patients who underwent major amputation, by readmission status [Frequency (Column percentage)].

Table 2

Diagnosis or condition	Not Readmitted (n = 1933)	Readmitted (n = 547)	Relative risk (95% CI)	p-value*
<i>Acute problems</i>				
Arterial embolism/thrombosis	149 (7.7)	52 (9.5)	1.19 (0.93 - 1.52)	.17
Cardiac complication or MI	89 (4.6)	23 (4.2)	0.93 (0.64 - 1.35)	.69
Fluid and electrolyte disorders	513 (26.5)	168 (30.7)	1.17 (1.00 - 1.37)	.05
Renal failure	359 (18.6)	89 (16.3)	0.88 (0.72 - 1.08)	.21
Respiratory	165 (8.5)	48 (8.8)	1.02 (0.79 - 1.33)	.86
Venous embolism or thrombosis	157 (8.1)	42 (7.7)	0.95 (0.72 - 1.26)	.73
<i>Chronic problems</i>				
Anemia	704 (36.4)	234 (42.8)	1.23 (1.06 - 1.43)	.006
Atrial fibrillation	337 (17.4)	100 (18.3)	1.05 (0.86 - 1.27)	.64
Chronic kidney disease	716 (37.0)	242 (44.2)	1.26 (1.09 - 1.46)	.002
COPD	283 (14.6)	93 (17.0)	1.15 (0.94 - 1.39)	.17
Conduction disorders	109 (5.6)	34 (6.2)	1.08 (0.80 - 1.47)	.60
Coronary artery disease	822 (42.5)	274 (50.1)	1.27 (1.09 - 1.47)	.001
Depressive disorders	197 (10.2)	52 (9.5)	0.94 (0.73 - 1.21)	.63
Diabetes	1250 (64.7)	347 (63.4)	0.96 (0.82 - 1.12)	.59
Disorders of lipid metabolism	646 (33.4)	219 (40.0)	1.25 (1.07 - 1.45)	.004
End stage renal disease	351 (18.2)	134 (24.5)	1.33 (1.13 - 1.58)	.001
Heart failure	445 (23.0)	161 (29.4)	1.29 (1.10 - 1.51)	.002
Hypertension	1317 (68.1)	433 (79.2)	1.58 (1.31 - 1.91)	<.001
Osteoarthritis	131 (6.8)	34 (6.2)	0.93 (0.68 - 1.27)	.64
Thyroid disorders	157 (8.1)	49 (9.0)	1.09 (0.84 - 1.40)	.53
<i>Infections</i>				
Any Infection**	962 (49.8)	263 (48.1)	0.95 (0.82 - 1.10)	.48
Lower extremity cellulitis	428 (22.1)	112 (20.5)	0.93 (0.77 - 1.11)	.40
Other infection	384 (19.9)	85 (15.5)	0.79 (0.64 - 0.97)	.02
Pneumonia	88 (4.6)	31 (5.7)	1.19 (0.87 - 1.63)	.28

Diagnosis or condition	Not Readmitted (n = 1933)	Readmitted (n = 547)	Relative risk (95% CI)	p-value*
Sepsis	313 (16.2)	76 (13.9)	0.87 (0.70 - 1.08)	.19
Surgical site infection	136 (7.0)	55 (10.1)	1.34 (1.06 - 1.70)	.02
Urinary tract infection	209 (10.8)	53 (9.7)	0.91 (0.71 - 1.17)	.45
<i>Complications</i>				
Complications of procedure	251 (13.0)	84 (15.4)	1.16 (0.95 - 1.42)	.15
Hemorrhage or hematoma	37 (1.9)	16 (2.9)	1.38 (0.91 - 2.09)	.14
Posthemorrhagic anemia	267 (13.8)	70 (12.8)	0.93 (0.75 - 1.17)	.54

CI = confidence interval; MI = myocardial infarction; COPD = chronic obstructive pulmonary disease

* Chi-square comparison of readmission versus no readmission.

** Any infection includes (lower extremity cellulitis, pneumonia, sepsis, surgical site infection, urinary tract infection, and other infection).

Association of post-operative medications and laboratory results for patients who underwent major amputation, by readmission status (Column percentage)].

Table 3

Medication or laboratory result	Not Readmitted (n = 1933)	Readmitted (n = 547)	Relative risk (95% CI)	p-value*
<i>Post-operative medications</i>				
ACE inhibitors	393 (20.3)	110 (20.1)	0.99 (0.82 – 1.19)	.90
Angiotensin II receptor antagonists	87 (4.5)	19 (3.5)	0.81 (0.53 – 1.22)	.29
Antiplatelet agents, non-aspirin	234 (12.1)	78 (14.3)	1.16 (0.94 – 1.42)	.17
Aspirin and aspirin combinations	465 (24.1)	114 (20.8)	0.86 (0.72 – 1.04)	.11
Beta blockers, cardio selective	573 (29.6)	188 (34.4)	1.18 (1.01 – 1.38)	.03
Beta blockers, non-cardio selective	432 (22.4)	112 (20.5)	0.92 (0.76 – 1.10)	.34
Bronchodilator	441 (22.8)	110 (20.1)	0.88 (0.73 – 1.06)	.17
Calcium channel blockers	363 (18.8)	97 (17.7)	0.95 (0.78 – 1.15)	.57
Diuretics	558 (28.9)	161 (29.4)	1.02 (0.87 – 1.20)	.79
Histamine H2-receptor antagonists	410 (21.2)	152 (27.8)	1.31 (1.12 – 1.54)	.001
HMG-CoA reductase inhibitors	348 (18.0)	97 (17.7)	0.99 (0.81 – 1.20)	.88
Insulin	863 (44.7)	228 (41.7)	0.91 (0.78 – 1.06)	.21
Other diabetes medications	174 (9.0)	43 (7.9)	0.89 (0.67 – 1.18)	.41
Nitroglycerin (sublingual)	48 (2.5)	9 (1.7)	0.71 (0.39 – 1.30)	.24
Proton pump inhibitors	454 (23.5)	134 (24.5)	1.04 (0.88 – 1.24)	.62
Steroids	88 (4.6)	28 (5.1)	1.10 (0.79 – 1.53)	.57
Vasodilators	13 (0.7)	11 (2.0)	2.10 (1.35 – 3.26)	.004
Vasopressors	348 (18.0)	88 (16.1)	0.89 (0.67 – 1.18)	.29
<i>Post-operative laboratory results</i>				
Blood urea nitrogen (mg/dL)				
Low (men < 8; women < 6)	443 (22.9)	88 (16.1)	0.74 (0.59 – 0.93)	.009
Normal (men 8-20; women 6-20)	650 (33.6)	187 (34.2)	reference	
High (> 20)	839 (43.4)	272 (49.7)	1.09 (0.93 – 1.29)	.27
Estimated GFR (mL/min)				
>= 90 (normal)	821 (42.5)	197 (36.0)	reference	
60-89 (mild reduction)	337 (17.4)	103 (18.8)	1.20 (0.98 – 1.49)	.07

Medication or laboratory result	Not Readmitted (n = 1933)	Readmitted (n = 547)	Relative risk (95% CI)	p-value*
30-59 (moderate reduction)	332 (17.2)	92 (16.8)	1.12 (0.89 – 1.39)	.31
<30 (severe reduction/failure)	443 (22.9)	155 (28.3)	1.33 (1.11 – 1.61)	.002
Serum glucose (mg/dL)				
Low (< 80)	36 (1.9)	11 (2.0)	1.10 (0.65 – 1.86)	.71
Optimal (80-180)	1418 (73.4)	382 (69.8)	reference	
High (> 180)	479 (24.8)	154 (28.2)	1.14 (0.97 – 1.35)	.10
Hemoglobin < 8 gm/dL	437 (22.6)	136 (24.9)	0.90 (0.76 – 1.07)	.26
Platelet count (1000/ μ L)				
Low (< 150)	409 (21.2)	115 (21.0)	1.01 (0.84 – 1.22)	.86
Normal (150-400)	1071 (55.4)	295 (53.9)	reference	
High (> 400)	453 (23.4)	137 (25.1)	1.07 (0.89 – 1.28)	.42
Serum potassium (mEq/L)				
Low (< 3.7)	432 (22.4)	105 (19.2)	0.87 (0.72 – 1.06)	.18
Normal (3.7-5.2)	1341 (69.4)	384 (70.2)	reference	
High (> 5.2)	160 (8.3)	58 (10.6)	1.19 (0.94 – 1.51)	.14
Serum sodium (mEq/L)				
Low (< 135)	597 (30.9)	152 (27.8)	0.90 (0.76 – 1.07)	.25
Normal (135-145)	1241 (64.2)	358 (65.5)	reference	
High (> 145)	95 (4.9)	37 (6.8)	1.25 (0.93 – 1.67)	.13
White blood cell count (1000/ μ L)				
Low (< 4.5)	292 (15.1)	85 (15.5)	1.12 (0.88 – 1.42)	.32
Normal (4.5-11.0)	603 (31.2)	151 (27.6)	reference	
High (> 11.0)	1038 (53.7)	311 (56.9)	1.15 (0.96 – 1.36)	.10

CI = confidence interval; ACE = Angiotensin-converting enzyme; HMG-CoA = 3-Hydroxy-3-Methylglutaryl-Coenzyme A; GFR = glomerular filtration rate

* Chi-square comparison of readmission versus no readmission.

Table 4

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

	Overall (N = 546)			Above Knee (N = 209)			Below Knee (N = 337)		
	Odds Ratio (95% CI)	p-value		Odds Ratio (95% CI)	p-value		Odds Ratio (95% CI)	p-value	
Amputation type - below knee	1.41 (1.15 - 1.74)	.001							
Age in years	1.00 (0.99 - 1.01)	.39		0.99 (0.98 - 1.00)	.20		1.00 (0.99 - 1.01)	.48	
Race (reference = Caucasian)									
African American	1.21 (0.97 - 1.50)	.09		1.42 (1.03 - 1.97)	.03		1.09 (0.82 - 1.44)	.54	
Other or unknown	0.96 (0.65 - 1.42)	.82		0.71 (0.36 - 1.41)	.32		1.10 (0.68 - 1.78)	.70	
Gender - Male	1.00 (0.82 - 1.23)	.99		0.88 (0.64 - 1.21)	.42		1.10 (0.84 - 1.45)	.48	
Teaching facility	1.38 (1.03 - 1.87)	.03		1.26 (0.77 - 2.05)	.35		1.40 (0.95 - 2.06)	.08	
Admission source (reference = elective)									
Emergent or urgent	1.32 (1.04 - 1.67)	.02							
Unknown	0.98 (0.75 - 1.29)	.89							
Discharge destination (reference = home)									
Other	0.85 (0.48 - 1.49)	.56		0.65 (0.23 - 1.88)	.42		0.92 (0.46 - 1.87)	.82	
Skilled nursing facility	1.88 (1.41 - 2.51)	<.001		2.07 (1.29 - 3.31)	.002		1.65 (1.15 - 2.38)	.007	
Acute problems									
Arterial embolism or thrombosis							1.85 (1.14 - 3.01)	.01	
Renal failure	0.74 (0.56 - 0.97)	.03					0.73 (0.51 - 1.06)	.09	
Chronic problems									
Anemia				1.32 (0.96 - 1.82)	.08				
Heart failure	1.39 (1.10 - 1.75)	.005					1.37 (1.02 - 1.85)	.03	
Coronary artery disease	1.23 (1.00 - 1.51)	.04					1.31 (1.00 - 1.70)	.04	
Diabetes	0.74 (0.60 - 0.92)	.006							
Hypertension	1.70 (1.33 - 2.16)	<.001		2.28 (1.53 - 3.39)	<.001		1.42 (1.05 - 1.91)	.02	
Infections									
Surgical site infection	1.44 (1.02 - 2.04)	.03							
Sepsis	0.76 (0.57 - 1.02)	.06					0.67 (0.45 - 1.01)	.05	
Pneumonia				1.71 (0.94 - 3.14)	.08				
Post-operative medications									

	Overall (N = 546)		Above Knee (N = 209)		Below Knee (N = 337)	
	Odds Ratio (95% CI)	p-value	Odds Ratio (95% CI)	p-value	Odds Ratio (95% CI)	p-value
Angiotensin II receptor antagonists						
Bronchodilator	0.76 (0.59 - 0.98)	.03			0.47 (0.24 - 0.95)	.03
Histamine H2-receptor antagonists	1.47 (1.17 - 1.84)	.001			1.59 (1.19 - 2.13)	.001
Beta blockers, cardio selective	1.22 (0.98 - 1.50)	.07				
Vasodilators					4.25 (1.48 - 12.2)	.007
Lab Results						
Sodium (reference = normal)						
High (> 145)	1.53 (1.00 - 2.36)	.05				
Low (< 135)	0.88 (0.71 - 1.10)	.27				

CI = confidence interval