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Predictors for readmission and reamputation following minor lower extremity amputation

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Abstract

OBJECTIVES—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. Recent data indicate that as many as 24% of Medicare patients require readmission following vascular surgery, although the rate of readmission following limited digital amputations has not been specifically examined. The present study was therefore undertaken to define the rate of unplanned readmission among patients following digital amputations, and to identify the factors associated with these readmissions to allow the clinician to implement strategies to reduce readmission rates in the future.

METHODS—The electronic medical and billing records of all patients undergoing minor amputations (defined as toe or transmetatarsal (TMA) amputations using ICD-9 codes from January 2000 through July 2012 were retrospectively reviewed. Data was collected for procedure, hospital-related variables, level of amputation, length of stay, time to readmission, level of re-amputation, and patient demographics including hypertension, diabetes, hyperlipidemia, smoking history, and history of myocardial infarction, congestive heart failure, PAD, COPD, and CVA.

RESULTS—Minor amputations were performed in 717 patients (62.2% male), including toe amputations in 565 (72.8%) and TMAs in 152 (19.5%). Readmission occurred in 100 (13.9 %) patients, including 28 within 30 days (3.9%), 28 between 30 and 60 days (3.9%) and 44 (6.1%) more than 60 days after the index amputation. Multivariable analysis revealed that elective admission (P<.001), PAD (P<.001) and chronic renal insufficiency (P=.001) were associated with readmission. The reasons for readmission were infection (49%), ischemia (29%), and non-healing wound (19%) and indeterminate (4%). Reamputation occurred in 95 (95%) of the readmitted patients, including limb amputation in 64 (64%) patients (below knee in 58, through knee in 2, and above knee in 4).

CONCLUSION—Readmission following minor amputation was associated with limb amputation in the majority of cases. Readmission following minor lower extremity amputation was affected by chronic renal insufficiency, history of peripheral artery bypass and manner of presentation,

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calling into question the ability of the surgeon to acutely mitigate readmission rates. As nearly half of the readmissions were for infection, this may represent an area for multi-disciplinary management to reduce readmission and subsequent reamputation rates. Further research is needed to establish evidence-based guidelines for acceptable readmission rates, especially in the era of increasing financial scrutiny for such occurrences.

Introduction

The American health care system is in the midst of dramatic evolution with the implementation of the Affordable Care Act (ACA). Goals of this legislation include extending affordable health care insurance to all citizens, establishing performance measures to ensure the delivery of high quality care and the control of rising health care costs. Unplanned hospital readmissions dramatically increase the cost of healthcare. It has been estimated that hospital readmissions contribute more than $40 billion in annual expenditures to Medicare.[1–3] Therefore, unplanned hospital readmission rates will be utilized as a quality of care benchmark measure with financial penalties for excessive rates of readmission and these data will be publicly reported.[4]

Hospital readmission appears to be an especially significant problem in the patient population with peripheral arterial disease (PAD). For example, in a recent analysis of the Medicare population, the readmission rate following vascular surgery was noted to be higher than that of the general surgical population (23.9 vs. 16.6%).[5] Even with the increasing performance of minimally invasive endovascular therapies, patients undergoing vascular surgery continue to demonstrate a persistently high rate of readmissions.[6]

Among the patient population with PAD, the short- and long-term risk of hospital readmission appears particularly pronounced among those patients who undergo amputation procedures.[7] For example, Kono et al reported a 49.1% re-amputation rate at 3 years, with 78.9% of these patients undergoing re-amputation within the first 6 months of their index operation.[7] The rate of readmission within 30 days of lower extremity procedures, in general, is as high as 15.3%.[6] Furthermore, hospital readmission following amputation appears to be associated not only with increased cost but also increased mortality.[8,9] Within the Medicare population, readmission is estimated to contribute $4.3 billion in expenditures among patients undergoing amputation.[10]

Identification of modifiable factors associated with readmission among this patient population is crucial in order for vascular surgeons to develop strategies to reduce the rate of hospital readmission following amputations. Although a recent population-based study identified factors associated with readmission among patients undergoing limb amputations as well as transmetatarsal amputations, to date there have been no studies examining the incidence of and factors associated with readmission exclusively following minor amputations.[11] The current study was designed to examine the incidence of unplanned early readmission following minor amputations, the factors associated with readmission, and the risk of subsequent amputation at a higher level in the limb.

Methods

Study design

Approval for this study protocol was obtained through the Johns Hopkins Hospital Institutional Review Board. Individual informed consent was waived after IRB review consistent with the retrospective review nature of the study. In this retrospective review, electronic medical and billing records for The Johns Hopkins Hospital were queried for International Classification of Disease, 9th Edition (ICD-9) codes corresponding to toe (84.11) or transmetatarsal amputation (84.12) that were performed from January 1, 2000 through July 1, 2012. Within the TMA code, patients were included in the TMA cohort only if amputation involved all digits; otherwise, they were included in the toe amputation cohort. Electronic medical records were then examined to identify procedure- and hospital stay-related variables including urgency of case (elective versus emergent/urgent), level of amputation, side of amputation, date of operation, date of discharge, readmission date, and level of re-amputation. Non-elective operations were characterized as those performed in the setting of sepsis or limb-threatening acute limb ischemia. Patient demographics were then collected to identify gender, hypertension, hyperlipidemia and a history of any of the following: myocardial infarction, congestive heart failure, cerebrovascular accident, chronic obstructive pulmonary disease, diabetes mellitus, PAD, end stage renal disease, previous lower extremity bypass and tobacco abuse. Patients younger than 18 years old and patients that did not have any follow up after the admission for their initial procedure were excluded from analysis. The primary outcome measure was unplanned readmission. Tobacco abuse was defined as active tobacco use within 60 days of the operation. Patients who underwent peripheral artery bypass at the time of their ipsilateral amputation were classified as having undergone bypass in categorization of their comorbidities.

Following initial collection, patients were then divided into three groups on the basis of any readmission. Patients who were readmitted as part of a defined treatment plan (“planned readmission”) were excluded. Within the unplanned readmission cohort, stratification into two discrete sub-cohorts based on readmission within 60 days was then performed. Admissions within 60 days were chosen based on the use of long-term intravenous antibiotics as a component of initial limb salvage attempts in many of our patients. Each patient encounter was examined as a unique instance, such that patients who underwent readmission within 60 days for one operation, and then after 60 days for another operation were viewed as two separate entries.

Statistical Analysis

Demographic data and baseline patient-specific characteristics were compared between the readmission cohorts (readmission ≤ 60 days, readmission > 60 days and no readmission). Univariate logistic regression modeling was performed to identify predictors of readmission (at any time point). Covariates that were significant at the univariate level ($P<.20$) were then included in a stepwise, forwards and backwards fashion into a multivariable model. The Akaike Information Criterion, Hosmer-Lemeshow goodness of fit test and likelihood ratio test were utilized to select the strongest model. Comparisons between categorical variables were performed with chi-squared or fisher’s exact test when applicable. Non-parametric variables are reported as median (IQR) and were compared with the Kruskal-Wallis analysis of variance. Significance was established at a p-value <.05. Statistical analysis was performed with STATA 12.1 (StataCorp, College Station, Texas).

Results

The initial query of electronic medical records during the study period returned 762 patients with matching ICD-9 codes for lower extremity amputation. After a complete chart review, 12 patients were subsequently excluded from analysis due to incomplete follow-up and 33 patients were excluded due to age less than 18 years. This yielded 717 patients for analysis. Patient demographics and comorbidities are listed in Table 1. In general, patients were predominately male with a significant burden of comorbid disease. Readmitted patients demonstrated higher rates of hypertension, PAD, previous lower extremity bypass, and renal failure. Additional cardiovascular risk factors, including congestive heart failure, cerebrovascular event history, diabetes mellitus, and history of tobacco abuse were similar between the cohorts (Table 1).

The index procedure was a toe amputation in 565 (78.8%) and TMA in 152 (22.2%) patients. The overall unplanned readmission rate was 13.9% (100/717), including 28 (28%) within 30, 28 (28%) from 30–60) and 44 (44%) more than 60 days after the index procedure. Based on primary operation, 71 (12.6%) patients and 29 (19.0%) patients were readmitted after digital amputations or TMA, respectively. The indication for unplanned readmission was infection in 49 (6.8%) patients, non-healing wound in 19 (2.6%) patients, signs of ischemia in 28 (3.9%) patients and undocumented in 4 (0.5%) patients. Infection included cellulitis of the leg or amputation site as well as wet gangrene. Patients were determined to have a non-healing wound if the wound directly corresponded to the amputation site. Within the readmission cohort, 56% (56/100) were readmitted within 60 and 28 (28%) within 30 days. Among readmitted patients, reamputation occurred in 94 (94.0%) patients, and major limb amputation occurred in 64 (64.0%) patients.

Nine variables (gender, non-elective status, hypertension, diabetes mellitus, hyperlipidemia, PAD, concomitant lower extremity bypass, myocardial infarction history and renal insufficiency) were included in the multivariable analysis. Six variables comprised the final multivariable model (3 were excluded due to a lack of explanatory power). Urgent/emergent case status (OR 2.78, CI=1.77–4.35, P<.001), lower extremity bypass (OR 1.66, CI=1.03–2.67, P<.001) and renal insufficiency (OR 2.85, CI=1.85–4.39, P=.001) were identified as independent predictors of readmission (Table 2).

Discussion

Unplanned hospital readmissions dramatically increase the cost of healthcare delivered in the United States. Beyond costs, unplanned readmission reflects an increased morbidity and mortality among surgical patients and even serves as an independent predictor for mortality in elderly adults.[9,12] When compared to non-surgical cohorts, patients undergoing vascular surgery experience significantly increased rates of readmission, as nearly one in four patients are re-hospitalized following their index operation.[5] Minor amputation/wound debridement, major amputation and non-healing wounds represent 33.4% of surgical causes of unplanned readmissions in vascular surgery patients.[13] Although previous work has documented readmission in as many as 15.3% of patients following amputations, this study specifically focused on the unplanned readmission rate after minor amputations, and demonstrated a similar rate of 13.9%.

As a fundamental component of the ACA, hospitals with “higher-than-expected” readmission rates within 30 days of operation are facing reduced reimbursement for treating Medicare patients.[14] This represents a substantial threat to hospital financial viability since as, Jencks et al demonstrated, nearly 20% of all Medicare patients require readmission.[5] Therefore, hospital systems will, by necessity, focus on strategies to identify potentially modifiable causes of readmission and to ultimately reduce those readmission rates. Since vascular surgical patients in general, and the subset requiring amputations appear to be at particular risk of readmission, vascular surgeons must focus on this issue. The impact that this may have on optimistic attempts at limb salvage rates is unclear.

It seems clear that patient comorbidity directly influences the risk of readmission both in the medical and surgical patient population. For example, in a combined cohort of medical and surgical patients, Van Walraven et al confirmed the negative impact of an increased Charlson index on the rate of readmission, with a 21% increased odds of readmission when comorbidities including hypertension, congestive heart failure, and chronic obstructive pulmonary disorder were present.[15] McPhee et al further examined specific patient- and hospital-level characteristics that impacted unplanned readmission rates in patients with critical limb ischemia undergoing infrainguinal bypass who were also enrolled in the PREVENT III trial. In their analysis, five factors (female gender, current smoking, dialysis dependence, in hospital graft event and tissue loss as an indication for surgery) independently increased the risk of readmission. Patients with even one of these risk factors experienced a readmission rate of 15.6% (compared with 24.4% for the entire cohort), with the highest risk patient’s being readmitted 38.0% of the time.[8] Of note, wound infections accounted for nearly 40% of these unplanned readmissions, consistent with our study where there was a 49% rate of infection-related readmission.

It is important to identify comorbid conditions that impact on readmission since these factors may be beyond the control of the practitioner and thus lead to a level of readmission beyond which improvement is not feasible. Our readmission rate in a tertiary care center as well as that of our published data suggest that there may be a nadir below which it is not reasonable to expect readmission rates to fall. Our analysis revealed two such patient-level risk factors associated with readmission, including chronic renal failure and PAD. Chronic uremia decreases the neutrophil response to infection and therefore may contribute to infectious complications.[16] Further, chronic PAD negatively impacts wound healing, which can also be expected to contribute to hospital readmissions. In patients undergoing amputations, decreased ABI and transcutaneous oxygen pressure (both measurements of severity of PVD) have been shown to predict poor wound healing and increased level of primary amputation or reamputation.[17,18] Though our data only demonstrated a trend towards statistical significance, diabetes adversely affects wound healing and resistance to infection and also may contribute to readmissions in this patient population. Although it has been suggested that efforts to improve mobility may help to lower readmission rates, it is unclear the degree to which this strategy can overcome the inherent limitations of chronic comorbid conditions.[19] An understanding of the impact of these risk factors on wound healing should inform pre-amputation decisions regarding amputation level, need for preoperative revascularization and planned management of open wounds.

Perhaps not surprisingly, we found that infection or a non-healing following a digital amputation were responsible for nearly 70% of total readmissions. Among these patients the treatment typically involved reamputation. Even for patients with initial amputations limited to the level of the toe, the most common level of reamputation in our review was a BKA (58% of all reamputations). In contemporary vascular surgical practice, great efforts are expended in order to achieve limb salvage. In many cases toe or transmetatarsal amputations are carried out in an effort to salvage the limb in many patients with marginal perfusion. It has clearly been not unreasonable to pursue this approach with the understanding that if the limited amputation does not heal, the patient will ultimately come to limb loss. However, our practice environment is clearly changing as a result of the ACA. One obvious strategy to reduce readmission rates in this patent population is to proceed with amputation of the limb at the initial presentation, and it remains to be seen whether increasing pressure to reduce rates of hospital readmission will result in a less aggressive approach to limb salvage by some clinicians during the index admission in the future. Beyond this, we may seek to "move the target." Given the chronic relationship often developed between the vascular surgeon and the patient with lower extremity vascular disease, the vascular surgery is in a prime position to collect highly granular, patient level data that allows for determination of a realistic readmission rate. Evaluation of individual center-based, as well as large database such as the Vascular Quality initiative, by the vascular surgery community may allow for consensus reporting on expected rates.

This study has a number of limitations. Most importantly are the limitations of a retrospective analysis of medical billing records at a single center. Though this method allowed for granular analysis of patient comorbidities not otherwise afforded by many large databases, it also limited the overall number of patients for statistical analysis. This precludes the ability to make definitive statements of significance for many of the factors that may influence readmission. Of note, socioeconomic status and race in particular may have an impact on readmission but were not captured within our analysis. However, recent orthopedic literature has not found an impact of these factors following surgery.[20] Another significant limitation is the grouping of the patient cohorts for analysis. Due to the inability to recognize the predicted difference in readmission rates using each separate cohort, the readmission cohorts were examined as a combined cohort against no readmission. These may, in fact, represent two distinct patient cohorts and may obscure the difference in reasons and outcomes from late readmissions versus earlier readmissions. Finally, because this is a single-hospital analysis, patients who may have sought care, either electively or in an urgent fashion, at another institute may not have been accurately captured.

Conclusions

Readmission following minor amputation is not uncommon and is multifactorial, including patient factors not infrequently beyond the control of the surgeon. Readmission following minor lower extremity amputation was associated with chronic renal insufficiency, history of peripheral artery bypass and manner of presentation, calling into question the ability of the surgeon to acutely mitigate readmission rates. As nearly half of the readmissions were for infection, this may represent an area for multi-disciplinary management to reduce readmission and subsequent reamputation rates. Further research is needed to establish evidence-based guidelines for acceptable readmission rates, especially in the era of increasing financial scrutiny for such occurrences.

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Table I

Baseline patient-specific characteristics and comorbid conditions stratified by readmission cohorts.

	Readmission		No readmission	
	≤60 days n=56	>60 days n=44	n=617	P-value
Age (years)	56 (50, 68)	52 (48, 62)	58 (49, 68)	0.34
Male	53.6% (30)	56.8% (25)	64.5% (398)	0.18
Non elective	53.6% (30)	59.1% (26)	30.2% (186)	<0.001
Hypertension	89.3% (50)	86.4% (38)	72.6% (448)	0.004
Diabetes mellitus	76.7% (43)	88.6% (39)	73.7% (455)	0.084
Congestive heart failure	14.3% (8)	15.9% (7)	12.8% (79)	0.81
Chronic obstructive pulmonary disease	5.4% (3)	4.6% (2)	6.0% (37)	0.91
Myocardial infarction	19.6% (11)	6.8% (3)	17.5% (108)	0.16
Cerebrovascular accident	16.1% (9)	9.1% (4)	10.4% (64)	0.39
Hyperlipidemia	46.4% (26)	38.6% (17)	33.2% (205)	0.12
Tobacco abuse	37.5% (21)	40.9% (18)	40.4% (249)	0.91
Peripheral arterial disease	87.5% (49)	95.5% (42)	67.4% (416)	<0.001
Previous lower extremity bypass	37.5% (21)	18.2% (8)	19.8% (122)	0.007
Renal insufficiency	42.9% (24)	61.4% (27)	26.7% (165)	<0.001
Renal failure requiring dialysis	23.2% (13)	27.3% (12)	11.4% (70)	0.001
Length of stay (days)				
Index	9 (4.5, 17)	9 (5.5, 15.5)	10 (5, 15)	0.98
Subsequent	11 (6, 15.5)	14 (7, 24)	--	

Table II

Univariate and multivariable predictors of readmission.

	Univariate analysis			Multivariable analysis		
	OR	95% CI	P-value	OR	95% CI	P-value
Age (years)	1.00	(0.98–1.01)	0.70	-	-	-
Male	1.49	(0.97–2.28)	0.07	1.22	(0.77–1.92)	0.40
Non elective status	2.94	(1.92–4.53)	<0.001	2.78	(1.77–4.35)	<0.001
Hypertension	2.77	(1.48–5.19)	0.002	1.92	(0.99–3.74)	0.06
Diabetes mellitus	1.62	(0.94–2.79)	0.08	-	-	-
Congestive heart failure	1.20	(0.66–2.18)	0.55	-	-	-
Chronic obstructive pulmonary disease	0.83	(0.32–2.15)	0.69	-	-	-
Myocardial infarction	0.77	(0.42–1.40)	0.39	-	-	-
Cerebrovascular accident	1.29	(0.68–2.44)	0.43	-	-	-
Hyperlipidemia	1.52	(0.99–2.33)	0.06	1.23	(0.79–1.93)	0.92
Tobacco abuse	0.94	(0.61–1.45)	0.80	-	-	-
Peripheral vascular disease	4.89	(2.41–9.89)	<0.001			
Previous lower extremity bypass	1.66	(1.03–2.67)	0.04	3.74	(1.82–7.71)	<0.001
Renal insufficiency	2.85	(1.85–4.39)	<0.001	2.19	(1.39–3.45)	0.001
Length of stay (index, days)	0.98	(0.96–1.01)	0.24	-	-	-