

Rates and predictors of readmission after minor lower extremity amputations

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Objective: 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 after vascular surgery, although the rate of readmission after limited digital amputations has not been specifically examined. The present study was therefore undertaken to define the rate of unplanned readmission among patients after 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 amputations using International Classification of Diseases, Ninth Revision, codes) from January 2000 through July 2012 were retrospectively reviewed. Data were collected for procedure- and hospital-related variables, level of amputation, length of stay, time to readmission, and level of reamputation. Patient demographics included hypertension, diabetes, hyperlipidemia, smoking history, and history of myocardial infarction, congestive heart failure, peripheral arterial disease, chronic obstructive pulmonary disease, and cerebrovascular accident.

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

Conclusions: Readmission after minor amputation was associated with limb amputation in the majority of cases. This study identified a number of nonmodifiable patient factors that are associated with an increased risk of readmission. Whereas efforts to reduce unplanned hospital readmissions are laudable, payers and regulators should consider these observations in defining unacceptable rates of readmission. Further, although beyond the scope of this study, it is not unreasonable to assume that pressure to reduce readmission rates in the population of patients with extensive comorbidity may induce practitioners to undertake amputation at a higher level initially to minimize the risk of readmission for reamputation and associated financial penalties and thus deprive the patient the chance for limb salvage. (*J Vasc Surg* 2015;62:101-5.)

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 the extension of affordable health care insurance to all citizens, the establishment of 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 health care. 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 used 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 population of patients with peripheral arterial disease (PAD). For example, in a recent analysis of the Medicare population, the readmission rate after 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 patients 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 and Muder⁷ reported a 49.1% reamputation rate at 3 years, with 78.9% of these patients undergoing reamputation within the first 6 months

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of their index operation. The rate of readmission within 30 days of lower extremity procedures, in general, is as high as 15.3%.⁶ Furthermore, hospital readmission after amputation appears to be associated not only with increased cost but also with 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 population of patients is crucial in order for vascular surgeons to develop strategies to reduce the rate of hospital readmission after amputations. Although a recent population-based study identified factors associated with readmission among patients undergoing limb amputations as well as transmetatarsal amputations (TMAs), to date there have been no studies examining the incidence of and factors associated with readmission exclusively after minor amputations.¹¹ The current study was designed to examine the incidence of unplanned early readmission after 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 Institutional Review Board 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 Diseases, Ninth Revision, codes corresponding to toe amputation (84.11) or TMA (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 vs emergent/urgent), level of amputation, side of amputation, date of operation, date of discharge, readmission date, and level of reamputation. Nonelective 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 and patients who 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.

After 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 subcohorts based on readmission within 60 days was then performed. Admissions within 60 days were chosen on the basis of 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, forward and backward fashion into a multivariable model. The Akaike information criterion, Hosmer-Lemeshow goodness of fit test, and likelihood ratio test were used to select the strongest model. Comparisons between categorical variables were performed with χ^2 or Fisher exact test when applicable. Nonparametric variables are reported as median (interquartile range) 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, Tex).

RESULTS

The initial query of electronic medical records during the study period returned 762 patients with matching International Classification of Diseases, Ninth Revision, codes for lower extremity amputation. After a complete chart review, 12 patients were subsequently excluded from analysis because of incomplete follow-up and 33 patients were excluded because of age younger than 18 years. This yielded 717 patients for analysis. Patient demographics and comorbidities are listed in [Table I](#). In general, patients were predominantly 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 I](#)).

The index procedure was a toe amputation in 565 patients (78.8%) and TMA in 152 patients (22.2%). The overall unplanned readmission rate was 13.9% (100 of 717), including 28 (28%) within 30 days, 28 (28%) from 30 to 60 days, and 44 (44%) > 60 days after the index

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