JRRD Volume 43, Number 7, Pages 917–928
November/December 2006
Journal of Rehabilitation Research & Development

Risk factors associated with mortality in veteran population following transtibial or transfemoral amputation

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Abstract—This study explored medical conditions associated with mortality among veterans following transfemoral amputation, transtibial amputation, or hip disarticulation. We applied logistic regression models to identify clinical factors associated with mortality postoperatively. The participants included patients with lower-limb amputations (n = 2,375) who were discharged from Veterans Health Administration hospitals between October 1, 2002, and September 30, 2003. Most (98.9%) were male. We measured cumulative in-hospital, 3-month, and 1-year mortality. The results were 180 in-hospital deaths, 368 by 3 months, and 634 by the 1-year postsurgical amputation date. Those who had perioperative systemic sepsis (odds ratio = 4.28, 95% confidence interval = 2.87–6.39) had more than a fourfold increased likelihood of in-hospital mortality. Congestive heart failure, renal failure, and liver disease were significantly associated with mortality at all time periods. Metastatic cancer was associated only at 3 months and 1 year. We concluded that high medical complexity and mortality rates attest to the need for careful medical oversight during the postacute rehabilitation period.

Key words: aging, amputation, artificial limbs, comorbidity, hospital mortality, mortality, regression analysis, rehabilitation, sepsis, veterans.

INTRODUCTION

Peripheral vascular disease (PVD) and diabetes mellitus are the most common reasons for lower-limb amputations [1–11]. Diabetes mellitus increases an individual's risk for amputation twelve- to fifteenfold and accounts for over 50 percent of all nontraumatic amputations in the United States annually [12–13]. Glycemic control, systolic blood pressure, microvascular complications (such as neuropathy, retinopathy, and nephropathy), and history of stroke have been found to be independent predictors of amputation [13].

Abbreviations: BIRLS = Beneficiary Identification Records Locator Subsystem; CI = confidence interval; COPD = chronic obstructive pulmonary disease; ICD-9-CM = International Classification of Diseases, 9th Revision, Clinical Modification; OR = odds ratio; PTF = Patient Treatment File; PVD = peripheral vascular disease; SD = standard deviation; VA = Department of Veterans Affairs; VAMC = VA medical center; VHA = Veterans Health Administration.

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DOI: 10.1682/JRRD.2006.03.0030

Mortality following a lower-limb amputation is quite high. Thirty-day mortality rates range from 6.3 to 42.3 percent [14–15]. Pohjolainen, Alaranta, and Wikstrom reported that 25.5 percent of patients with lower-limb amputations in Finland died within 2 months of the amputation and nearly 40 percent within 1 year [7]. Survival rates at 2 to 5 years are also poor, with over 50 percent of patients dying at 2 years and roughly 70 percent by 5 years [1,6–8,14–15].

Little has been written about the implications of high mortality rates in a population of patients typically considered for rehabilitation following surgery. This article explores the factors associated with mortality following transtibial or transfemoral amputation or hip disarticulation and considers the affect on the rehabilitation decision-making process.

METHODS

Description of Data Sources

To capture diagnostic information from different aspects of the patient care process, our analyses included four separate database sources of administrative data from the Veterans Health Administration (VHA). The first source was the Patient Treatment File (PTF) database, including the International Classification of Diseases, 9th Revision, Clinical Modification (ICD-9-CM) codes relevant to the entire inpatient hospital stay. One variable in the PTF is the principal diagnosis (Dx Prime), and nine additional variables are available to express secondary diagnoses. Another variable describes the diagnosis most responsible for the major part of the patient's full length of stay (Dx Lsf). The PTF record associated with the hospitalization within which the primary amputation surgery occurred is called the "index PTF" and is the baseline patient record.

The second source was a database that includes multiple individual "bed section" records that capture diagnostic information collected on patients receiving care on particular services (surgery, intensive care unit, medicine, etc.) during the entire hospital stay. Each bed section record includes a variable describing the medical condition most responsible for the length of stay in the bed section and four variables for secondary diagnoses directly related to care received during that treatment period. Patients typically have multiple bed section records for each hospitalization (associated with the index PTF). Each bed section record has admission and discharge dates which, when linked, correspond to the full PTF stay.

The third database source describes outpatient visits. During each outpatient visit, a principal diagnosis intended to describe the reason for the visit is coded (Dx Lsf) in one variable. Nine additional variables are available for secondary diagnostic information.

Finally, the fourth database was the Department of Veterans Affairs (VA) Beneficiary Identification Records Locator Subsystem (BIRLS) death file. The PTF identifies patients who died in a VA hospital. The BIRLS database contains records of all beneficiaries, including veterans whose survivors applied for death benefits [16]. Combining the BIRLS with the PTF will provide a thorough list of the veterans with lower-limb amputations who died. Neither the PTF nor the BIRLS provides specific cause of death information as indicated by an ICD-9-CM code.

Database Development

We combined ICD-9-CM codes from the PTF, bed section, and outpatient files to distinguish between diagnoses that likely contributed directly to amputation, otherwise known as etiological conditions, and concurrent conditions less likely to be directly related to the amputation, or comorbidities. The etiological and comorbid conditions were captured with ICD-9-CM codes in each PTF case record. Two physician authors established the list of etiological diagnoses in conjunction with a literature review and the conditions in the Dx Prime and Dx Lsf variables of the PTF [2,5,17–18]. Clinically, similar ICD-9-CM codes were grouped into 11 etiological categories (**Table 1**).

Rather than seeking to assign a single etiological cause for the amputation, we considered the cause of limb loss to be multifactorial, recognizing that many clinical conditions interact and ultimately lead to limb loss. Groups of ICD-9-CM codes evidencing trauma, systemic sepsis, skin breakdown, device infection, local significant infection, previous amputation complication, diabetes mellitus (types 1 and 2), chronic osteomyelitis, problems with peripheral circulation, congenital disorders, and cancer of the lower limb were included as etiologies. The etiological variables captured diagnostic information from the index PTF and all outpatient files where the date of contact fell within 3 months preceding the index PTF admission date. The etiological variables also included diagnostic codes from any bed section record where the admission date occurred no earlier than 3 months preceding the index PTF admission date.

Table 1.
Conditions contributing to etiology of amputation and their International Classification of Diseases, 9th Revision, Clinical Modification (ICD-9-CM) codes.

Condition	Diagnostic Description	ICD-9-CM Codes
Chronic Osteomyelitis	Chronic osteomyelitis of pelvic region and thigh, lower leg, ankle, and foot.	730.15–730.17
Congenital Deformity	Transverse deficiency of lower limb, longitudinal deficiency of lower limb.	755.31–755.39
Device Infection	Vascular device, internal orthopedic device, tissue graft, joint prosthesis.	996.1, 996.4, 996.52, 996.62, 996.66, 996.67, 996.69, 996.7, 996.74
Diabetes	Diabetes mellitus type 1 with and without manifestations, diabetes mellitus type 2 with and without manifestations.	250–250.93
Local Significant Infection	Gangrene, actinomycotic infections, cellulitis, pyogenic arthritis, infective myositis, necrotizing fasciitis.	040.0, 395, 440.24, 681.10, 682.6–682.8, 711.06, 728.0, 728.86, 729.4, 785.4
Lower-Limb Cancer	Malignant neoplasm of pelvic bones, sacrum, coccyx, long and short bones of lower limb, connective tissue of lower limb including hip, skin of lower limb including hip.	170.6–170.8, 171.3, 172.7, 173.7
Previous Amputation Complication	Infected amputation residual limb.	997.62
Problems with Peripheral Circulation	Atherosclerosis, aortic aneurysm, venous thrombosis, arterial stricture or stricture of graft, circulatory disease, venous insufficiency, organ or tissue replaced by blood vessel, gangrene, vascular complications of other vessels.	440.0–441.9, 442.3, 443.1–443.9, 444.0, 444.81, 447.1, 453.8, 459.81–459.9, 557.1–557.9, 785.4, 997.79, 434 (procedure), 38.48 (procedure)
Skin Breakdown	Ulcer or decubitus ulcer of lower limb.	440.23, 454.0, 454.2, 707.0, 707.10, 707.12–707.9
Systemic Sepsis	Septicemia, gram negative septicemia, E. coli, other type of systemic sepsis, bacteremia.	038.11, 038.40, 038.42, 038.8, 038.9, 790.7
Trauma	Acute osteomyelitis, closed or open fractures to lower limbs, fracture of one or more phalanges of foot, trauma to above-knee amputation or below-knee amputation, open wound to lower limb, burns of lower limb, fracture of lower limb, open wound of lower limb, late effects of injuries, poisonings, toxic effects and other external causes, crushing injury of lower limb.	730.05–730.08, 820.8, 821.21, 821.23, 821.30, 823.82, 823.92, 824.1, 826.0, 837.0, 890.1–890.2, 891.1–891.2, 892.1–892.2, 893.1–893.2, 894.1–894.2, 897.0–897.2, 905.4, 928.0–928.8, 945.22, 945.25–945.26, 945.32–945.33, 959.6–959.7

Codes from bed sections with admission dates after the surgical date were not included.

Comorbidity was expressed by the Elixhauser Measure. The Elixhauser consists of 31 separate measures expressing each condition separately by combining sets of related ICD-9-CM codes [19]. The conditions include ICD-9-CM codes describing congestive heart failure, arrhythmias, valvular disease, pulmonary circulation disease, PVD, hypertension, hypertension with complication, paralysis, other neurological disorders, chronic obstructive pulmonary disease (COPD), diabetes mellitus, diabetes mellitus with complication, hypothyroidism, renal failure, liver disease, peptic ulcer disease, acquired immune deficiency syndrome, lymphoma, metastatic cancer, solid tumor without metastases, rheumatoid arthritis, coagulopathy, obesity, weight loss, fluid and electrolyte disorders, chronic blood loss anemia, deficiency anemias, alcohol abuse, drug abuse, psychoses, and depression. Although less commonly reported in the literature than the Deyo version of the Charlson index [20], the Elixhauser Measure includes a broader array of diagnostic conditions. Some evidence has shown that it is a superior predictor of mortality [21]. Diabetes mellitus, diabetes mellitus with complication, and PVD were not included among the Elixhauser conditions, since they were already included as contributing etiological conditions. An individual could have multiple etiological or comorbid diagnoses. Each etiological or comorbid condition was coded “1” if present and “0” if absent.

Case Inclusions

This study included all 2,375 patients who were admitted to 100 VA medical centers (VAMCs) around the nation for transtibial or transfemoral amputation and hip disarticulation and had acute hospital discharge dates between October 1, 2002, and September 30, 2003. The hospital stay at the time the surgical amputation occurred represented the “index stay.” Patients were excluded if they had amputations that involved toes only or had a record of a previous lower-limb amputation within the 12 months preceding the index surgical amputation. Surgical amputation that includes transtibial, transfemoral, and hip disarticulation was captured with the surgical ICD-9-CM procedure codes 84.10, 84.13–84.19, and 84.91 [15].

Approach to Modeling

Using the statistical analyses, we developed a multivariate model to determine the clinical factors most associated with mortality following amputation. The analyses began with a series of cross-tabulations between each explanatory variable and mortality at three time-points: in-hospital, 3-month, and 1-year. The presence versus absence of each etiological and comorbid condition was expressed as a dichotomous indicator. Sociodemographic variables included age and sex. Age was entered as a series of segmented dummy variables, with 50 years and younger as the reference group. Females were the reference group for sex. Variables that predicted mortality were included in multivariate models only when expected values were five or more individuals. No case from our sample had an ICD-9-CM code for obesity as defined by the Elixhauser Measure. We used logistic regression modeling to control for multiple variables simultaneously and to compute 95 percent confidence interval (CI) around each odds ratio (OR). We assessed the impact of increasingly detailed information on the likelihood of mortality through a series of fixed multiple logistic regressions, where sets of clinically related variables were entered in sequential models. Amputation level and sociodemographic variables were entered together as a block, followed by contributing etiological diagnoses, and finally by comorbidities. The *C* statistic assessed model performance corresponding to the area under the receiver operating characteristic curve [22]. *C* statistics closer to 1.0 denote greater model prediction power. We applied the Hosmer-Lemeshow goodness-of-fit statistic to test-fit the data to the model. Statistical significance at $p < 0.05$ was used to reject the hypothesis of fit [23]. Analyses were performed with SAS Version 9.1 (SAS Institute, Cary, North Carolina). The *p*-values were two-sided, with $p < 0.05$ being considered statistically significant. An association is statistically significant at this level if its 95 percent CI does not include 1.0.

RESULTS

Study Population

Among the 2,375 veterans included in the study, 98.9 percent were male, average age was 67.3 years (standard deviation [SD] = 11.0), and average length of stay was 28.6 days (SD = 52.3). Over one-half or 59.5 percent of the amputations were transtibial, 39.7 percent were transfemoral, and 0.7 percent were hip. Four cases had an unknown level of amputation. Their level of amputation was imputed using hot-deck methods [24]. The in-hospital mortality rate was 7.6 percent, the 3-month mortality rate was 15.5 percent, and the 1-year mortality rate was 26.7 percent. **Table 2** characterizes the population by indicating mortality prevalence associated with each candidate predictor variable. **Table 3** shows the adjusted OR for each explanatory variable according to the completely saturated models of in-hospital, 3-month, and 1-year mortality. The *C* statistic for the model predicting in-hospital mortality based on age, sex, and level of amputation was 0.66. With the addition of the contributing etiological conditions, it increased to 0.73. With the addition of the Elixhauser conditions, the *C* statistic increased to 0.80. *C* statistic increases were similar for the 3-month and 1-year regressions; however, as shown by **Table 3**, model performance was slightly better for in-hospital than for 3-month and 1-year mortalities.

Table 2.
Characteristics of study sample (N = 2,375) according to mortality.

Characteristic	Prevalence	Survival	Mortality		
			In-Hospital	3-Month	1-Year
Age (mean ± SD)	67.3 ± 11.0	66.0 ± 10.9	70.0 ± 10.3	71.4 ± 10.3	71.0 ± 10.6
Sex, No. (%)					
Male	2,349 (98.9)	1,722 (73.3)	178 (7.6)	362 (15.4)	627 (26.7)
Female	26 (1.1)	19 (73.1)	2 (7.7)	6 (23.1)	7 (26.9)
Level of Amputation, No. (%)					
Transtibial	1,413 (59.5)	1,119 (79.2)	66 (4.7)	152 (10.8)	294 (20.8)
Transfemoral	942 (39.7)	607 (64.4)	109 (11.6)	211 (22.4)	335 (35.6)
Hip Disarticulation	16 (0.7)	11 (68.8)	5 (31.3)	5 (31.3)	5 (31.3)
Nonchronic Etiologies, No. (%)*					
Device Infection	266 (11.2)	204 (76.7)	21 (7.9)	40 (15.0)	62 (23.3)
Local Significant Infection	1,850 (77.9)	1,337 (72.3)	141 (7.6)	296 (16.0)	513 (27.7)
Previous Amputation Complication	197 (8.3)	156 (79.2)	12 (6.1)	20 (10.2)	41 (20.8)
Skin Breakdown	1,509 (63.5)	1,112 (73.7)	108 (7.2)	222 (14.7)	397 (26.3)
Systemic Sepsis	250 (10.5)	143 (57.2)	54 (21.6)	79 (31.6)	107 (42.8)
Trauma	326 (13.7)	253 (77.6)	16 (4.9)	30 (9.2)	73 (22.4)
Chronic Etiologies, No. (%)*					
Chronic Osteomyelitis	157 (6.6)	129 (82.2)	5 (3.2)	9 (5.7)	28 (17.8)
Diabetes Mellitus Type 1	416 (17.5)	310 (74.5)	32 (7.7)	48 (11.5)	106 (25.5)
Diabetes Mellitus Type 2	1,546 (65.1)	1,151 (74.5)	96 (6.2)	213 (13.8)	395 (25.5)
Problems with Peripheral Circulation	2,063 (86.9)	1,487 (72.1)	161 (7.8)	334 (16.2)	576 (27.9)
Chronic Conditions, No. (%)*					
Acquired Immune Deficiency Syndrome	17 (0.7)	13 (76.5)	2 (11.8)	3 (17.6)	4 (23.5)
Alcohol Abuse	130 (5.5)	105 (80.8)	9 (6.9)	17 (13.1)	25 (19.2)
Arrhythmias	382 (16.1)	226 (59.2)	52 (13.6)	97 (25.4)	156 (40.8)
Chronic Blood Loss Anemia	45 (1.9)	28 (62.2)	6 (13.3)	13 (28.9)	17 (37.8)
Chronic Obstructive Pulmonary Disease	477 (20.1)	298 (62.5)	47 (9.9)	101 (21.2)	179 (37.5)
Coagulopathy	104 (4.4)	65 (62.5)	18 (17.3)	32 (30.8)	39 (37.5)
Congestive Heart Failure	539 (22.7)	330 (61.2)	67 (12.4)	125 (23.2)	209 (38.8)
Deficiency Anemias	451 (19.0)	313 (69.4)	35 (7.8)	79 (17.5)	138 (30.6)
Depression	211 (8.9)	162 (76.8)	12 (5.7)	27 (12.8)	49 (23.2)
Drug Abuse	54 (2.3)	46 (85.2)	2 (3.7)	3 (5.6)	8 (14.8)
Fluid and Electrolyte Disorders	447 (18.8)	287 (64.2)	61 (13.6)	105 (23.5)	160 (35.8)
Hypertension	1,390 (58.5)	1,047 (75.3)	85 (6.1)	186 (13.4)	343 (24.7)
Hypertension with Complication	13 (0.5)	9 (69.2)	1 (7.7)	2 (15.4)	4 (30.8)
Hypothyroidism	89 (3.7)	57 (64.0)	8 (9.0)	15 (16.9)	32 (36.0)
Liver Disease	81 (3.4)	54 (66.7)	11 (13.6)	21 (25.9)	27 (33.3)
Lymphoma	9 (0.4)	5 (55.6)	2 (22.2)	4 (44.4)	4 (44.4)
Metastatic Cancer	32 (1.3)	14 (43.8)	5 (15.6)	16 (50.0)	18 (56.3)
Other Neurological Disorders	72 (3.0)	46 (63.9)	11 (15.3)	16 (22.2)	26 (36.1)
Paralysis	93 (3.9)	77 (82.8)	4 (4.3)	8 (8.6)	16 (17.2)
Peptic Ulcer Disease with Bleeding	35 (1.5)	28 (80.0)	3 (8.6)	5 (14.3)	7 (20.0)
Psychoses	164 (6.9)	124 (75.6)	13 (7.9)	26 (15.9)	40 (24.4)
Pulmonary Circulation Disease	17 (0.7)	7 (41.2)	4 (23.5)	6 (35.3)	10 (58.8)
Renal Failure	410 (17.3)	242 (59.0)	59 (14.4)	98 (23.9)	168 (41.0)
Rheumatoid Arthritis	32 (1.3)	24 (75.0)	1 (3.1)	4 (12.5)	8 (25.0)

Table 2. (Continued)
Characteristics of study sample (*N* = 2,375) according to mortality.

Characteristic	Prevalence	Survival	Mortality		
			In-Hospital	3-Month	1-Year
Chronic Conditions, No. (%)*(continued)					
Solid Tumor Without Metastases	166 (7.0)	98 (59.0)	16 (9.6)	31 (18.7)	68 (41.0)
Valvular Disease	111 (4.7)	61 (55.0)	15 (13.5)	30 (27.0)	50 (45.0)
Weight Loss	109 (4.6)	74 (67.9)	8 (7.3)	25 (22.9)	35 (32.1)

Note: Only one person was coded with a congenital deformity, and no persons were coded with either lower-limb cancer or obesity.
*Cases associated with etiologies and chronic conditions do not sum to total sample size because a person can have multiple conditions.
SD = standard deviation.

Etiological Factors

In-hospital mortality and likelihood of mortality at all subsequent time periods were most strongly associated with systemic sepsis in the perioperative period after the adjustment for sociodemographic differences, level of amputation, and comorbidities. Likelihood of mortality was not significantly increased according to any of the other etiological factors. In-hospital rates of mortality were significantly lower among patients identified as having diabetes mellitus type 2 and 3-month mortality rates were lower for those coded with chronic osteomyelitis. Two of the eleven etiological category variables, congenital deformity (one case) and lower-limb cancer (zero cases), were not analyzed in the multivariate models because of insufficient prevalence.

Level of Amputation

After adjusting for age, etiological factors, and comorbidities, we found almost a thirteenfold increased risk of in-hospital mortality among patients with hip disarticulation compared with those with transtibial amputation (OR = 12.94; 95% CI = 3.36–49.86). In-hospital mortality was also elevated for veterans with transfemoral amputations compared with transtibial (OR = 2.52; 95% CI = 1.75–3.63). No association was found between increased likelihood of 1-year mortality and hip disarticulation, whereas mortality risk remained elevated among those with transfemoral amputations compared with transtibial (OR = 2.00; 95% CI = 1.61–2.48).

Comorbidities

Using logistic regression models, we found that adjusted in-hospital, 3-month, and 1-year mortalities were significantly elevated among patients with evidence of congestive heart failure, renal failure, and liver disease. Three-month mortality likelihood was significantly increased with coagulopathy. In-hospital and 3-month mortality rates were higher among those who experienced in-hospital fluid and electrolyte disorders. Those patients with documented metastatic cancer had higher 3-month and 1-year mortality rates. Among those with solid tumor without metastases and those with COPD, 1-year mortality, but not 3-month or in-hospital, was elevated. Patients with hypertension listed among their diagnoses had a reduced likelihood of in-hospital, 3-month, and 1-year mortality.

Age

Unadjusted risk of mortality increased with age. Strength of this association decreased progressively with the addition of more diagnostic details. The association between in-hospital mortality and age was no longer statistically significant after adjusting for level of amputation, etiological contributing factors, and comorbid conditions. In contrast, the association between longer-term mortality and age diminished but remained statistically significant among the oldest veterans with amputations. When compared with those aged 70 or younger, veterans with amputations aged 71 and older had higher adjusted 3-month mortality risks. Only those aged 81 and older had higher adjusted 1-year mortality risks. We found nearly a fourfold increased risk of mortality at 1 year, even after removing the effects of perioperative medical complexity among those over the age of 86 (OR = 3.86; 95% CI = 1.91–7.79). Among those over the age of 86 (OR = 6.86; 95% CI = 2.53–18.59), close to a sevenfold increase in likelihood of mortality at 3 months was found.

Table 3.
Odds ratio (OR) with 95% confidence interval (CI) for likelihood of mortality in total population (N = 2,375).

Variable	OR (95% CI)		
	In-Hospital	3-Month	1-Year
Age (Ref: 50 or Younger)			
51–55	1.43 (0.44–4.64)	1.27 (0.50–3.23)	0.68 (0.38–1.22)
56–60	1.86 (0.58–5.92)	2.22 (0.91–5.39)	0.78 (0.44–1.37)
61–65	2.05 (0.64–6.62)	2.40 (0.98–5.91)	0.99 (0.56–1.76)
66–70	2.41 (0.77–7.51)	2.24 (0.92–5.43)	0.93 (0.54–1.62)
71–75	2.43 (0.79–7.47)	3.45 (1.45–8.20)*	1.60 (0.94–2.74)
76–80	2.51 (0.81–7.78)	3.46 (1.45–8.23)*	1.54 (0.90–2.65)
81–85	2.04 (0.61–6.85)	5.20 (2.11–12.77)*	2.13 (1.19–3.82)*
86	3.43 (0.91–12.98)	6.86 (2.53–18.59)*	3.86 (1.91–7.79)*
Level of Amputation (Ref: Transtibial)			
Transfemoral	2.52 (1.75–3.63)*	2.06 (1.59–2.68)*	2.00 (1.61–2.48)*
Hip Disarticulation	12.94 (3.36–49.86)*	4.54 (1.22–16.85)*	2.47 (0.74–8.23)
Sex (Ref: Female)			
Male	0.61 (0.13–2.86)	0.45 (0.16–1.22)	0.82 (0.32–2.10)
Nonchronic Etiologies			
Device Infection	0.87 (0.51–1.48)	0.97 (0.65–1.44)	0.87 (0.62–1.21)
Local Significant Infection	0.95 (0.61–1.49)	1.04 (0.74–1.45)	1.11 (0.84–1.46)
Previous Amputation Complication	1.02 (0.53–1.96)	0.76 (0.46–1.27)	0.85 (0.58–1.26)
Skin Breakdown	0.92 (0.64–1.32)	0.93 (0.71–1.21)	0.98 (0.79–1.22)
Systemic Sepsis	4.28 (2.87–6.39)*	3.08 (2.20–4.32)*	2.26 (1.67–3.06)*
Trauma	0.67 (0.37–1.19)	0.65 (0.42–1.00)	0.95 (0.70–1.30)
Chronic Etiologies			
Chronic Osteomyelitis	0.42 (0.16–1.10)	0.37 (0.18–0.77)	0.68 (0.43–1.08)
Diabetes Mellitus Type 1	1.23 (0.77–1.94)	0.76 (0.53–1.10)	1.00 (0.76–1.32)
Diabetes Mellitus Type 2	0.63 (0.43–0.93)	0.88 (0.66–1.16)	0.99 (0.78–1.25)
Problems with Peripheral Circulation	1.17 (0.65–2.12)	1.26 (0.80–1.99)	1.23 (0.86–1.76)
Chronic Conditions			
Acquired Immune Deficiency Syndrome	1.71 (0.27–10.73)	1.43 (0.33–6.21)	1.05 (0.30–3.69)
Alcohol Abuse	1.06 (0.49–2.31)	0.98 (0.53–1.79)	0.81 (0.49–1.35)
Arrhythmias	1.35 (0.90–2.02)	1.26 (0.93–1.71)	1.30 (1.00–1.69)
Chronic Blood Loss Anemia	1.77 (0.67–4.67)	1.91 (0.91–4.00)	1.49 (0.76–2.91)
Chronic Obstructive Pulmonary Disease	1.04 (0.70–1.56)	1.23 (0.92–1.65)	1.65 (1.29–2.10)*
Coagulopathy	1.84 (1.00–3.39)	2.01 (1.22–3.30)*	1.36 (0.85–2.16)
Congestive Heart Failure	1.81 (1.24–2.64)*	1.66 (1.25–2.20)*	1.65 (1.30–2.09)
Deficiency Anemias	0.81 (0.53–1.24)	0.98 (0.72–1.33)	1.05 (0.82–1.35)
Depression	0.85 (0.43–1.67)	1.00 (0.62–1.59)	1.05 (0.73–1.52)
Drug Abuse	0.95 (0.20–4.46)	0.68 (0.19–2.41)	0.93 (0.40–2.13)
Fluid and Electrolyte Disorders	1.87 (1.29–2.71)*	1.46 (1.09–1.96)*	1.28 (1.00–1.64)
Hypertension	0.67 (0.48–0.94)*	0.70 (0.55–0.90)*	0.78 (0.63–0.96)*
Hypertension with Complication	0.52 (0.05–5.40)	0.72 (0.13–3.90)	0.94 (0.25–3.58)
Hypothyroidism	0.92 (0.40–2.12)	0.80 (0.42–1.51)	1.14 (0.69–1.89)
Liver Disease	2.29 (1.04–5.02)*	3.07 (1.66–5.68)*	2.04 (1.19–3.50)*
Lymphoma	1.90 (0.27–13.28)	2.94 (0.58–14.86)	1.12 (0.24–5.20)
Metastatic Cancer	1.86 (0.64–5.43)	5.24 (2.40–11.43)*	3.16 (1.47–6.80)*
Other Neurological Disorders	3.20 (1.55–6.61)*	1.84 (0.99–3.43)	1.81 (1.06–3.10)

Table 3. (Continued)
Odds ratio (OR) with 95% confidence interval (CI) for likelihood of mortality in total population (*N* = 2,375).

Variable	OR (95% CI)		
	In-Hospital	3-Month	1-Year
Chronic Conditions (continued)			
Paralysis	0.42 (0.14–1.23)	0.48 (0.22–1.07)	0.55 (0.31–1.00)
Peptic Ulcer Disease with Bleeding	1.71 (0.47–6.27)	1.41 (0.50–3.94)	0.92 (0.38–2.25)
Psychoses	1.10 (0.57–2.11)	1.08 (0.66–1.76)	0.89 (0.59–1.35)
Pulmonary Circulation Disease	2.16 (0.57–8.22)	2.00 (0.64–6.26)	2.31 (0.79–6.79)
Renal Failure	2.29 (1.55–3.38)*	1.87 (1.38–2.53)*	2.21 (1.71–2.85)*
Rheumatoid Arthritis	0.26 (0.03–2.26)	0.64 (0.19–2.13)	0.89 (0.37–2.18)
Solid Tumor Without Metastases	1.51 (0.84–2.73)	1.19 (0.76–1.86)	1.94 (1.36–2.78)*
Valvular Disease	1.09 (0.57–2.07)	1.31 (0.80–2.15)	1.50 (0.98–2.32)
Weight Loss	0.61 (0.27–1.39)	1.28 (0.75–2.16)	1.15 (0.73–1.82)
C Statistic for Full Model	0.80	0.77	0.75
Hosmer-Lemeshow *p*-Value	0.99	0.60	0.09

*Statistically significant, $p = 0.05$.
Ref = reference (for group).

DISCUSSION

The in-hospital mortality rate found in this study is consistent with previously reported data; however, the 1-year survival rate was slightly higher in this population than in other VA reports and among those treated in the private sector (**Table 4**) [6,14,25–27]. Some trend has shown that over the years, survival rates have improved; however, based on a post hoc random-effects model, survival rates were not statistically significantly higher than those found in the other studies. The trend toward higher survival rates found in our study may be related to overall improvements in technology that were not available to clinicians when the earlier studies were conducted. It may also be that VA patients have better access to the full continuum of services ranging from emergent to long-term and nursing home care than private sector patients. Perhaps veterans who have a lower-limb amputation performed in the VA healthcare system are provided a more coordinated and vertically integrated approach to postacute services, which in turn may affect longer-term survival.

Systemic sepsis was the single most predictive etiological factor of mortality in our analysis. In a recent retrospective study at an academic tertiary care center, Aulivola et al. found that cardiac complications were the leading cause of death within 30 days following lower-limb amputation (10/35), followed by sepsis (5/35) and pneumonia (4/35) [26]. The 30-day mortality rate was 8.6 percent in this population, and patients with sepsis requiring guillotine amputation had a significantly higher 30-day mortality rate of 14.3 percent [26].

Age has been noted to predict mortality following nontraumatic lower-limb amputation [15,25]. However, in this analysis, except for very elderly patients, the importance of age as a factor declined with the addition of more diagnostic details. This finding suggests that the associated burden of illness, rather than age, most influences mortality among persons with lower-limb amputation. Comorbidities appeared to affect mortality rates postamputation in logical ways. Severe progressive conditions including renal failure, liver disease, and congestive heart failure predicted mortality at all three postoperative time-points. Unsurprisingly, fluid and electrolyte disorders during the hospitalization were associated with higher rates of in-hospital and 3-month mortality. Also reasonable was that the presence of metastatic cancer and solid tumor without metastases significantly increased likelihood of mortality at 3 months and 1 year, respectively.

The comorbid conditions found to be positive predictors of mortality are consistent with other studies. Collins et al. identified COPD, renal dysfunction, and poor functional status preoperatively as indicators for 30-day mortality [25]. Using VA National Surgical Quality Improvement Program data, O'Hare et al. found that mortality rates within 30 days following lower-limb nontraumatic amputation were quite

Table 4.
Comparison of survival rates (%) over time within Department of Veterans Affairs (VA) and non-VA sectors.

Author	Year Published	Data Collected	VA Population	In-Hospital (%)			1-Year (%)		
				Transtibial	Transfemoral	Hip Disarticulation	Transtibial	Transfemoral	Hip Disarticulation
Bates et al. [1]	2006	2002–2003	Yes	95.3	88.4	68.7	79.2	64.6	68.7
Feinglass et al. [2]	2001	1991–1995	Yes	93.7	86.7	—	77.0	59.0	—
Mayfield et al. [3]	2001	1992	Yes	93.0	88.9	—	—	—	—
Aulivola et al. [4]	2004	1990–2001	No	94.3	83.5	—	74.5	50.6	—
Pohjolainen and Alaranta [5]	1998	1984–1985	No	—	—	—	70.0	—	—
Rommers et al. [6]	1997	1991–1992	No	89.0*	89.0*	—	—	—	—
Pohjolainen et al. [7]	1989	1984–1985	No	—	—	—	69.9	53.8	71.4

*Survival was not reported by level of amputation.

1. Bates B, Stineman MG, Reker DM, Kurichi JE, Kwong PL. Risk factors associated with mortality in veteran population following transtibial or transfemoral amputation. J Rehabil Res Dev. 2006;43(7):917–28.
2. Feinglass J, Pearce WH, Martin GJ, Gibbs J, Cowper D, Sorensen M, Henderson WG, Daley J, Khuri S. Postoperative and late survival outcomes after major amputation: Findings from the Department of Veterans Affairs National Surgical Quality Improvement Program. Surgery. 2001;130(1):21–29. [PMID: 11436008]
3. Mayfield JA, Reiber GE, Maynard C, Czerniecki JM, Caps MT, Sangeorzan BJ. Survival following lower-limb amputation in a veteran population. J Rehabil Res Dev. 2001;38(3):341–45. [PMID: 11440266]
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5. Pohjolainen T, Alaranta H. Ten-year survival of Finnish lower limb amputees. Prosthet Orthot Int. 1998;22(1):10–16. [PMID: 9604271]
6. Rommers GM, Vos LD, Groothoff JW, Schuiling CH, Eisma WH. Epidemiology of lower limb amputees in the north of the Netherlands: Aetiology, discharge destination and prosthetic use. Prosthet Orthot Int. 1997;21(2):92–99. [PMID: 9285952]
7. Pohjolainen T, Alaranta H, Wikstrom J. Primary survival and prosthetic fitting of lower limb amputees. Prosthet Orthot Int. 1989;13(2):63–69. [PMID: 2780262]

high in patients on dialysis and that patients with even moderate renal insufficiency were at higher mortality risk than those with mild or no renal disease [27]. Kantonen et al. likewise found the presence of coronary artery disease and renal dysfunction to be associated with higher postoperative mortality rates [28]. The presence of complex medical conditions such as congestive heart failure, hypothyroidism, renal failure, coagulopathies, and fluid and electrolyte disorders signals the need for vigilant acute and longer-term medical management of patients with a lower-limb amputation. In one VA study, nearly 50 percent of the veterans with congestive heart failure died within 1 year [15].

Our findings that diabetes mellitus and hypertension appeared protective regarding mortality are clinically counterintuitive, but consistent with the findings of others. Patients who have these conditions documented in their administrative records have significantly lower rates of mortality [29–30]. Perhaps the coding of more severe acute and complicating conditions among the seriously ill takes precedence. Or, perhaps because these patients have chronic conditions, they are monitored more carefully, and when problems do arise, they are caught early and do not develop into fatal issues.

Our finding that hip disarticulation was strongly associated with in-hospital mortality, but not longer-term mortality, suggests that the need for this high level of amputation is signaling greater perioperative acuity and complications but may not be associated with comorbidities associated with mortality. Other studies have shown lower survival rates for more proximal amputation levels [8,31–32]. Pohjolainen et al. reported survival rates at 2 months of 83.3 percent for patients with transtibial amputations, dropping to 67.7 percent for transfemoral [7]. By 1 year, survival was 69.9 and 53.8 percent, respectively [7].

For rehabilitation of patients following a nontraumatic lower-limb amputation, care teams need a better understanding of mortality risk in the months and years following surgery to target services to this population. For patients at high risk of mortality within 6 months to 1 year, early intervention and rehabilitation goals that focus on appropriate mobilization, activities of daily living, and quality-of-life issues become critical. A better understanding of mortality risk factors would help care teams develop improved, integrated treatment plans for frail dysvascular patients at high mortality risk. A balance between early intervention and longer-term goals is the key.

Evidence suggests that with early and aggressive rehabilitation following stroke, patients improved faster, which led to higher functioning levels more quickly, even though the control group caught up to them within 9 months [33]. For a patient with a recent amputation, our data showed that 3 months or 1 year is a large percentage of the patient's remaining life span and that rehabilitation must focus on appropriate activities that help patients function more quickly, thus adding quality to their remaining lifetime. While mortality following a lower-limb amputation for vascular disease is high, many patients who survive the immediate postoperative period receive a prosthesis [1,7,9,34–38]. These patients function reasonably well, at least in the short term. When one considers the high-mortality and long-term outcomes, optimal postoperative care following a lower-limb amputation requires close collaboration and a team approach involving surgery, medicine, and rehabilitation to identify the most appropriate treatments, goals, and location of care.

While numerous clinical practice guidelines exist for the poststroke population [39–42], review of the literature found none for the postamputation population. Providing early and aggressive rehabilitation following lower-limb amputation makes intuitive sense, but evidence is lacking and should be a focus of future research. Development of a rehabilitation clinical pathway for patients with amputation would be one possible method of ensuring early postamputation involvement of rehabilitation professionals and could help in the careful analysis of the impact of early intervention. Because our sample was primarily male, the degree to which findings would generalize to female is unknown.

CONCLUSIONS

High mortality rates attest to the frailty of the postamputation veteran population. Rehabilitation strategies targeted to enhance the function of this larger population of patients with amputations need to address the shortened life span of many of these patients, and rehabilitation goals need to be adjusted accordingly. Careful medical oversight in the weeks and months following a nontraumatic amputation is critical in helping these patients achieve their highest functioning levels.

ACKNOWLEDGMENTS

This material is based upon work supported in part by the National Institutes of Health (R01 HD042588). It is also supported by resources and the use of facilities at the Samuel S. Stratton VAMC, Albany, New York, and the Kansas City VAMC, Kansas City, Missouri.

The opinions and conclusions of the authors are not necessarily those of the sponsoring agencies.

The authors have declared that no competing interests exist.

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Submitted for publication March 23, 2006. Accepted in revised form August 30, 2006.