Functional outcome in a contemporary series of major lower extremity amputations

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Purpose: **We undertook this study to document the functional natural history of patients undergoing major amputation in an academic vascular surgery and rehabilitation medicine practice.**
Methods: **A retrospective review was conducted of consecutive patients undergoing major lower extremity amputation and rehabilitation in a university and Department of Veterans Affairs hospital. Main outcome variables included operative mortality, follow-up, survival, median time to incision healing, secondary operative procedures for wound management, and conversion from below-knee amputation (BKA) to above-knee amputation (AKA). For surviving patients, quality of life was determined by degree of ambulation, eg, outdoors, indoors only, or no ambulation; use of a prosthesis; and independence, eg, community housing or nursing facility.**
Results: **From August 1997 through March 2002, 154 patients (130 men; median age, 62 years) underwent 172 major amputations, 78 AKA and 94 BKA, because of either critical limb ischemia (87%) or diabetic neuropathy (13%). Thirty-day operative mortality was 10%. Mean follow-up was 14 months. Healing at 100 and 200 days, as determined with the Kaplan-Meier method, was 55% and 83%, respectively, for BKA, and 76% and 85%, respectively, for AKA. Twenty-three BKA and 16 AKA required additional operative revision, and 18 BKA ultimately were converted to AKA. Survival was 78% at 1 year and 55% at 3 years. Function in surviving patients at 10 and 17 months, respectively, was as follows: 21% and 29% of patients ambulated outdoors, 28% and 25% ambulated indoors only, and 51% and 46% of patients were nonambulatory; 32% and 42% of patients used prosthetic limbs; and 17% and 8% of patients who lived in the community before amputation required care in a nursing facility.**
Conclusions: **We were surprised to find that vascular patients in a contemporary setting who require major lower extremity amputation and rehabilitation often remain independent despite infrequent prosthesis use and outdoor ambulation. Although any hope for postoperative ambulation in this population requires salvaging the knee joint, because of the morbidity incurred in both wound healing and rehabilitation efforts, aggressive effort should be reserved for selected patients at good risk. Ability to predict ambulation after BKA in the vascular population is poor. (J Vasc Surg 2003;38: 7-14.)**

Most vascular surgeons approach critical limb ischemia in neurologically intact patients with the goal to save as much limb length as possible. Digit amputation is preferred over ray amputation, transmetatarsal amputation is preferred over below-knee amputation (BKA), and BKA is preferred over above-knee amputation (AKA). However, significant technical difficulty and patient morbidity are associated with incision of any type distal to the knee joint in patients with critical limb ischemia.[1-4] The motivation for efforts to salvage the knee joint in patients in whom amputation is necessary has been the lesser energy expenditure associated with prosthetic use after healed BKA compared with AKA.[5] Inability to ambulate was presumed to necessitate long-term nursing care for most patients with critical limb ischemia.[6] Ambulation is an important postoperative goal after major lower extremity amputation for patients and physicians alike.

With a population that is aging, increasingly obese, and with significant comorbid conditions, ubiquitous ambulation for all patients with major lower extremity amputation may be impractical. Since passage of the Americans with Disabilities Act in 1990,[7] the environment into which amputees must assimilate has changed markedly. Traditional arguments for preserving maximum limb length may be invalid. At both our university hospital and Department of Veterans Affairs Medical Center, we have a modern rehabilitation service that aggressively pursues postoperative ambulation for patients without neurologic impairment or dementia. We have developed a database that permits collection of multiple clinical variables and functional outcome in this population. Analysis of comorbid conditions and functional results of major lower extremity amputation on the vascular service at our two hospitals forms the basis of this report.

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MATERIAL AND METHODS

At the University of Colorado Health Sciences Center and the Denver Veterans Affairs Medical Center, vascular surgeons perform most major lower extremity amputations. No standard preoperative vascular evaluation other than physical examination to assess for presence of a femoral pulse and normal calf skin temperature for below-knee healing, and clinical judgment as to whether postoperative ambulation would be probable, considering comorbid conditions including obesity, cardiopulmonary disease, and preoperative ambulatory status, is used to determine level of amputation. Most AKAs were performed on the basis of poor functional prognosis rather than poor healing potential. However, some patients considered not significant ambulatory candidates refused primary AKA and underwent BKA. The Burgess technique[8] was used for BKA. Use of immediate protective casting varied among the three attending surgeons. Protective casts were placed on all limbs operated on in patients referred for rehabilitation medicine in the immediate postoperative period, provided they had no open wounds. Our rehabilitation service aggressively pursues some level of ambulation in all patients without dementia or neurologic impairment.

In December 1998, with initial grant funding from The Hartford Foundation, we created a Health Insurance Portability and Accountability Act (HIPAA)[9]–compliant Internet-based comprehensive database (MedXchange, Tampa, Fla) regarding functional outcome in patients with critical limb ischemia at the University of Colorado Health Sciences Center and Denver Veterans Affairs Medical Center. The initial plan was to track patients undergoing lower extremity revascularization; however, the database quickly became a tool to track all patients seen at both hospitals with critical limb ischemia, as defined by Reporting Standards, or foot lesions due to diabetic neuropathy. The data were both prospectively and retrospectively entered into the database.

The database is relational, with multiple forms linked to a patient identification number. A password-protected key with patient identifiers housed locally is used to correlate identification numbers on the Internet database to patients allowing HIPAA-compliant data entry. Data collected at enrollment include demographics, comorbid conditions, and previous vascular procedures. Data related to comorbidity were collected from the diagnosis in the problem list of the admission history and physical examination or the discharge summary. The remainder of the data were entered multiple times per patient, categorized by date to allow longitudinal collection of events and outcome. Patient variables include symptoms (duration before presentation, rest pain or necrosis, and details of any major adverse antecedent events in the 6 months before presentation to the vascular surgeon that may have contributed to eventual limb loss), foot lesions (categorization of extent of foot necrosis at presentation), laboratory values, blood pressure, weight, hospitalization history (admission and discharge dates, discharge status with regard to independence and ambulation, complications, and all operative procedures), and follow-up (incision healing, independence and ambulation, prosthesis use, and significant adverse medical and functional events).

Statistical analysis. Data were analyzed with SAS software (SAS, Cary, NC), broken down into demographics, hospital care, and outcome. Patient or symptom demographic data included age, gender, comorbidity (from the medical history), body mass index [BMI], previous vascular procedures, baseline laboratory values (hematocrit, albumin concentration), duration of symptoms before vascular surgical evaluation, and type of symptoms (rest pain, necrosis). Details of the 6-month history before referral for vascular surgery included any major adverse event that precipitated or contributed to the presenting problem that led to amputation.

Limb lesion demographics included a detailed description of the nature of necrotic lesions, including extent of the necrotic process based on findings at physical examination at initial presentation. Necrotic extent was categorized as forefoot (single versus multiple sites and digit-limited versus involvement of the metatarsal head, and location of more proximal lesions), malleolar, midfoot, heel, and global. Lesions were classified as ulceration, dry gangrene, or sepsis, with the most severe process involved predominating. For example, clinical wet gangrene would be categorized as sepsis, with the understanding that differentiation between the two is not always clear at physical examination alone. However, limb salvage decisions are made in part on the basis of findings at physical examination of the foot, because foot imaging can be innacurate[10] and in this series was not uniformly performed because of the variety of processes and extent of lesions, and the classification system was designed to reflect this.

Hospital care data included length of stay, details regarding amputation (guillotine, BKA, AKA, and wound debridement), and in-hospital complications. Longitudinal functional outcome included time to incision healing, need for additional operations, conversion of BKA to AKA, incidence over time of prosthesis use, ambulation status, and independence. For these analyses, BKA and AKA groupings were made on an intention to treat basis. Therefore the BKA group included surviving patients who first underwent BKA, and therefore included some patients who eventually underwent conversion to AKA. The final three functional outcome items were grouped at 6-month and 12-month intervals. These were defined as the first follow-up data identified 6 or more months and 12 or more months after the amputation date for each surviving patient. Therefore the data represent mean follow-up data for all patients at 10.3 and 17.5 months, because the study included no specific follow-up intervals. In addition, subgroup analysis of function was performed in patients who were nonambulatory at baseline, patients with mental illness or substance abuse, and age stratified at 75 years.

Data were summarized descriptively with frequency and percentage of patients or procedures, as appropriate, for categorical end points such as gender, risk factors,

Table I. Baseline medical comorbidity and functional variables in patients undergoing major lower extremity amputation

Risk factor	*n*	*%*
Medical (N = 153*)		
Diabetes	100	65
Coronary artery disease	60	39
Previous MI	40	26
CHF	38	25
Previous CABG	24	16
Smokers	131	86
Current	73	48
Stroke	22	14
COPD	23	18
O_2 dependent	4	3
Renal replacement	27	18
Functional (N = 153*)		
Mental illness	25	16
Substance abuse	54	35
Total hip arthroplasty	9	6
Independence (N = 154)		
Community living	134	87
Care facility resident	20	13
Ambulation (N = 154)		
Nonambulatory	25	16
Indoors only	23	15
Outdoors	106	69

MI, Myocardial infarction; *CHF,* congestive heart failure; *CABG,* coronary artery bypass graft; *COPD,* chronic obstructive pulmonary disease.
*Data not available for one patient.

Table II. Baseline laboratory values in patients undergoing major lower extremity amputation

Value	*Mean*	*SD*	*25th percentile*	*75th percentile*
Albumin* (Gmg/dL)	2.4	0.7	1.9	2.9
Hematocrit† (%)	33.2%	5.7	29.1	37.4
BMI‡	25	5.7	20.9	28.1

*Value closest to date of amputation or initial vascular evaluation ± 30 days; available for 101 patients.
†Preoperative value closest to amputation date within 30 days; available for 97 patients.
‡Body mass index before amputation; available for 118 patients.

complications, and functional outcome. Continuous end points such as age, BMI, and albumin concentration were summarized as mean, standard deviation, and percentile. Comparisons between baseline comorbidity and functional outcome categories for patients with BKA versus AKA were performed with the χ^2 test. Patient survival and time to incision healing were determined with the Kaplan-Meier method. $P \leq .05$ was considered statistically significant.

RESULTS

From August 1, 1997, through March 2, 2002, 154 patients (130 men; median age, 62 years; 90 from the Veterans Affairs Medical Center) underwent major lower extremity amputation. Clinical data for these patients are presented in Table I, and laboratory values are presented in Table II. Variables that differed significantly between patients with BKA and AKA, respectively, were congestive heart failure (18% vs 35%; $P = .02$), diabetes (72% vs 56%; $P = .03$), renal replacement (19% vs 3%; $P = .004$), and previous myocardial infarction (20% vs 35%; $P = .04$). Forty-seven patients (30%) had some history of claudication. Previous vascular procedures at presentation included one or more revascularization procedures in 41 patients (27%), involving the present symptomatic limb in 90%. Forty patients (26%) had undergone one or more previous minor amputations, involving the present symptomatic limb in 78%. Twenty-three patients (15%) had undergone a previous contralateral major lower extremity amputation. In the 6 months before vascular surgery consultation, 38 patients (25%) had one or more major adverse events (n = 44) that contributed in part to eventual limb loss. The most common event was graft occlusion (n = 15); other major events included myocardial infarction (n = 6), major fracture (n = 11), stroke (n = 4), ruptured abdominal aortic aneurysm (n = 3), burn trauma (n = 2), coronary artery bypass vein harvest (n = 2), and lower extremity arterial graft infection (n = 1). Mean duration of symptoms before vascular consultation was far less for patients with rest pain (27 ± 55 days) than for patients with foot necrosis (73 ± 82 days).

At presentation, 87% of patients (n = 134) had critical limb ischemia and 13% of patients (n = 20) had complications of diabetic neuropathy. Details of foot lesions in the patients with necrosis are presented in Table III. At initial evaluation, 62 patients were considered candidates for revascularization. However, 25 patients eventually underwent amputation, despite patent bypass grafts or successful interventions (17 surgical, 8 percutaneous transluminal angioplasty [PTA]), because of ongoing foot ischemia; 21 patients eventually underwent amputation after reconstruction (20 surgical, 1 PTA), because of occlusion or infection; 10 patients had no acceptable distal target for bypass grafting, as demonstrated on arteriograms; and 6 patients eventually underwent amputation because of deterioration in medical status before revascularization. Minor amputation was performed in 7 patients, without arteriography, because of limited foot lesions, normal arterial circulation at noninvasive evaluation, or significant comorbidity that precluded revascularization. The remaining 85 patients underwent primary major lower extremity amputation because of poor functional status, significant comorbidity, extensive foot necrosis, or a combination of these factors. No difference was noted in preoperative variables between patients who underwent primary amputation and those who underwent revascularization or minor amputation. During the same 5-year period, 165 patients underwent surgical revascularization to treat critical limb ischemia.

One hundred seventy-two major lower extremity amputations were performed (78 AKA, 94 BKA; 14 BKA were initial guillotine amputations). Median hospital stay was 14 days. Thirty-four patients had one or more complications; the most frequently occurring are listed in Table IV. Peri-

Table III. Details of presenting foot lesions in 132 limbs with foot necrosis in patients undergoing major lower extremity amputation

	Ulceration (N = 25)		*Dry gangrene (N = 56)*		*Sepsis (N = 51)*		*Total (N = 132)*	
Location	*n*	*%*	*n*	*%*	*n*	*%*	*n*	*%*
Forefoot								
Digit, single	4	16	4	7	3	6	11	8
Digit, multiple	6	24	11	20	2	4	19	14
MTH, single	2	8	3	5	5	10	10	8
MTH, multiple	0	0	6	11	8	16	14	11
Malleolar	1	4	3	5	2	4	6	5
Midfoot	4	16	5	9	16	31	25	19
Heel	6	24	13	23	10	20	29	22
Global*	2	8	11	20	5	10	18	13

Categorization based on gross appearance of the foot necrosis on preoperative physical examination alone.
MTH, Metatarsal head.
*Either complete breakdown of previous amputation, extremity with large gangrenous defects, or extremity nonviable at either the foot or calf level at presentation.

Table IV. Perioperative complications* in 154 patients

	Total		*Fatal*	
Complication	*n*	*%*	*n*	*%*
Decubitus (sacral and/ or remaining heel)	10	6.5	0	0
Pulmonary	8	5.2	3	1.9
Cardiac	12	7.8	10	6.5
Sepsis	4	2.6	2	1.3
Bleeding	3	1.9	0	0
Renal	1	0.6	1	0.6

*Data for most significant perioperative complications encountered.

Table V. Medical and functional events during follow-up*

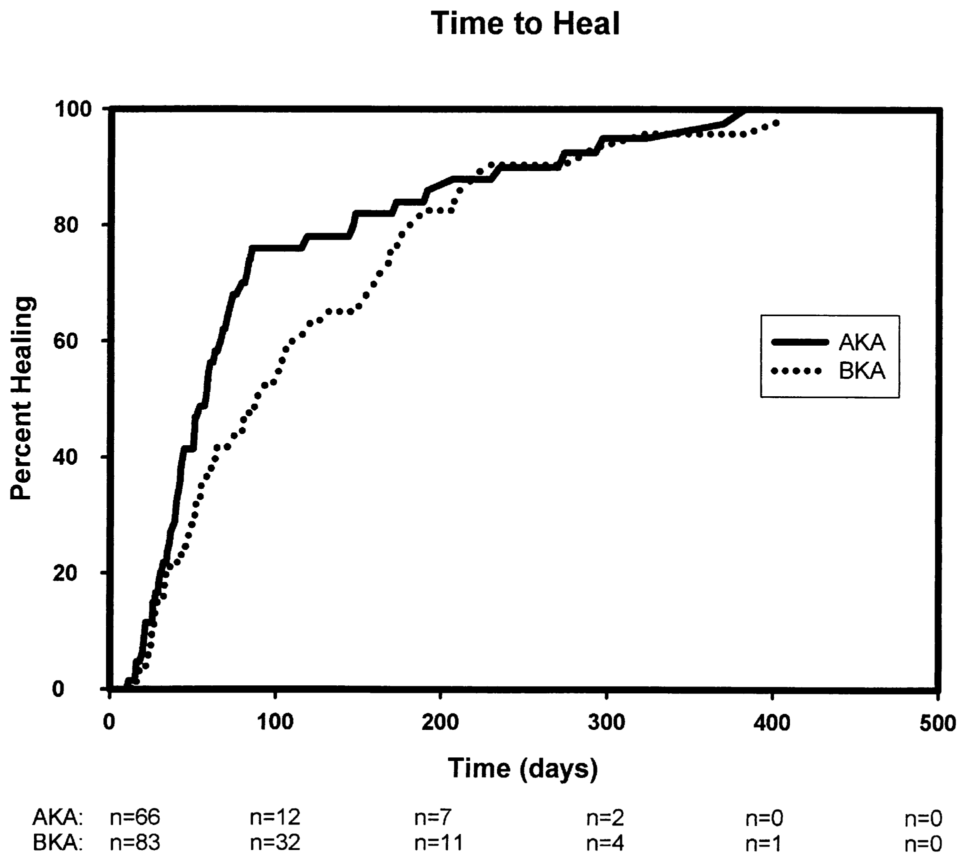
Event	*n*	*%*
Medical requiring hospitalization		
Renal failure requiring dialysis	6	4.2
Sepsis	8	5.6
Cardiac†	9	6.3
Liver failure	5	3.5
Pulmonary	4	2.8
Thromboembolism	3	2.1
Stroke	2	1.4
Suicide attempt	2	1.4
Functional		
Traumatic fall‡	23	16
Major fracture	4	2.8
Noncompliance§	6	4.2

*Data for most common events encountered over mean follow-up of 14 months in 143 amputees who survived to discharge or >30 days.
†Myocardial infarction, congestive heart failure.
‡All traumatic falls required temporary or permanent cessation of rehabilitation program.
§To degree prompting permanent cessation of rehabilitation program.

operative mortality was 10.4%; fatal complications are listed in Table V. Mean follow-up was 14 months. Eighteen patients (11%) were lost to follow-up at a mean of 7.4 months. Incision healing is illustrated in the Figure. At 100 days, 55% of BKA were healed, compared with 76% of AKA. At 200 days, 83% of BKA and 85% of AKA were healed. There was no linear correlation between healing rate and baseline albumin concentration. Twenty-three BKA and 16 AKAs required additional operative revision, and 18 BKA (19%) ultimately were converted to AKA. Seven BKA failures were in patients with acute ischemia and failed revascularization, with calf muscle that was not salvaged; 11 BKA failures were in patients with chronic ischemia and nonhealing incisions. Two patients had undergone previous revascularization procedures; 3 patients had renal failure; 2 patients had contractures; and 2 patients had persistent sepsis at the level of the BKA. Patient survival was 78% at 1 year and 55% at 3 years (Kaplan-Meier method). Major adverse events occurred in 66 surviving patients (48%) during follow-up; the most commonly occurring are listed in Table V.

Functional outcome is summarized in Table VI. Inasmuch as there was no set protocol for follow-up, functional data for 6-month and 12-month follow-up are organized in mean time from amputation of 10.3 and 17.5 months, respectively. Fewer than half of surviving patients used a prosthesis, and most of these had undergone BKA. Fewer than a third of surviving patients ambulated outdoors, and almost all had undergone BKA. Another fourth of patients ambulated indoors only, and a slightly greater number of these patients had undergone BKA compared with AKA. However, despite significantly superior rates of ambulation and prosthesis use at 10 and 17 months in surviving patients with BKA, there was no significant difference in rate of move from community living to a residential care facility at either interval.

Functional outcome according to subgroup analysis is demonstrated in Table VII. Patients who were nonambulatory at baseline never ambulated independently during follow-up. Patients with substance abuse and mental illness



Healing time in 172 major lower extremity amputations, 94 below-knee and 78 above-knee (Kaplan-Meier method).

at baseline had no change in ambulation, but significant reduction in use of a prosthesis. Patients older than 75 years rarely ambulated or used a prosthesis during follow-up. There was no difference in prosthesis use or functional results in patients in whom an initial attempt at revascularization had been made versus those with primary amputation.

DISCUSSION

The present study challenges tradition that salvage of the knee joint is required to maintain patient independence. As in other reports, most amputations are necessitated by complications of critical limb ischemia.[11-13] Mean duration of symptoms before presentation was often extremely long, several weeks to months, and was much greater for patients with necrosis than for patients with ischemic rest pain. Most patients did not describe claudication with antecedent vascular symptoms before onset of critical limb ischemia.[14] In one fourth of patients acute adverse events contributed in part to limb loss, with graft occlusion and major orthopedic injury the most common. Comorbid conditions in the population were substantial, most notably, cardiopulmonary disease, renal failure, inadequate nutrition, and anemia. In addition, a modest number of patients had significant antecedent functional impairment, including substance abuse and mental illness.

Analysis of lower extremity amputation in this disadvantaged population produced both predictable and unexpected results. Perioperative mortality was consistent with that in other reports.[15,16] BKA-AKA ratio was roughly 1:1, as in other major series.[17-21] Healing rate for BKA was markedly less than for AKA, with a 20% rate of eventual conversion of BKA to AKA, also in accord with published series.[14,22-27] Survival decreased markedly over time, emphasizing the palliative nature of amputation. Approximately half of surviving amputees ambulated at 10 and 17 months, with half of this ambulation limited to indoors only. Despite an aggressive rehabilitation program, only one fourth of surviving amputees were able to walk out of their homes. Fewer than half of patients used prostheses during the same interval; many patients ambulated indoors only in a limited fashion with an assist device. However, despite the disadvantaged population and low rate of ambulation, few patients required an extended care facility postoperatively when they had been living in the community preoperatively. This would suggest that inability to ambulate was compensated for by improved wheelchair

Table VI. Functional outcome in surviving patients* after major lower extremity amputation

Parameter	*Follow-up at 10.3 months*† *n*	*%*	*Follow-up at 17.5 months*‡ *n*	*%*
All Patients	(N = 90)		(N = 69)	
Ambulatory outdoors	19	21	20	29
Ambulatory indoors only	25	28	17	25
Nonambulatory	46	51	32	46
Prosthesis Use	29	32	29	42
Community to care facility	15	17	6	8
Below-knee amputation group	(N = 60)		(N = 48)	
Ambulatory outdoors	17	28	18	38
Ambulatory indoors only	20	33	13	27
Nonambulatory	23	38	17	35
Prosthesis use	26	43	25	52
Community to care facility	9	15	3	6
Above-knee amputation group	(N = 30)		(N = 21)	
Ambulatory outdoors	2	7	2	10
Ambulatory indoors only	5	17	4	19
Nonambulatory	23	77	15	71
Prosthesis use	3	10	4	19
Community to care facility	6	20	3	14

*One hundred forty-three amputees who survived to discharge or >30 days.
†Mean follow-up for 6-month group.
‡Mean follow-up for 12-month group.

Table VII. Functional outcome in patient subgroups

Parameter	*Subgroup 1* *n*	*%*	*Subgroup 2* *n*	*%*	P
Mental illness and/or substance abuse	No		Yes		
Ambulatory outdoors	12	26.7	7	15.6	.43
Ambulatory indoors only	12	26.7	13	28.9	
Nonambulatory	21	46.7	25	55.6	
Prosthesis use	17	37.8	12	26.7	.26
Patients with ≥6-month follow-up by age					
Age	*<75 years*		*≥75 years*		
Ambulatory outdoors	18	22.8	1	9.1	.09
Ambulatory indoors only	24	30.4	1	9.1	
Nonambulatory	37	46.8	9	81.8	
Prosthesis use	28	35.4	1	9.1	.08
Patients with ≥ 6-month follow-up, by initial therapy					
*Initial therapy**	*Primary amputation*		*Attempted revascularization*		
Ambulatory outdoors	9	18.0	6	20.7	.95
Ambulatory indoors only	15	30.0	8	27.6	
Nonambulatory	26	52.0	15	51.7	
Prosthesis use	16	32.0	9	31.0	.93

*Excluding conservative therapy group.

access, enabling patients to perform activities of daily living and remain in the community.

Table III describes new information in the literature on critical limb ischemia. Unlike atherosclerosis in multiple anatomic areas,[28-30] there is no classification system for foot lesions in critical limb ischemia, despite the rather obvious implications regarding ultimate function, advisability of limb salvage, and long-term morbidity. Table III is easy to interpret. The amount of tissue involved in the process increases as one proceeds down column 1, and the clinical severity of the process increases as one proceeds from left to right (accepting some limitations in completely stratifying the various processes and extent of involvement in a linear fashion). Therefore, the more values in the lower right portion of the table the worse the foot necrosis in the population and the less the likelihood for reasonable limb salvage, regardless of the arterial circulation. In our series of major amputations, three fourths of necrotic lesions were either dry gangrene or sepsis, and two thirds involved the metatarsal head or more proximal forefoot.

Because the data were collected from a Veterans Affairs and University practice, our functional results may be criticized as not applicable to other patient populations. We disagree with this reproach. As stated, our technical results are in accord with many other reported series in the literature. Our rate of ambulation is also similar to that in several reports,[20,31,32] particularly in view of the often vaguely defined end point of "ambulation." Most of our functional outcome data are from detailed physical therapy and rehabilitation notes, and follow-up history and examination of patients in the combined vascular clinics. The number of patients with available data and percent lost to follow-up are typical of clinical research in this area. This study provides pilot data on functional outcome of patients with critical limb ischemia undergoing major limb amputation; we hope it will engender larger prospective multicenter studies of various populations to determine whether some of our original observations are consistently accurate.

Is an end point of bipedal gait with prosthetic limbs unrealistic for most amputees? From a physiologic standpoint, the answer must be yes for many patients. We were surprised to find that a history of substance abuse, poor nutrition, and anemia, in addition to the typical comorbid conditions in a population with critical limb ischemia, frequently do not dissuade the rehabilitation service from aggressively pursuing prosthetic ambulation. This philosophy produced morbidity in several patients, who sustained falls and major fractures during rehabilitation. Others were predictably noncompliant with an arduous program designed to improve strength and balance. Perhaps it is not surprising that many frail patients faced with the choice between such physically demanding activity and a less strenuous primary wheelchair existence eventually choose the latter. Increased community wheelchair access in the last decade may have actually promoted this shift in behavior.

In retrospect, preoperative clinical variables used to decide whether AKA or BKA was performed were inconsistent with regard to implications of function. The nature of the foot lesions, age, preoperative BMI, albumin concentration, and hematocrit were not statistically different in the two groups (BKA vs AKA). In addition, no variables were found to be different in the groups who underwent primary amputation compared with revascularization or minor amputation initially. Therefore, although a clear algorithm would help to make sense of our approach, we do not have one. We have become more inclined to perform AKA in patients with significant comorbidity, obesity, skin changes related to edema or venous stasis that make a BKA flap problematic, and poor albumin concentration. In addition, we are now factoring the potential morbidity of rehabilitation into the decision. Patients with poor balance with two limbs, as a result of previous stroke, neuropathy, or artificial joints, are considered for AKA. Patients with substance abuse or mental illness are less likely to use a prosthesis. Most important, we counsel our patients about realistic post-amputation goals. Many patients remain adamant about preserving the knee joint and firm in their belief that they will regain bipedal gait. Usually BKA is technically feasible, and we comply with their wishes.

Several disclaimers are in order. Clearly, we made some clinical errors in attempting to salvage the knee joint in patients with acute ischemia and failed limb salvage. Additional limitations relate to the partial retrospective nature of the project, incomplete data for all patients, and the limited numbers in subgroups raising the potential for type II error. Nevertheless, our findings raise the question that perhaps our results could be improved with better patient selection based on risk factors, albumin concentration, and hematocrit. Albumin concentration has been correlated with hospital mortality and length of stay in several large clinical series,[33,34] and hematocrit has cardiovascular implications.

Finally, it is important to present alternative interpretations of our data. Clearly, if any significant prosthetic ambulation is to be expected in this population, the knee joint is necessary. However, current methods for predicting prosthetic ambulation appear poor. Salvage of the knee joint and a rigorous rehabilitation program have some drawbacks in this population with a short life expectancy. Community living with predominantly wheelchair ambulation is currently the option for many vascular amputees, with or without a knee joint. One could argue, Why amputate an extremity without obtaining detailed arterial anatomic information to determine whether revascularization and potential salvage is possible? We would counter, Why attempt to salvage an extremity in all patients without proof that they will benefit functionally, particularly when abbreviated life expectancy, nature of the foot wounds, long-term pain issues, and premorbid function and comorbidity are considered. We salvage extremities with lower extremity revascularization, but our attempted bypass surgery–primary amputation ratio is probably lower than at many centers. Over the 5 years of this study, critical limb ischemia care at our center has evolved to minimize (1) the number of patients who die early after bypass grafting without ultimate incision and wound healing, (2) the number of limbs eventually amputated after bypass grafting, despite multiple attempts to either salvage a reconstruction or forefoot amputation, or (3) both. The expense of this approach is primary amputation of some limbs that, despite substantial morbidity, could ultimately be salvaged. However, our approach has tended to minimize procedure-related morbidity in the remaining months for patients with end-stage systemic disease.

In summary, this report challenges traditional approaches to critical limb ischemia in patients facing amputation. Efforts to save the knee joint incur significant morbidity in terms of delayed healing, wound complications, and eventual failure. In a population that is clinically and physiologically severely ill, we found that a significant number of amputees are unable to regain bipedal gait despite aggressive rehabilitation. In fact, some patients sustain significant morbidity from attempted ambulation with prostheses as a result of falls and fractures. Despite a low rate of postoperative ambulation, most patients remain living in the community. Given the palliative nature of care in most patients with critical limb ischemia, aggressive attempts at salvaging the knee joint should be reserved for selected patients at good risk.

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