In the United States, an estimated 23.6 million people have diabetes, and that number is expected to more than double by 2040.1, 2 Among the many complications encountered by these patients, foot ulcers and lower-extremity amputations are common. Up to 25% of individuals with diabetes will develop a foot ulcer during their lifetime.3 Foot ulcers precede amputations in 85% of cases.4 Slightly more than half of ulcers will become infected during their lifecycle.5 Infection and critical limb ischemia are major risk factors for lower-extremity amputation.6 It has been stated that every 30 seconds, somewhere in the world a limb is lost as a consequence of diabetes.7 The costs attributed to diabetic foot ulcers and amputations in the United States were estimated to be $30.6 billion in 2007.8

The World Health Organization9 and the International Diabetes Federation10 estimate that up to 85% of lower-extremity amputations in diabetes are preventable. In 1990, the Saint Vincent Declaration called for a reduction in the incidence of diabetes-related lower-extremity amputations by 50%.11 This has not been realized. In the United States, the age-adjusted lower-extremity amputation rate per 10,000 population has steadily increased from 2.0 in 1990 to 2.6 in 2003.12 Although these data overall are depressing, isolated centers are reporting successful reductions in diabetes-related amputations.

Eskelinen et al13 reported a decrease in major amputations in Finland that they attribute to a rising interest in amputation prevention and an increase in distal vascular procedures. The Netherlands has also seen a nationwide reduction in amputations by 34% accredited to the increase in the number of podiatric physicians and multidisciplinary care teams.14 In Brazil, there has been a national effort to reduce lower-extremity amputations by creating approximately 20 satellite diabetic foot clinics throughout the country.15 In Italy, Anichini et al16 reported a reduction in hospitalizations for diabetic foot lesions and amputations after implementation of a referral system for high-risk feet and a multidisciplinary care team. Canavan et al17 described a reduction in the lower-extremity amputation rate in the United Kingdom after the introduction of “better organized diabetic foot care.” The organization consisted of community-based chi-

Organized Programs to Prevent Lower-Extremity Amputations

Lee C. Rogers, DPM*
Nicholas J. Bevilacqua, DPM*

Background: Diabetes-related lower-extremity amputations are largely preventable. Eighty-five percent of amputations are preceded by a foot ulcer. Effective management of ulcers, which leads to healing, can prevent limb loss.

Methods: In a county hospital, we implemented a six-step approach to the diabetic limb at risk. We calculated the frequency and level of lower-extremity amputations for 12 months before and 12 months after implementation of the amputation prevention program. We also calculated the high-low amputation ratio for the years reviewed. The high-low amputation ratio is a quality measure for the success of amputation prevention measures and is calculated as the ratio of the number of high amputations (limb losses) over the number of low (partial foot) amputations.

Results: The frequency of total amputations increased from 24 in year 1 to 46 in year 2. However, the number of limb losses decreased from 7 to 2 (72%). The high-low amputation ratio decreased eightfold in 1 year, which serves as a marker for limb salvage success.

Conclusions: Improvement in care organization and multidisciplinary-centered protocols can substantially reduce limb losses. (J Am Podiatr Med Assoc 100(2): 101-104, 2010)
Podiatry clinics with multidisciplinary care pathways and protocols. In the United States, Wrobel et al. visited ten Veteran’s Affairs medical centers and found six factors associated with a reduction in amputations: addressing foot-care needs, appropriate referrals, ease in recruiting staff, confidence in staff, available stand-alone specialized diabetic-foot-care services, and providers who attended diabetic-foot-care education in the past 3 years. Another study found that a specialized limb preservation service was able to reduce the amputation rate by 82% at a military medical center even while the rate of patient visits for diabetes increased by 48% across 4 years.

Although there are many modalities that can be used in the treatment and prevention of diabetic foot ulcers (the leading cause of amputation), we concentrated on modalities for which a high volume of evidence exists. Management of infection, restoration of vascular flow, off-loading pressure, wound debridement, promotion of granulation tissue, and wound closure are six important categories of wound management. The American Diabetes Association published a consensus document emphasizing the importance of many of these categories.

Wrobel et al. proposed the high-low amputation ratio as a quality indicator for preventing major amputation. The high-low ratio is calculated as the ratio of the number of high amputations (above-the-knee and below-the-knee) over the number of low amputations (any partial-foot amputation). The authors reported the adjusted mean (SD) high-low amputation ratio to be 1.35 (0.42) for 1996 to 1997 in US Medicare enrollees. Using surveillance data from the Centers for Disease Control and Prevention, the adjusted mean high-low ratio was 0.7 to 0.8 for 1992 to 2002. The aim of this study was to determine the success of an amputation prevention program across 1 year compared with the year before implementation.

**Materials and Methods**

We evaluated the success of an intensive amputation prevention program in a county hospital setting at Broadlawns Medical Center, Des Moines, Iowa, with an active group concentrating on limb salvage. The amputation prevention program was implemented by two podiatric physicians (L.C.R. and N.J.B.) fellowship trained in diabetic-limb preservation. The protocol-driven program focused on multidisciplinary care of patients with limbs at risk for amputation. A six-step process was implemented for those with wounds, which account for 85% of all lower-extremity amputations (Table 1). Data were obtained from the hospital coding service by mining for all Current Procedural Terminology codes for lower-extremity amputation for the 12 months before (July 2006 to June 2007) and the 12 months after (July 2007 to June 2008) initiation of the amputation prevention program. Table 2 presents the Current Procedural Terminology codes searched for inclusion. The high-low amputation ratios were calculated for each year.

**Results**

Between July 2006 and June 2007, before implementation of the amputation prevention program, 24 amputations were performed (7 high and 17 low). During the year after the amputation prevention program was in effect, between July 2007 and June 2008, there were 46 amputations (2 high and 44 low) (Table 3). The high-low amputation ratio for year 1 was 0.41 and for year 2 was 0.05. In comparison, the national average of the high-low amputation ratio for Medicare enrollees in 1996 to 1997 was 1.35. In the present study, there was an increase in the total number of

| Table 1. The Six-Step Protocol Implemented by the Amputation Prevention Program |
|------------------|-----------------------------------------------------------------|
| Process | Components |
| 1. Identification and management of infection | • Diagnosis based on clinical signs and symptoms <br>• Treatment includes antibiotics <br>• Consideration of bacterial resistance |
| 2. Identification and management of ischemia | • Noninvasive vascular tests for macrovascular and microvascular flow <br>• Referral to vascular surgery for evidence of ischemia |
| 3. Off-loading pressure (needs to be maintained throughout wound healing) | • Use of total-contact cast, instant total-contact cast, diabetic cast walker, wheelchair, crutches, bed rest <br>• Surgical correction of deformity, pressure focus |
| 4. Debridement of wound | • Preference given to surgical debridement, including hydrosurgical scalpels <br>• Enzymatic, mechanical, maggots |
| 5. Promotion of granulation tissue | • Use of negative-pressure wound therapy, growth factors, marrow-derived stem cell transplantation |
| 6. Closure of wound | • Split-thickness skin graft, bioengineered skin substitutes, surgical flaps |
amputations in year 2, mostly in the number of foot-sparing amputations. However, the number of limb losses decreased by 72%.

Discussion

The high-low amputation ratio can serve as a quality indicator for an amputation prevention program or hospital. One deficiency in the high-low ratio when mining for data using Current Procedural Terminology coding without cross-referencing medical record numbers and patient names, as in the study by Wrobel et al21 and the present study, could be the capture of multiple amputations on the same patient. The study period was short at 1 year, which should limit reamputations on the same patient. Furthermore, we saw an overall reduction in limb losses by 72%. The decrease in high amputations was coupled with an increase in the number of proximal foot-sparing amputations (at the transmetatarsal and Chopart levels). We attribute this substitution of partial foot amputations to improved vascular care involving endovascular procedures and open bypass surgery. Another weakness is that the present study design can account for patients who had continuing care at our facility only, and any amputations performed at outside hospitals would not be captured. Reviewing only Current Procedural Terminology code frequencies excludes the collection of demographic and comorbidity data. Although diabetes is certainly the leading cause of amputation worldwide, this study could not discriminate between those with diabetes and those without.

As illustrated by previous works and the present study, simple organizational measures can reduce the number of major amputations performed at a center. Our example shows that significant improvements are possible after implementation of an amputation prevention program in a hospital already exhibiting a good track record for preventing limb loss. These results, in an American public hospital, mirror those achieved in isolated centers in other parts of the globe citing that better-organized care with a multidisciplinary team approach of vascular and podiatric medical services can reduce major amputations.

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Conflict of Interest: None reported.

References


7. “Every thirty seconds a limb is lost somewhere in the world as a consequence of diabetes.” Lancet 366: No. 9498, November 12, 2005, cover quote.