Evaluation and Treatment of the Infected Foot in a Community Teaching Hospital

WILLIAM F. TODD, DPM*
DAVID G. ARMSTRONG, DPM†
PAUL J. LISWOOD, DPM‡

More inpatient hospital days are used for the care of diabetic foot infection than for any other diabetic sequela. Both the number of lower extremity amputations and the overall treatment cost of treating diabetic infections may be reduced by using a team approach in the care of the infected diabetic pedal wound. The authors propose an evaluation and treatment protocol of infected pedal ulcerations in an urban, community teaching institution when admitted to an established, multidisciplinary diabetic foot care team. The hospital course of 111 patients admitted with a primary diagnosis of infected pedal ulceration are retrospectively reviewed. Results revealed an average-length hospital stay of 7.4 days with a 96% limb-salvage rate. The authors suggest that in the treatment of the infected pedal wound, a diabetic foot care team with a well developed treatment protocol may yield a consistently favorable outcome and a cost-effective hospital course.

The most common complication of diabetes mellitus is the foot infection. More inpatient days are used treating diabetic foot infections than any other complication.[1, 2] Of all diabetic hospital admissions, 20% are for pedal sequelae.[3] It has been estimated that 15% of all persons with diabetes will develop a pedal ulceration during the course of the disease. Of the approximately 125,000 lower extremity amputations performed each year, 50% to 83% are directly attributable to diabetes mellitus. Edmonds et al[4] report that three fourths of diabetic amputations stem directly from a pedal ulceration causing deep space plantar infection.

Following a patient's first major lower extremity amputation, there is an up to 68% incidence of contralateral amputation within 5 years.[5, 6] The 3-year mortality rate of diabetic amputees approaches 50%.[7] It has been estimated that nearly 85% of diabetic foot and leg amputations can be prevented with proper pedal ulcer care.[8, 9] Unfortunately, on both an outpatient and inpatient basis, the diabetic foot is generally infrequently and inadequately evaluated.[10-12]

Several authors have advocated the team approach in the treatment of the diabetic foot ulcer as both a more efficacious and cost-effective limb salvage implement.[13-16] This approach has reportedly reduced the incidence of lower extremity amputation and has reduced hospital stays by an average of 33%.[17, 18] Apelqvist et al[19] calculated that total cost for patients treated by a multidisciplinary foot care team was an average of 85% lower than for those primarily treated with amputation. Giacalone et al[19] reported a 89% limb-salvage rate in a 1994 review of their multidisciplinary approach to treatment of the infected diabetic foot. The authors evaluate the treatment of the infected diabetic

*Director, Diabetic Foot Centers of America, Madison Heights, MI.

†Assistant instructor and Diabetic Foot Fellow, Department of Orthopaedics and Podiatry, University of Texas Health Science Center, San Antonio. *Mailing address:* 107 W Orange St, Santa Maria, CA 93454.

‡Private practice, Brooklyn, NY.

pedal wound in an urban, community teaching institution with a dedicated diabetic foot care team in place.

Materials and Methods

Participants in this survey were patients admitted to a 50-bed community teaching hospital between January 1, 1991, and December 31, 1994, with a primary admission diagnosis of infected diabetic foot ulceration. Patients were identified using the ICD-9-CM codes 250.8 and 707.1.[20] All patients were diagnosed with diabetes mellitus using the criteria set forth by the World Health Organization.[21] The authors abstracted medical records to identify the following parameters: lower extremity vascular assessment, sensory assessment, ulcer examination, laboratory tests, radiographic studies, surgery performed, consultations requested, and outcomes. The diabetic foot service has a rigid, established, multidisciplinary evaluation and treatment protocol (Fig. 1).

Results

Participants in the care of all admissions are summarized in Table 1. On physical examination, all patients were evaluated for presence or absence of pulses. All patients were examined for pedal sensorimotor integrity. Size of ulcerations was measured in all patients and all were evaluated for depth or involvement of underlying structures. Surrounding tissue was assessed in every pedal wound.

Radiographs were ordered in all cases. No scintigraphic studies were ordered for inpatients. Bacterial cultures were taken in 99% of admissions. Blood cultures were drawn from 11% of those studied. Segmental Doppler vascular analysis was performed on 29% of admissions. Three percent of patients received angiograms on an inpatient basis. These inpatient data are summarized in Table 2.

Ninety-eight percent of patients were treated with daily, normal saline wet-to-dry dressing changes. Two percent of patients were closed primarily and therefore did not require wet-to-dry changes. These

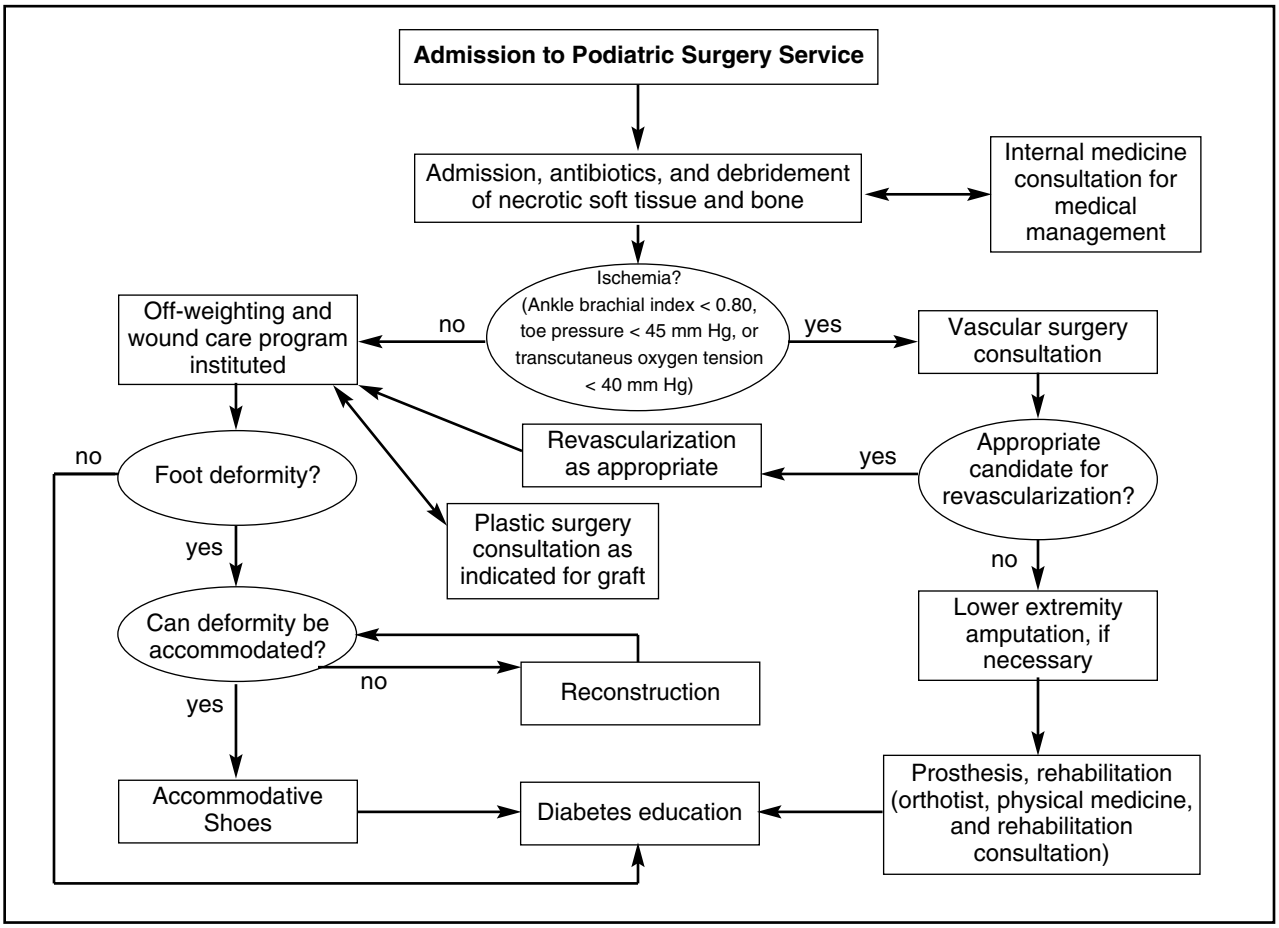

Figure 1. Team approach to limb salvage.

Table 1. Participating Services	Cases (%)
Podiatric surgery	100
Endocrinology	100
Pedorthics and prosthetics	99
Plastic surgery	15
Vascular surgery	9
Infectious disease	1

Table 2. Inpatient Studies Ordered	Cases (%)
Radiographs	100
Bone scans	0
Wound Gram's stain	99
Wound culture and sensitivity	99
Blood cultures	11
Segmental Doppler vascular analysis	29

subjects underwent distal Syme's-type digital amputations with well localized zones of nonviable tissue distal to the incision line. Ninety-five percent of patients had daily sterile bedside ulcer debridements in concert with the above-mentioned normal saline dressing changes.

Of all admissions, 80% received intraoperative debridement, with 33% of admissions receiving some form of lower extremity or pedal amputation. Of these procedures, 78% were digital or ray resections, 11% of amputations were performed at the level of the metatarsus or tarsus, and 11% were below the knee amputations. No patients received above the knee amputations. Thirty-five percent of the subjects who underwent intraoperative debridement required further revisional surgery. The overall limb-salvage rate, defined as the incidence of high-level amputations (proximal to the malleoli) performed during the hospital admission, was 96%.

The average length of hospital stay for all admissions studied was 7.4 ± 4.1 days (range 2 to 20). These data are divided by procedure performed in Figure 2. Discharge information is summarized in Table 3.

Discussion

In 1991, the US Department of Health set a goal for a 40% reduction in leg amputations in patients with diabetes by the year 2000.[22] In the continuing effort to achieve this goal, the authors believe that when treating the acutely infected pedal wound, certain clinical parameters must be established. These include level of neuropathy, presence of vascular compromise, degree of involvement of deep structures including bone, causative organisms, and overall salvageability of the extremity. All ancillary tests and consultations ordered should have a definite purpose toward the establishment of one or more of the above-mentioned parameters.

Peripheral neuropathy is present in more than 80% of patients with pedal wounds.[23] It is this lack of sensation that exposes the patient to undue sudden or repetitive stress, eventual tissue breakdown, and subsequent infection. All patients in this study were examined for lower extremity neuropathy using a digital proprioceptive examination and the Semmes-Weinstein monofilament wire system. Neuropathy is defined as diminished or absent sensation to vibration or proprioception and light touch, with absent protective threshold. As described above, loss of protective threshold is defined as the inability to detect palpation with the Semmes-Weinstein 5.07 monofilament wire.

The lower extremity vascular examination is critical in establishing the healing potential of the diabetic wound regardless of the presence or absence of infection. It has been estimated that pe-

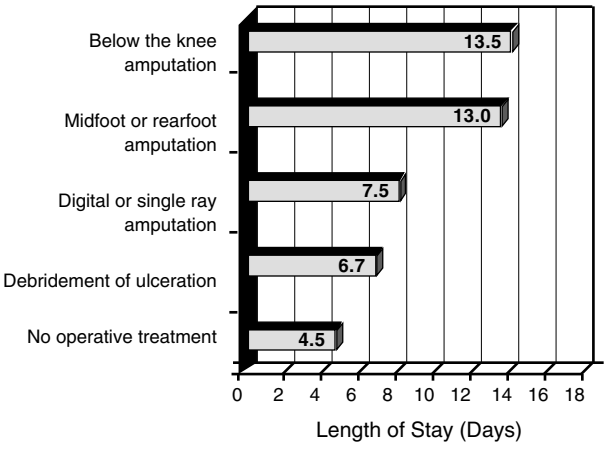

Figure 2. Average length of stay by procedure.

Table 3. Discharge Status	Cases (%)
Home health care	79
Shoe appointment	99
Endocrinology appointment	100
Wound care appointment	100

ripheral vascular disease is present in nearly 60% of nonhealing ulcers.[24] Noninvasive studies should be used, if necessary, to complement careful bedside examination and sound clinical judgment. Angiography is the definitive method for determining arterial occlusion. This test should be reserved for those patients who are potential candidates for arterial reconstruction. Limb-threatening infections should be debrided and sepsis controlled prior to attempting revascularization even in the most vascularly compromised extremity.[7, 25] Infected patients with impaired vascular supply were debrided and immediately referred to vascular surgery for further treatment following control of sepsis.

Evaluation of the ulceration itself is critical in the overall pedal infection treatment scheme. Width of the ulcer should be initially recorded to help monitor overall treatment progress. Depth of the ulcer and involvement of underlying structures (such as tendon, capsule, or bone) should be ascertained using a sterile blunt probe. The presence or absence of sinus tracts can be similarly appreciated in this manner. Drainage should be carefully examined and described as either serous or purulent, with further description of odor or color as necessary. Wound margins may be classified as either viable or nonviable. The ulcer base should be described as granular, fibrotic, or necrotic. Periulcer edema, erythema, or subcutaneous emphysema must also be recorded. The presence or absence of lymphadenopathy or lymphangitis may also be reported.

Cultures of pedal wounds, when performed appropriately, are vital to guiding an effective course of antibiotic therapy. In this study, cultures were secured either intraoperatively or, if surgery was not performed, from wound base curettage. Blood cultures, while beneficial in identifying systemic sepsis, are generally not of great value in establishing the causative organism in pedal infection. When the organism is identified and sensitivities obtained, the course of antibiotic therapy may be altered from a costly, broad-spectrum antibiotic to a more microbiologically focused, cost-effective agent. Following initial culture results and subsequent antibiotic therapy, the resolution of infection is based on clinical observation rather than repetitive culturing of the wound.

Technetium bone scans are expensive and are not specific in diagnosing osteomyelitis.[26] Indium scans, while still expensive, have been shown to be far more specific.[27] Probing to bone, in concert with radiographic and clinical evaluation, may be the most accurate and cost-effective means of clinically diagnosing osteomyelitis prior to surgical debridement and definitive bone biopsy.[23, 28] Bone scanning was not used to assist in diagnosis of osteomyelitis in the acutely infected foot. Indium-111 scintigraphy may prove to be of some limited use on an outpatient basis in two instances. The first instance is to initially assist in differentiation between osteomyelitis and diabetic neuropathic osteoarthropathy (Charcot's joint) in the presence of a pedal ulceration. Secondly, several weeks after debridement of osteomyelitic bone, indium-111 scanning may provide some benefit in determining adequacy of bony resection.

It has been suggested by numerous authors that whirlpool therapy, iodine, topical enzymes, hydrogen peroxide, and various astringents may interfere with wound healing.[29-32] It has been well established that wounds heal best in a moist environment.[33] All wounds were treated with sterile, normal saline wet-to-dry dressings. Dressing-change intervals varied from one to four times daily, depending on the quality of the wound and amount of exudate encountered. The only exception to this regimen was following delayed primary or primary wound closure, when dry sterile dressings were applied.

Shoes may serve as either a precipitating or a preventative factor in the genesis or prevention of foot infections in people with diabetes, respectively. Giacalone et al[20] reported that irritative shoes were the etiology in 90% of all neuropathic ulcerations included in their study. This finding is further supported by Edmonds[16]. Chantelau and Haage[34] showed that wearing accommodative custom shoes (following healing) reduced ulcer relapse rate by more than 50%. In a hospital lacking a dedicated diabetic foot care team, appropriate referral to a certified pedorthist or orthotist for temporary or permanent accommodative shoes may be overlooked. It should be stressed that, as Caputo et al[26] indicate, "The term 'healing shoe' may be a misnomer." Patients are discharged postoperatively with accommodative shoes designed to remove weight from the affected area.

Following resolution of infection, a specific plan of off-weighting the defect should be instituted. This may include any one of three methods depending on numerous factors including ulcer site, vascular status, and patient compliance. These methods include total contact casting, complete nonweightbearing (crutches or walker), or custom-fabricated braces or sandals. Following healing, patients may be provided with accommodative or custom-molded shoes fashioned by a certified pedorthist.

The authors believe that an important factor af-

fecting the high limb-salvage rate was the prompt and aggressive debridement instituted in the majority of admissions. Often, the most conservative approach in treating the infected diabetic pedal wound is a surgical one. The limb-salvage rate should, however, be considered with the knowledge that the majority of the patients admitted for care to the diabetic foot service were ambulatory and independent prior to development of pedal infection. The patients who underwent high-level amputations in this study (n = 4) revealed clinically nonsalvageable extremities to the extent that avascular, necrotic, nonviable tissue comprised the majority of the foot and leg. All limbs cannot be salvaged. This should not detract from the practice that infected patients with salvageable extremities and impaired vascular supply should, as discussed above, have sepsis controlled through surgical debridement prior to any attempt at revascularization.

Conclusion

This survey analyzes the protocol for treatment provided at an urban community teaching institution with a dedicated diabetic foot care team. The authors postulate that the pooling of resources in establishing a multidisciplinary diabetic foot care and limb-salvage service as used in the above-mentioned facility may lead to an improved outcome, reduced length of stay, and a more cost-effective hospital course.

Acknowledgments. Samantha Lucier, ART, and Kathy MacNaughton, ART; Lowell Scott Weil First Place recipient for Scientific Poster Presentation, American College of Foot and Ankle Surgeons, March, 1996.

References

1. Gibbons G, Eliopoulos GM: "Infection of the Diabetic Foot," in *Management of Diabetic Foot Problems*, ed by GP Kozak, CS Hoar, JL Rowbotham, WB Saunders, Philadelphia, 1984.
2. Pliskin MA, Todd WF, Edelson GW: Presentations of diabetic feet. Arch Fam Med **3:** 273, 1994.
3. Levin ME: "Pathophysiology of Diabetic Foot Lesions," in *Clinical Diabetes Mellitus: A Problem-Oriented Approach*, ed by JK Davidson, Theime Medical, New York, 1991.
4. Edmonds ME, Blundell MP, Morris HE, et al: The diabetic foot: impact of a foot clinic. QJM **232:** 763, 1986.
5. Roon AJ, Moore WS: Below knee amputation: a modern approach. Am J Surg **134:** 153, 1977.
6. Goldner MG: The fate of the second leg in the diabetic amputee. Diabetes **9:** 100, 1960.
7. Todd WF, Laughner T, Samojla BG: "The Diabetic Foot," in *Primary Podiatric Medicine*, ed by JM Robbins, WB Saunders, Philadelphia, 1994.
8. "Diabetes in the United States: A Strategy for Prevention," US Department of Health and Human Services, Public Health Service, Centers for Disease Control, Atlanta, 1992.
9. National Diabetes Advisory Board: "The National Long-Range Plan to Combat Diabetes," US Department of Health and Human Services, Public Health Services, National Institutes of Health, NIH publication no. 88-1587, Bethesda, MD, p. 24-25, 1987.
10. Edelson GW, Armstrong DG, Lavery LA, et al: The acutely infected diabetic foot is not adequately evaluated on an impatient setting. Arch Int Med (In press).
11. Wylie-Rosset J, Walker EA, Shamoon H, et al: Assessment of documented foot examinations for patients with diabetes in inner-city primary care clinics. Arch Fam Med **4:** 46, 1990.
12. Bailey TS, Yu HM, Rayfield E: Patterns of foot examination in a diabetic clinic. Am J Med **78:** 371, 1985.
13. Centers for Disease Control and Prevention: *Diabetes in the United States: A Strategy for Prevention*, Atlanta, 1993.
14. Levin ME: "The Diabetic Foot: Pathophysiology, Evaluation, and Treatment," in *The Diabetic Foot*, ed by ME Levin, LW O'Neal, CV Mosby, St Louis, 1988.
15. Tan JS, Flanagan PJ, Donovan DL, et al: Team approach in the management of diabetic foot infections. J Foot Surg **26:** S12, 1987.
16. Edmonds ME: "Experience in a Multidisciplinary Diabetic Foot Clinic," in *The Foot in Diabetes*, ed by H Connor, AJM Boulton, JD Ward, John Wiley & Sons, Chichester, UK, 1987.
17. Reiber GE: Diabetic foot care: financial implications and practice guidelines. Diabetes Care **15:** 29, 1992.
18. Gibbons GW, Marcaccio EJ Jr, Burgess AM, et al: Improved quality of diabetic foot care, 1984 *vs.* 1990: reduced length of stay and costs, insufficient reimbursement. Arch Surg **128:** 576, 1993.
19. Apelqvist J, Ragnarson-Tennvall G, Persson U, et al: Diabetic foot ulcers in a multidisciplinary setting: an economic analysis of primary healing and healing with amputation. J Intern Med **235:** 463, 1994.
20. Giacalone VF, Krych SM, Harkless LB: The University of Texas Health Science Center at San Antonio: experience with foot surgery in diabetics. J Foot Ankle Surg **33:** 590, 1994.
21. Birke JA, Simms DS: Plantar sensory threshold in the ulcerative foot. Lepr Rev **57:** 261, 1986.
22. Orchard TJ, Strandness DE: Assessment of peripheral vascular disease in diabetes: report and recommendation of an international workshop. Diabetes Care **83:** 685, 1993.
23. Department of Health and Human Services: "Healthy People 2000: National Health Promotion and Disease Prevention Objectives," Government Printing Office, Washington, DC, 1991:73:117 (DHHS publication no. 91-50213).
24. Boulton AJM: The diabetic foot: neuropathic in aetiology? Diabet Med **6:** 852, 1990.
25. Pomposelli FB Jr, Jepsen SJ, Gibbons GW: Efficacy of the dorsal pedal bypass for limb salvage in diabetic patients: short-term observations. J Vasc Surg **11:** 745, 1990.

26. Caputo GM, Cavanagh PR, Ulbrecht JS, et al: Assessment and management of foot disease in patients with diabetes. N Engl J Med **332:** 854, 1995.
27. Keenan AM, Tindel NL, Alavi A: Diagnosis of pedal osteomyelitis in diabetic patients using current scintigraphic techniques. Arch Intern Med **149:** 2262, 1989.
28. Schauwecker DS: The scintigraphic diagnosis of osteomyelitis. Am J Roentgenol **158:** 9, 1992.
29. Grayson ML, Balogh K, Levin E, et al: "'Probing to Bone,' a Useful Clinical Sign of Osteomyelitis in Diabetic Fetid Feet," in *Program and Abstracts of the 30th Interscience Conference on Antimicrobial Agents and Chemotherapy*, Atlanta, October 21-24, American Society for Microbiology, Washington, DC, 1990.
30. Kucan JO, Robson MC, Heggers P, et al: Comparison of silversulfadiazine, povidone-iodine and physiologic saline in the treatment of chronic pressure ulcers. J Am Geriatr Soc **29:** 232, 1981.
31. Lineaweaver W, Howard R, Soucy D, et al: Topical antimicrobial toxicity. Arch Surg **120:** 267, 1985.
32. Oberg MS, Lindsey D: Do not put hydrogen peroxide or povidone iodine into wounds! Am J Dis Child **141:** 27, 1987.
33. Rodeheaver G, Bellamy W, Kody M, et al: Bactericidal activity and toxicity of iodine-containing solutions in wounds. Arch Surg **117:** 81, 1982.
34. Chantelau E, Haage P: An audit of cushioned diabetic footwear: relation to patient compliance. Diabet Med **11:** 114, 1994.