REVIEW

CME CREDIT

JEFFREY M. ROBBINS, DPM
Director, Podiatry Service, Veterans Administration Central Office; chief, Podiatry Services, Louis Stokes Cleveland Department of Veterans Affairs Medical Center (VAMC), Cleveland, OH

BONNIE J. NICKLAS, DPM
Staff surgeon, Podiatry Service, Louis Stokes Cleveland VAMC, Cleveland, OH

SARAH AUGUSTINE, MD
Inpatient medical director, Louis Stokes Cleveland VAMC, Cleveland, OH

Reducing the rate of amputations in acute diabetic foot infections

ABSTRACT

Many older diabetic patients present to the emergency room with limb-threatening foot complications, and may at the same time need attention to life-threatening endocrine, cardiac, or renal complications. To better serve the elderly veteran population at our institution, we designed a multidisciplinary, algorithmic approach that links the podiatry and medicine services to facilitate appropriate referral, admission, and management, with the ultimate goal of reducing the rate of amputations.

KEY POINTS

Our approach includes proper wound care, appropriate rehabilitation, adequate prosthetic and orthotic control, and aggressive management of concurrent medical problems (specifically, aggressive glycemic and blood pressure control), as well as continuing surveillance in podiatry, vascular medicine, and general medicine clinics.

After we implemented our protocol, age-adjusted overall amputation rates for patients with diabetes decreased from 5.64 to 4.12 per 1,000 patients from 2001 through 2004. The rate of major amputations decreased from 2.15 in 2001 to 1.42 in 2004. The rate of minor amputations decreased from 3.49 in 2001 to 2.70 in 2004.

DIABETIC FOOT INFECTIONS present a complex challenge requiring integrated multidisciplinary care. We need a system of care that prevents diabetic foot complications such as neuropathy, ischemia, and immunopathy, and a system that also addresses coexisting conditions. Without proper surveillance, these complications can progress rapidly to overt infection and ultimately require amputation.

At the Louis Stokes Veterans Administration (VA) Medical Center, we sought to improve the care of patients with diabetic ulcers once they presented with overt infection with or without ulceration, with the ultimate goal of decreasing the amputation rate. In order to accomplish this, we devised a multidisciplinary approach to care that combines proper wound care, appropriate rehabilitation, adequate prosthetic and orthotic control, and aggressive management of concurrent medical problems (specifically, aggressive glycemic and blood pressure control), as well as continuing surveillance in podiatry, vascular, and general medicine clinics. In this article we describe our approach and how it affected the amputation rate at our institution.

IMPETUS FOR CHANGE

Nelson et al[1] described a "microsystem of care" as an approach to maximize the quality of care, defining a microsystem of care as a system of policies, staff, and technology within the overall health care system or medical center that focuses on a specific patient population with a narrow need or condition. Indeed, improvements in health care have been linked to improvements in the systems or processes of care and are especially effective

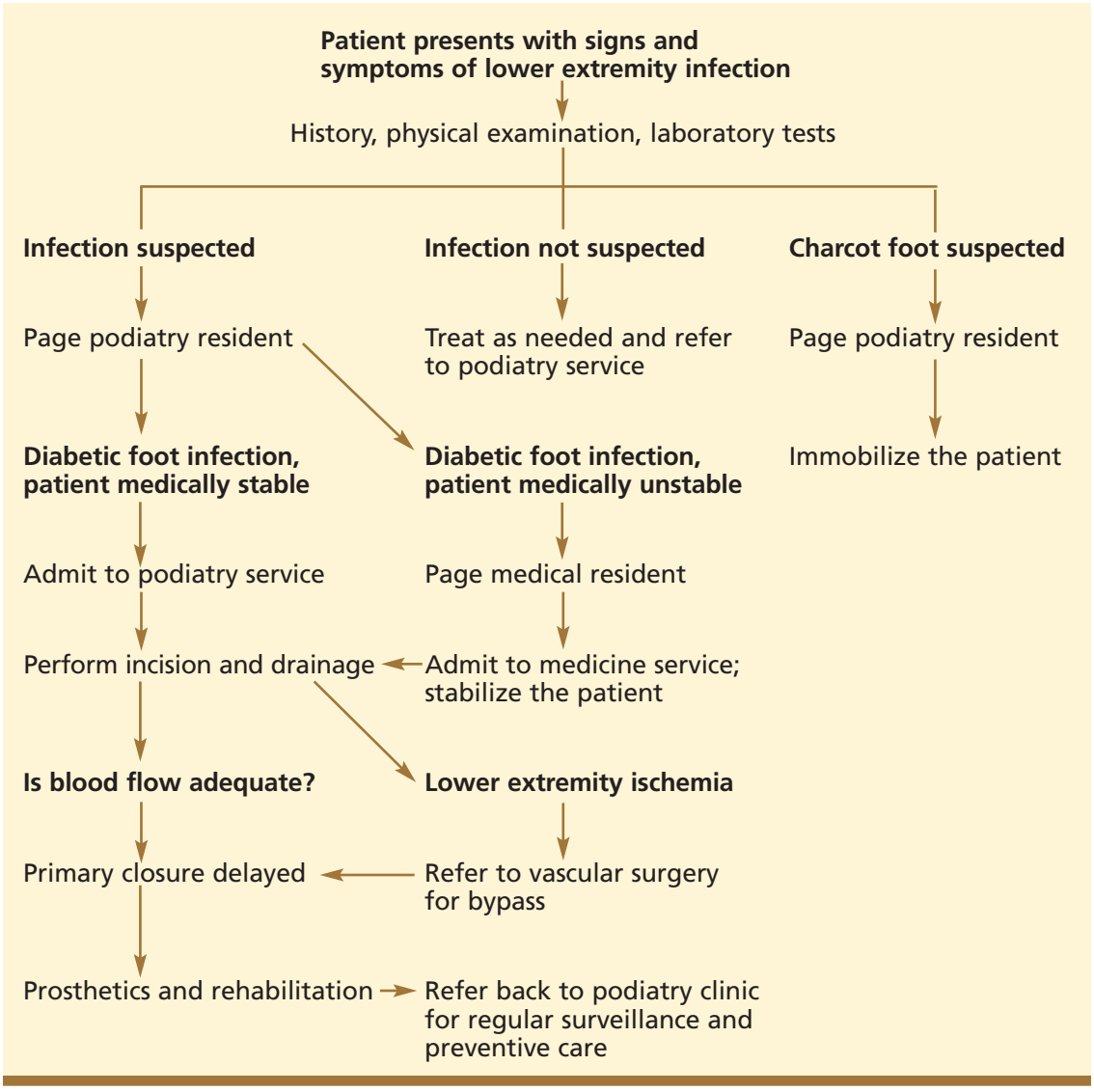

FIGURE 1. Algorithmic approach to care of patients with acute diabetic foot infections

when disciplines collaborate to negotiate the best plan of care.[1–5]

At our institution we chose to focus on patients with potentially limb-threatening acute diabetic foot conditions, since diabetic foot infections and ulcerations commonly lead to amputation. We determined that the process of care at our institution needed to be improved, and that we needed to immediately introduce a system to prevent inappropriate and late referrals that often resulted in prolonged hospital stays and amputations. To this goal, we developed and tested a microsystem of care that included the urgent care center, the internal medicine service, the infectious disease service, the podiatry service, the vascular surgery service, and the prosthetic service in order to expedite and facilitate the care of major diabetic foot infections. Our system was patient-centered and made use of care maps and algorithms, and it negotiated admission policies among the different services. The principles underlying our approach included early and accurate diagnosis, screening, surveillance, and limb-salvage procedures.

ADVANTAGES OF MULTIDISCIPLINARY CARE

Multidisciplinary care improves outcomes in patients with complex medical problems.

TABLE 1

Admission criteria for diabetic patients with acute foot infection

MANDATORY ADMISSION TO MEDICINE SERVICE, WITH PODIATRY CONSULT	SUITABLE FOR ADMISSION TO PODIATRY SERVICE
Unstable coronary artery disease	Stable coronary artery disease
Decompensated congestive heart failure	Compensated congestive heart failure
Poorly controlled diabetes mellitus (blood glucose consistently > 300 mg/dL)	Controlled diabetes
Poorly controlled hypertension (average blood pressure 170/100 mm Hg)	Controlled hypertension
Positive blood cultures	Negative blood cultures
Worsening renal function from baseline	Stable chronic renal failure
Mental status changes	No mental status changes
Concurrent central line and catheter infections	No concurrent line infections
New requirement for supplemental oxygen	No new requirement for supplemental oxygen

Ziran et al[6] reported improved outcomes in patients with osteomyelitis when followed by both an orthopedic surgeon and a dedicated musculoskeletal infectious disease specialist. Wrobel et al[7] showed that, within the VA system, patients with diabetes had significantly lower rates of amputation in facilities with higher levels of programming and feedback coordination.

In addition to improving patient outcomes, multidisciplinary care has also been shown to lead to significant savings in health care expenditures.[7] In a recent Markovian analysis by Ortegon et al, the combination of intensive glycemic control and optimal foot care was estimated to reduce the amputation rate by 58%, with a cost per quality-adjusted life-year gained of $12,165.[8]

OUR SYSTEM

Diabetic foot infections present a complex challenge and are best approached with integrated multidisciplinary care. We sought to improve the care of patients with diabetic ulcers at our institution once they presented with overt infection with or without ulceration, with the ultimate goal of decreasing the amputation rate.

To accomplish this, we devised an algorithm (FIGURE 1) for a multidisciplinary approach including proper wound care, appropriate rehabilitation, adequate prosthetic and orthotic control, and aggressive management of concurrent medical problems (specifically, aggressive glycemic and blood pressure control), as well as continuing surveillance in podiatry, vascular medicine, and general medicine clinics. Not surprisingly, this approach necessitated a great deal of coordination by both the podiatry and the medicine services.

Our 'microsystem' of care coordinates podiatry and medicine staff and care

In our model, when a diabetic patient with a complicated foot ulcer presents to our urgent care center or to the clinic, the first decision is whether admission is required. Once this decision is made, our on-call podiatry resident evaluates the patient, performs a detailed podiatric examination, and makes a provisional diagnosis. During this assessment, a determination is made about the general medical and vascular status of the patient, which then helps decide to which service the patient will ultimately be admitted.

To ensure that the patient is admitted to the appropriate service, we developed a set of guidelines to help in the decision-making process. These guidelines were developed by staff members from both podiatry and medicine services and were subsequently shared with members of both services for concurrence. The criteria we devised for admission to both services are outlined in TABLE 1.

For this system to be successful, it was necessary to ensure that our medicine consultation service was available 24 hours a day, 7 days a week. During regular working hours, the medicine consultation service is staffed by the VA inpatient chief resident. After hours and on weekends, the on-call admitting resident evaluates all consults and assigns a care team or physician to these patients by phone with the chief medical resident.

The chief resident is available to evaluate patients during off hours if necessary. All consultations are completed the same day, with a formal consultation placed in our computerized patient record system. The medicine consult service is expected to continue to follow each of these patients on the podiatry service, either until the patient is discharged or until a mutual decision has been reached between the medicine and the podiatry services that consultative services are no longer required. In addition, any recommendations from the medicine consult service regarding the care of the patient are to be ordered by the medicine consult team, specifically blood draws, medication changes, radiographic studies, and additional consultative services. If at any time after being admitted the patient should require one of these services, the patient is immediately transferred to the medicine service with the podiatry service following in a consultative role. With this system, we have been able to provide seamless care for patients, in addition to providing for better continuity among care providers.

Improving the process improves the care

THE SYSTEM IN ACTION: AN EXAMPLE

T.H. is a 52-year-old white man with multiple medical problems including diabetes mellitus requiring insulin, multiple distal amputations, and coronary artery disease with a Saint Jude aortic valve. He presented to our institution with a chief complaint of fevers, redness, and swelling of his right lower extremity. He also reported nausea, lack of appetite, and episodic chest pain over the previous 4 days. At the time of admission, the patient was on aggressive medical management for his coronary disease, as well as glyburide and neutral protamine Hagedorn (NPH) insulin for his diabetes.

The physical examination revealed cellulitis of the right foot, palpable distal pulses, and an ulceration 0.5 cm in diameter on the plantar aspect of the right foot. Neurologic examination showed absent sensation in the plantar aspect of the right foot and loss of proprioception. Radiographs of the affected foot suggested osteomyelitis.

Laboratory tests on admission showed a normal white blood cell count and mild anemia. Electrocardiography and chest radiography were normal.

The patient was diagnosed with an infected diabetic mal perforans ulceration with concurrent cellulitis and osteomyelitis. Additionally, a deep space abscess was suspected, ultimately leading to surgical debridement with limb-sparing primary amputation of nonfunctional digits 3, 4, and 5. Broad-spectrum antibiotics were started empirically and were tailored according to the culture results.

Based on our decision tree, the patient was determined to be appropriate for admission to the general medicine service, given that he had complained of recent chest pain and had known coronary disease with poorly controlled diabetes and hypertension. The medicine service managed the patient's acute medical needs as mentioned above, in addition to managing the perioperative coagulation issues related to his artificial heart valve. All other perioperative care was managed by the podiatry service.

Immediately after surgery, the wound was packed open and was examined on a daily basis by the podiatry service. All wound care, including sterile wound irrigation and bedside dressing changes, were performed by the podiatry service until clinical and laboratory data supported delayed primary closure of the wound. Primary closure was performed 5 days after the initial surgical procedure, and the patient was transferred to the podiatry service 24 hours later, as he was deemed medically stable. Three days later, when the values of the patient's coagulation profile had reached therapeutic levels, he was discharged home.

THE RESULTS OF OUR MULTISYSTEM APPROACH

FIGURE 2 shows the results of our amputation prevention strategies, which included foot

screening, risk assessment, and timely and appropriate referral through the use of our algorithm and admission criteria. The program began in August 2002. Age-adjusted overall amputation rates for patients with diabetes decreased from 5.64 to 4.12 per 1,000 patients from fiscal year 2001 through fiscal year 2004 (although the fiscal year 2003 amputation rate was 3.74).

On further analysis, we found that the rate of major amputations (defined as any amputation at or above the ankle) decreased steadily from 2.15 in 2001 to 1.42 in 2004. The rate of minor amputations decreased from 3.49 in 2001 to 2.70 in 2004 (although the 2003 rate was 2.27). It would seem that the increase in the overall amputation rate from 2003 to 2004 was due to an increase in the number of minor and not major amputations. This may be due to improved screening or earlier detection and intervention, or it may be an equivocal finding.

If amputation has to be performed, it is better that a toe, ray, or partial foot amputation be performed to spare as much walking surface as possible. This helps improve outcomes by maintaining as many distal joints as possible, permitting fitting of the smallest and lightest prosthetic device possible.

FIGURE 3 shows the major to minor amputation ratios, with 2004 data showing the best ratio. These numbers further suggest that screening may discover foot pathology earlier, resulting in more distal amputations.

We recognize the limitations of these data and do not suggest a correlation between the use of the algorithm alone and the improvements in amputation prevention. However, we do suggest the data may identify an association between our system of care—ie, foot screening, risk assessment, and timely and appropriate referral—and the improvement in the amputation rates. The principles used are all previously validated methods of prevention.

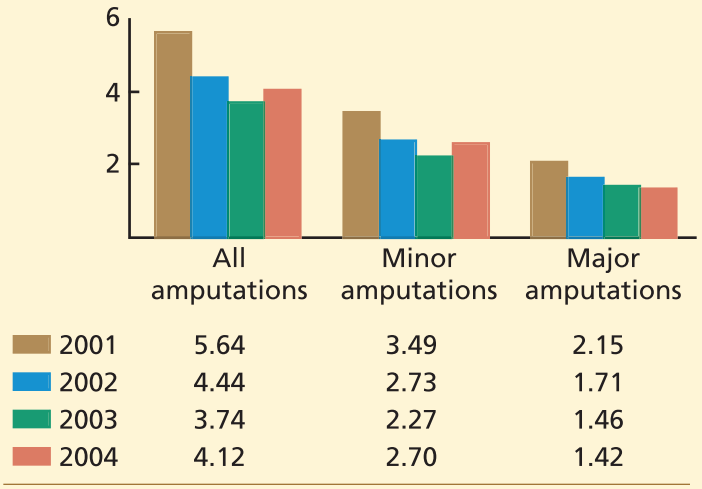

FIGURE 2. Age-adjusted amputation rates per 1,000 patients with diabetes during the years 2001 to 2004.

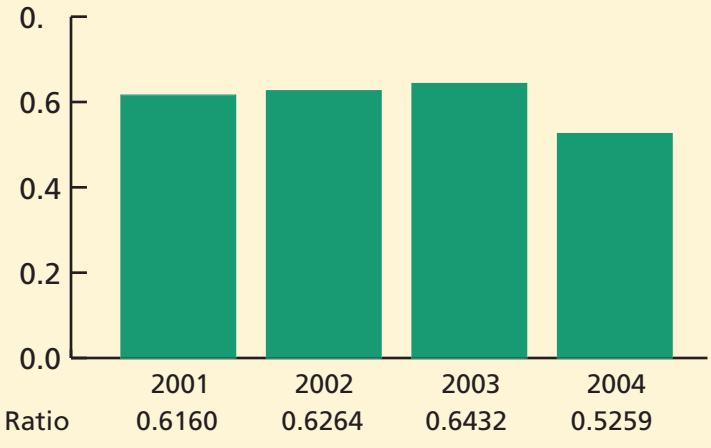

FIGURE 3. Ratio of major to minor amputations.

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ADDRESS: *Jeffrey M. Robbins, DPM, Podiatry Service, Louis Stokes VAMC, 10701 East Boulevard, Cleveland, OH 44106; e-mail Jeffrey.robbins@med.va.gov.*