The Management of Foot Infections

By Min Lee, MD FRCSC; John Steinberg, DPM

Limb preservation can involve both established and emerging strategies to identify, prevent and surgically manage foot infections in patients living with peripheral arterial disease (PAD), chronic limb-threatening ischemia, and diabetes. If a person with diabetes needs treatment, a multidisciplinary approach is recommended. This approach combines antiplatelet agents, a statin, glucose management, exercise therapy, hypertension management and hyperlipidemia management.[1–2]

Each health-care professional should focus on the three main goals of any multidisciplinary wound care team: eliminate infection, treat ischemia and address biomechanical abnormalities of the foot. Diabetic foot infections cause more inpatient days than any other diabetes-related complication. In the United States, diabetic foot infections amount to 20 to 25% of all diabetes-related hospital admissions. Clinics in the United States often implement low-cost treatments like dressings before moving to higher-cost items like inpatient admission and amputation.[3–4] Given the expense involved for inpatient and surgical care, we should consider more frequent use of "expensive conservative care" (e.g., specialty offloading devices, at-home advanced nursing care, wound care products and frequent wound care visits), as these outpatient costs are a fraction of inpatient care. This care could include advanced tissue products, grafting, offloading and weekly outpatient clinic visits. Waiting to treat uncomplicated diabetic foot ulcers can lead to high-cost treatments to heal infected ulcers and to amputate limbs.

Three Factors: A Systematic Approach

Three factors lead to diabetic foot infection: immunopathy (e.g., polymorphonuclear dysfunction), angiopathy (e.g., ischemia, impaired healing, poor perfusion of oxygen, nutrients and antibiotics) and neuropathy (i.e., inability to detect trauma, dry or cracked skin, abnormal biomechanics).

Treating these factors requires a systematic approach. It is crucial that surgical treatment be pursued aggressively with careful planning for the whole process of incisions, wound exploration, culture-taking, debridement, reaching hemostasis, lavage, dressing application and medical management. Complex wound reconstruction, debridement and closures should be staged ahead of time. This list is simple to read, but in practice, the preparation is complex. In the case of severe diabetic foot infection, source control with incision and drainage, or guillotine amputation may be required first to prevent overwhelming sepsis.

Managing Infection Versus Managing Ischemia

Clinicians must differentiate between managing infection and managing ischemia. In earlier years,

ischemia was prioritized over infection. It has since been found, however, that infection control should be prioritized before revascularization is considered. Therefore, the health-care team should in most cases consider revascularization before completion and closure in the final stage of an amputation.

When treating infections, the collection and culturing of soft tissue specimens is valuable in identifying which antibiotics to use. But the method with which cultures are taken matters. Blood cultures should be performed for patients with severe infections and systemic illnesses. Swab cultures are considered a poor method but may be the only option for practices not equipped to take tissue cultures. Superficial swab culture collections are not very useful, but samples from deep inside wounds or sinus tracts can be helpful, particularly when taken in the operative room after debridement of the wound site.[5–6]

> In earlier years, ischemia was prioritized over infection. It has since been found, however, that infection control should be prioritized before revascularization is considered.

Imaging methods are also a valuable tool when treating infections. There is a preference toward serial plain film radiographs to evaluate bone changes over time.[7] MRIs and bone scans can be misleading when trying to diagnose conditions like osteomyelitis in small bone structures.[7] Though bone biopsies are generally considered the gold standard for diagnosing osteomyelitis, the recent literature provides conflicting viewpoints.

A New Method for Heel Wounds

Vertical contour calcanectomy is a new treatment for heel wounds.[8] The operation is a modified partial calcanectomy that goes against old teachings about amputations being better for the patient than any method that removes the Achilles tendon. Steinberg, among others, has found that these traditional beliefs are not necessarily relevant, especially for geriatric patients who are able to keep ambulatory with appropriate footwear. Vertical contour calcanectomies require extensive pre-surgery markings. The procedure involves making a deep enough incision to create two medial/lateral full-thickness tissue flaps along the heel that can be used for primary closure in place of skin grafts. Next, the surgeon excises the entire ulcer, detaches and excises the Achilles tendon and removes 50 to 75% of the calcaneus bone. To facilitate closure, the team ensures patients scar on the operated-on area and can then wear a brace for weight-bearing. After these operations, previously non-closable ulcers can heal successfully.

Vascular Status

Identifying the circulation issues associated with diabetic foot ulcers is a significant factor in the treatment plan. Peripheral arterial disease (PAD) and diabetes are closely connected. Diabetes causes aggressive inflammation of blood vessels that leads to plaque build-up, which in turn leads to stenosis. The diabetic pattern of PAD is particular and can mainly be seen in infrapopliteal and pedal developments. There may also be unique and complex changes occurring at the microcirculatory level that prevent ulcers from healing, even after a patient has been treated for large vessel disease.

Min Lee is a staff physician at Queen Elizabeth Health Sciences Centre. She trained in general surgery at Dalhousie University, vascular surgery at the University of Ottawa, and endovascular surgery at the University of Medicine and Dentistry of New Jersey.

John Steinberg is a professor and full-time faculty member in the department of plastic surgery at Georgetown University School of Medicine in Washington, DC. He is Co-Director of the Center for Wound Healing at MedStar Georgetown University Hospital, where his practice emphasizes multidisciplinary resident and student teaching. He is Program Director for the MedStar Washington Hospital Center Podiatric Residency Program.

The blood vessels of individuals with diabetes also tend to be significantly calcified—the degree and extent are associated with disease severity and poor outcomes, including risk of amputation and all-cause mortality.

The prevalence of diabetes continues to increase. This will have a massive impact on the number of patients with arterial disease that clinicians will be treating in the near future. Diabetes is a major risk factor for PAD, with prevalence rates for PAD being 10 and 40% among individuals with diabetes.[9] A combination of PAD and diabetes has a five-year mortality rate of almost 50%, and a similar two-year mortality rate for such patients who have amputations.[10] Upwards of 50% of patients with foot ulcers will have PAD, and 40 to 50% of PAD patients will have diabetes.[11] This emphasizes the importance of revascularization. It is recommended that all patients with diabetes have an arterial assessment by the age of 50 so that treatment plans can be modified if necessary.[10]

Upwards of 50% of patients with foot ulcers will have PAD, and 40 to 50% of PAD patients will have diabetes.

The health-care professional should begin the assessment of a patient's vascular status with a physical exam of pulse volume recordings and segmental pressure tests. Calculating a patient's arterial brachial index (ABI) requires taking blood pressure readings from their arms and ankles, then dividing the ankle's systolic pressure by the arm's systolic pressure. In the presence of calcified tibial arteries that are not compressible, toe pressures can be obtained. An ABI less than 0.8 is indicative of peripheral vascular disease, and referral to vascular specialist should be considered (see Table 1).[12] Some blood vessels, like non-compressible tibial vessels, can be compared to lead pipes: difficult to view and not easily diagnosed. It is possible to take transcutaneous oxygen measurements of these vessels, but that method is not widely available in Canada.

Not every diabetic ulcer with associated PAD requires revascularization, however. Conservative

Table 1: Arterial Flow and Perfusion[13]

Classification	ABPI	Toe Brachial Index	Toe Pressure	Waveforms	$TcPO_2$* (indicating perfusion)
Non-compressible	> 1.40 Be aware of possible falsely elevated measures	Preferred when non-compressible vessels are present	Preferred when non-compressible vessels are present		Preferred when non-compressible vessels are present
Normal Range	1.0–1.40	> 0.7	> 70 mmHg	triphasic	> 40 mmHg
Borderline	0.91–0.99	> 0.6	> 70 mmHg	biphasic/mono	> 40 mmHg
Abnormal	< 0.90	> 0.6	< 70 mmHg	biphasic/mono	< 40 mmHg
Mild	0.7–0.9	> 0.4	> 50 mmHg	biphasic/mono	30–39 mmHg
Moderate	0.4–0.69	> 0.2	> 30 mmHg	biphasic/mono	20–29 mmHg
Severe	< 0.4 Critical limb ischemia	> 0.2	< 30 mmHg	monophasic	< 20 mmHg

*Transcutaneous oxygen pressure

treatment is possible if there's an acceptable toe pressure or ABI, but clinicians should regularly reassess the patient's circulation and ensure that everything is optimized medically and biomechanically. In some cases there shouldn't be any vascular intervention, as when a patient has a massive diabetic foot infection that clearly requires amputation.

Barriers

There are several barriers to changing practice, including inadequate training about assessment of vascular status, the need for appropriate offloading, inadequate access to primary care, specialists, or multidisciplinary teams and clinics, inadequate initiation of medical treatment, and patients' socio-economic status. Solutions to these barriers include education through conferences like Wounds Canada's, involvement in policy making and government lobbying to fund multidisciplinary teams, funding for better nutrition, social supports, and national pharmacare and foot care.

The areas of diabetic foot wound care and limb preservation have undergone a huge shift in the last few years. What was previously a miserable and often negative topic has become increasingly positive, as long as treatment is aggressive. ■

References

1. Conte MS, Bradbury AW, Kolh P, White JV, Dick F, Fitridge R, et al. Global vascular guidelines on the management of chronic limb-threatening ischemia. Eur J Vasc Endovasc Surg. 2019;58(1S):S1–S109.
2. Hingorani A, LaMuraglia GM, Henke P, Meissner MH, Loretz L, Zinszer KM, et al. The management of diabetic foot: A clinical practice guideline by the Society for Vascular Surgery in collaboration with the American Podiatric Medical Association and the Society for Vascular Medicine. J Vasc Surg. 2016;63(2 Suppl):3S–21S.
3. Edelson GW, Armstrong DG, Lavery LA, Caicco G. The acutely infected diabetic foot is not adequately evaluated in an inpatient setting. Arch Intern Med. 1996;156(20):2373–2378.
4. Tennvall GR, Apelqvist J. Health-economic consequences of diabetic foot lesions. Clin Infect Dis. 2004;39(Suppl 2):S132–S139.
5. Lipsky BA, Berendt AR, Deery HG, Embil JM, Joseph WS, Karchmer AW, et al. Infectious Diseases Society of America. Diagnosis and treatment of diabetic foot infections. Clin Infect Dis. 2004;39(7):885–910.
6. Slater RA, Lazarovitch T, Boldur I, Ramot Y, Buchs A, Weiss M, et al. Swab cultures accurately identify bacterial pathogens in diabetic foot wounds not involving bone. Diabet Med. 2004;21(7):705–709.
7. Meyr AJ, Seo K, Khurana JS, Choksi R, Chakraborty B. Level of agreement with a multi-test approach to the diagnosis of diabetic foot osteomyelitis. J Foot Ankle Surg. 2018;57(6):1137–1139.
8. Elmarsafi T, Pierre AJ, Wang K, Evans KK, Attinger CE, Kim PJ, et al. The vertical contour calcanectomy: An alternative surgical technique to the conventional partial calcanectomy. J Foot Ankle Surg. 2019;58(2):381–386.
9. American Diabetes Association. Peripheral arterial disease in people with diabetes. Diabetes Care. 2003;26(12):3333–3341.
10. Canadian Cardiovascular Society. Peripheral Arterial Disease. Canadian Cardiovascular Society Consensus Conference. 2005. Retrieved from: https://ccs.ca/app/uploads/2020/12/PAD_CC_2005.pdf.
11. Hinchliffe RJ, Forsythe RO, Apelqvist J, Boyko EJ, Fitridge R, Hon JP, et al. Guidelines on diagnosis, prognosis, and management of peripheral artery disease in patients with foot ulcers and diabetes (IWGDF 2019 update). Diabetes Metab Res Rev. 2020;36(S1):e3276.
12. Beaumier M, Murray BA, Despatis MA, Patry J, Murphy C, Jin S, et al. Best practice recommendations for the prevention and management of peripheral arterial ulcers. In: Foundations of Best Practice for Skin and Wound Management. A supplement of Wound Care Canada; 2020. 78 pp. Retrieved from: www.woundscanada.ca/docman/ public/health-care-professional/bpr-workshop/1690-wc-bpr-prevention-andmanagement-of-peripheral-arterial-ulcers-1921e-final/file.
13. Canadian Association of Wound Care. Advances for the Management of Diabetic Foot Complications. Session workbook. 2016.