

# Variation in clinical presentation of hospitalized patients with diabetic foot ulcers who underwent lower leg amputation in the Bronx from 2016–2021

Ava Tsapatsaris<sup>1</sup>, Denise A Levy<sup>2</sup>, Alyson K Myers<sup>3</sup>, Johanna P Daily<sup>4</sup> and Manasa Kanneganti<sup>5</sup>

<sup>1</sup>Gallatin School of Individualized Study New York University, New York, USA

<sup>2</sup>Department of Podiatric Medicine, Montefiore Medical Center/Albert Einstein College of Medicine, Bronx, New York, USA

<sup>3</sup>Division of Endocrinology, Department of Medicine, Montefiore Medical Center/Albert Einstein College of Medicine Bronx, New York, USA

<sup>4</sup>Division of Infectious Disease, Department of Medicine, Montefiore Medical Center/Albert Einstein College of Medicine Bronx, New York, USA

<sup>5</sup>Department of Surgery, Montefiore Medical Center/Albert Einstein College of Medicine, Bronx, New York, USA

Correspondence should be addressed to A Tsapatsaris: [at5477@nyu.edu](mailto:at5477@nyu.edu)

## Summary

Lower extremity amputation secondary to diabetic foot ulcers (DFU) is associated with a 50% mortality rate within 5 years. The aim of this case series is to understand the risk factors and management of DFU leading to above-knee or below-knee amputation at an urban medical center. We conducted a retrospective review of the medical history, foot examination findings, noninvasive vascular studies, angiographic imaging, and radiology results from hospital stays during which patients underwent amputation. A total of 35 patients with DFU who underwent amputation between 2016 and 2021 were evaluated. Of these, 16 ambulatory patients had complete medical data and were included in the analysis. Risk factors for amputation, clinical presentation, diagnostic findings (e.g. vascular studies or imaging), and amputation approaches were analyzed. Our study found significant variability in the medical history, presentation, and management of patients with DFU who underwent lower extremity amputations, including differences in vascular abnormalities and the timing of care. Poor glucose control (median HbA1c of 10.3%) and delayed presentation likely contributed to tissue loss and amputation. Understanding the individual medical presentations and management of patients undergoing leg amputation secondary to DFU may inform the development of more effective strategies to prevent this complication in patients with diabetes.

## Learning points

- There is significant variability in the presentation and progression of diabetic foot ulcers (DFUs).
- Diagnostic evaluation of DFU varies between patients; a more standardized evaluation to inform best practices could be useful.
- Socioeconomic status (SES) plays a role in the increased risk of amputations among DFU patients, including delay in care and access to limb salvage programs.
- Multidisciplinary care, including early detection of DFU, patient education, and routine screenings, is essential for improving outcomes and reducing the risk of amputations in high-risk DFU patients.

keywords: diabetes mellitus; lower extremity amputation; diabetic foot ulcer

## Background

Patients with a below-knee amputation (BKA) or an above-knee amputation (AKA) secondary to diabetic foot ulcers (DFU) have an associated 50% mortality rate within 5 years (1). Avoiding AKA/BKA and promoting limb salvage will improve survival and quality of life for patients with DFU. There are standardized and comprehensive guidelines for the management of DFU (2). However, there are no standardized guidelines for diabetes-related amputation. The decision to recommend AKA/BKA is based on various patient-specific factors, including the patient's ambulatory status, functional status, extent of infection, severity of peripheral arterial disease, and surgical expertise (3). The goal of this case series is to review the history and evaluation of patients who underwent an AKA/BKA and identify potential areas of improvement in the care of DFU to increase limb salvage. We report the clinical evaluation and diagnostic workup of 16 ambulatory patients with DM who underwent AKA/BKA from a cohort of hospitalized patients with DFU at an academic medical center in the Bronx, NY, between 2016 and 2021.

We studied patients with DFU who underwent a BKA or AKA in an urban medical center that provides care to an underserved population. We identified patients from a cohort of 650 adults admitted with DFU between June 1, 2016, and May 31, 2021 (4). For this study, we focused on those who underwent either a BKA or AKA and classified them into two groups: ambulatory and nonambulatory. Ambulatory patients could walk independently or with the aid of an assistive device, while nonambulatory patients were wheelchair-bound or bed-bound. Only ambulatory patients were analyzed, as the study aimed to assess limb preservation efforts in individuals who were still ambulatory at the time of presentation. Amputation in previously ambulatory patients will have much greater impact on the individual's health and well-being compared to those that are previously nonambulatory. Medical history, severity of the ulcer using the Wagner scale, and noninvasive tests and imaging data were extracted from the electronic health record. The study was approved by the institutional review board (IRB number 2022-14264).

## Case presentation

Twenty-six patients underwent a BKA, and nine patients had an AKA (Table 1). Of the 35 patients, 16 patients were ambulatory, and we provide in depth details of this group who had a median age of 55 years at the time of the amputation, and 50% were female. All ambulatory patients who underwent BKA or AKA were either Black and/or Hispanic. Their medical history, presentation, and management are described below (Fig. 1).

**Table 1** Demographic and clinical data of patients presenting with DFU who underwent an amputation. Data are presented as *n* (%).

Variable	Ambulatory	Non-ambulatory
<i>n</i>	16	19
Sex (male)	50%	68%
Age (years)		
Median	55	64
<40	2 (13)	0 (0)
40–49	2 (13)	1 (5)
50–60	6 (37)	6 (32)
61–70	5 (31)	8 (42)
≥75	1 (6)	4 (21)
Race		
Black	9 (56)	5 (26)
Hispanic	7 (44)	10 (52)
White	0 (0)	2 (11)
Other	0 (0)	2 (11)
HbA1c (%)	10.5	8.8
Amputation type		
AKA	1 (6)	8 (42)
BKA	16 (94)	11 (58)

### Case 1

A 51-year-old non-smoking male with type 2 diabetes (T2D), diabetic neuropathy, and peripheral artery disease (PAD) presented with sepsis from a right diabetic foot infection (DFI). The patient presented directly from the Dominican Republic, where he had undergone serial debridement of the wound and required a skin graft. He had non-palpable right lower extremity (RLE), dorsal pedis (DP), and posterior tibialis (PT) pulses. The patient had significant edema with large wounds exposing the talonavicular joint with visible synovial fluid, pus, and necrotic tendon, consistent with a Wagner stage 3 ulcer. The patient had an HbA1c of 11% at the time of admission. The patient did not undergo vascular testing due to extensive tissue loss and infection. The patient underwent a right BKA.

### Case 2

The patient was an 81-year-old non-smoking male with T2D and PAD who initially presented to his podiatrist with discoloration of the right foot fourth digit. He was started on antibiotics without improvement, and after 1 week, his podiatrist noted purulent draining of the wound and sent the patient to the emergency department (ED) for further treatment. He had a Wagner stage 3 right foot ulcer with bilateral non-palpable DP and PT pulses. The patient had an HbA1c of 11% at admission. He had an arterial duplex, which showed tibial disease bilaterally, with right-sided anterior tibial and peroneal occlusive disease and narrowed posterior tibial and dorsalis pedis arteries. He underwent tibial atherectomy and angioplasty with patency of the posterior tibial artery and branches restored. After revascularization, he underwent

Case	Palpable Pulses	Non-Palpable Pulses	ABI	Arterial Duplex	Angiogram	Foot X-Ray	Foot MRI	Foot CT Scan
1								
2								
3								
4								
5								
6								
7								
8								
9								
10								
11								
12								
13								
14								
15								
16								

**Figure 1**

Diagnostic evaluations of patients presenting with DFU. Clinical, vascular, and imaging evaluation of sixteen ambulatory patients who underwent AKA/BKA for DFU. ABI: Ankle-brachial index.

amputation of the infected fourth and fifth metatarsals. He underwent a second angiogram due to re-occlusion of the tibial vessels. However, the patient did not have adequate restoration of flow and underwent a right BKA.

### Case 3

A 56-year-old non-smoking female with T2D, diabetic neuropathy, and PAD presented with chronic RLE cuboid osteomyelitis and foot abscesses. The patient had a history of recurrent admissions for DFU with previous amputation of the hallux and debridement. Her medical team had discussed the options of limb salvage versus amputation due to her recurrent infections and tissue loss, and she opted for limb salvage with wound care and long-term antibiotics. After her previous admission, her visiting nurse services were discontinued, and she had been without wound care. She had a right foot Wagner stage 3 ulcer at admission, with a palpable right DP and no PT pulse, and underwent a bedside incision and drainage in the ED. The patient had an HbA1c of 10% at admission. She underwent vascular evaluation (arterial duplex, PPG, and ABI/PVR) and had microvascular disease without any evidence of large vessel disease on the duplex. MRI of the right foot showed progression of the patient's previously diagnosed osteomyelitis to the distal tibia with multiple abscesses in the foot. The patient underwent a right BKA.

### Case 4

A 54-year-old non-smoking female with T2D, diabetic neuropathy, and PAD presented with increasing right

foot swelling and discoloration for 1 week, which was a Wagner stage 5 ulcer with extensive necrotic tissue over the medial forefoot and entire dorsum, with erythema tracking above the ankle. There were non-palpable pedal pulses bilaterally. The patient had an HbA1c of 14% at the time of admission. On the right, PVR waveforms were normal at the level of the thigh and calf and mildly diminished at the ankle, with an ABI of 0.7 bilaterally and adequate perfusion to the metatarsal level on the ABI/PVR study. The patient's duplex showed tibial disease bilaterally. The patient underwent a staged guillotine BKA due to extensive infection. There was no history of podiatry care documented before surgery.

### Case 5

A 54-year-old non-smoking male with T2D and PAD presented with a 2-day history of RLE pain and swelling occurring after a fall. On exam, the patient had superficial skin breakdown, dry eschar at the posterior medial aspect approximately 2 cm (about 0.79 in) in diameter, erythema, and swelling extending from the midfoot to above the ankle, consistent with a Wagner stage 4 ulcer. He had palpable DP and PT pulses bilaterally. The patient had an HbA1c of 8% at admission. An x-ray of the right foot showed extensive fractures throughout the metacarpal and metatarsal bones. There was also extensive subcutaneous air overlying the dorsum of the foot and soft tissue edema. The patient underwent a staged debridement, as he refused the recommended below-knee amputation, followed by guillotine BKA and closure due to progressive infection. The patient had not received previous podiatry care.

### Case 6

A 36-year-old non-smoking female with T1D presented with necrotizing infected DFU of the RLE, septic right swollen foot, foul-smelling, draining dishwasher liquid-colored fluid and pus, and crepitus from the dorsum of the foot to the distal anterior shin. The patient had a Wagner stage 3 ulcer. She had non-palpable DP and PT pulses and an HbA1c of 11.8% at admission. She had a foot x-ray showing extensive metatarsal fractures, gas in the midfoot and distal leg, and advanced Charcot arthropathy of the midfoot. The patient underwent a staged guillotine BKA followed by closure due to the severity of the infection. The patient had no documented visit to podiatry before surgery.

### Case 7

A 67-year-old non-smoking female with T2D and neuropathy presented with a non-healing right DFU. She had previously been admitted to an outside hospital for management of a DFU and underwent extensive debridement of the right foot. That hospitalization was complicated by a non-ST-elevation myocardial infarction. Her right foot ulcer was Wagner stage 3 at presentation to our institution. The patient had non-palpable pedal pulses bilaterally. The patient had an HbA1c of 7.2% at the time of admission. The patient underwent ABI/PVR and was found to have 0.8 bilaterally, suggestive of PAD, and tibial disease. The arterial duplex showed evidence of tibial disease bilaterally. The MRI demonstrated fluid suggestive of infection in the midfoot. The patient underwent a staged guillotine BKA with closure due to the extent of tissue loss. The patient had no history of engagement with podiatry before admission.

### Case 8

A 62-year-old male with T2D and tobacco use disorder presented with a right DFU. The patient was transferred from an outside hospital for management of a right foot ulcer after previously refusing an amputation. He had a Wagner stage 3 right DFU and palpable DP and PT pulses bilaterally. There was no HbA1c result reported. The PVR findings demonstrated tibial and metatarsal disease on the right. The ABI could not be obtained secondary to incompressible vessels. Arterial duplex showed tibial disease bilaterally. The angiogram showed tibial disease without any runoff vessels into the foot, indicating microvascular disease. The patient underwent foot debridement but ultimately underwent BKA due to extensive tissue loss. The patient was referred to podiatry in 2013 but was not seen.

### Case 9

A 36-year-old female with poorly controlled T2D, tobacco use disorder, and diabetic neuropathy presented with

persistent drainage from a right transmetatarsal amputation site. The patient had a history of multiple digit amputations and was now status post bilateral transmetatarsal amputation for osteomyelitis and had been treated by podiatry. She had a right Wagner stage 3 foot ulcer and an HbA1c of 8.2% at admission. Pulses and noninvasive studies were not documented, and no angiogram was performed. MRI showed osteomyelitis of the talus and calcaneus with an associated joint effusion. The patient underwent a right BKA due to infection and extensive tissue loss.

### Case 10

A 55-year-old non-smoking male with T2D presented with a left midfoot DFU. The patient had blistering and drainage for 1 week that prompted presentation to the ED. The patient had a left foot Wagner grade 3 ulcer and non-palpable DP and PT pulses on the left side. The patient had an HbA1c of 13.3% at admission. ABI/PVR showed no hemodynamically significant stenosis noted in the evaluated arteries bilaterally. Arterial duplex showed no evidence of disease bilaterally. The patient underwent a staged guillotine BKA with closure due to the extent of infection. The patient had no engagement with podiatry before surgery.

### Case 11

A 66-year-old female with T2D and tobacco use disorder presented with a gangrenous right transmetatarsal amputation site and gangrene of the left first through third toes. She had previously undergone an endovascular revascularization with iliac stenting. Her foot ulcers were Wagner grade 2 bilaterally, and her PT pulses were non-palpable, and no HbA1c was reported. The patient had an arterial duplex showing significant tibial disease bilaterally without revascularization options. On the right side, she had nonreconstructible vascular disease and underwent an AKA. There was an attempt to revascularize the left lower extremity. However, the angiogram showed significant tibial disease without any outflow options into the foot, which precluded surgical intervention. As a result, she underwent a left AKA. The patient had been referred to podiatry by the ED 2 years before surgery for paronychia of the right foot.

### Case 12

A 43-year-old male with T1D and tobacco use disorder presented in diabetic ketoacidosis with a RLE necrotizing DFU. The patient was admitted with a right Wagner grade 3 ulcer and had a palpable anterior tibial pulse. No HbA1c was reported. He underwent an x-ray of his right foot showing gas in the soft tissues of the foot without evidence of osteomyelitis. He did not undergo further testing due to the extent of infection and need for

amputation. The patient underwent a staged guillotine BKA with closure. The patient had no engagement with podiatry before surgery.

### Case 13

A 55-year-old non-smoking female with T2D presented with right necrotizing DFI. Trauma to the area occurred when the patient scraped the skin over the dorsum of her right foot while wearing flip flops. She attempted to care for it with topical powders for 5 days, with worsening of the wound, and presented to the emergency room with a Wagner grade 3 right foot ulcer. Her right pedal pulses were non-palpable. The patient had an HbA1c of 11.5% at admission. She did not undergo non-invasive studies or an angiogram due to the extent of infection. The patient underwent a staged guillotine BKA with closure. The patient had no engagement with podiatry before surgery.

### Case 14

A 68-year-old non-smoking male with T2D presented with right foot pain, swelling, and redness for 3 weeks. He had a right foot Wagner grade 3 ulcer. The patient had a palpable anterior tibial pulse. The patient had an HbA1c of 8.9 at admission. He had an x-ray of the RLE which showed extensive soft tissue gas throughout the foot and calf without osteomyelitis. The patient underwent a staged guillotine BKA with closure.

### Case 15

A 72-year-old non-smoking male with T2D presented with left DFI with large ulceration on the lateral foot with exposed tendon and muscle. He had previously undergone a transmetatarsal amputation in the Dominican Republic that healed. He noted that the current ulceration had been present for the past several months. The left foot ulcer was Wagner grade 3 and he had non-palpable pulses. The patient had an HbA1c of 7% at admission. Arterial duplex showed patent arteries throughout with no indication for revascularization. The patient underwent a staged guillotine BKA with closure. The patient had engagement with podiatry as an outpatient before surgery.

### Case 16

A 48-year-old non-smoking female with T2D complicated by neuropathy presented with right necrotizing DFU after stepping on glass 10 days prior. She had a right foot Wagner grade 3 ulcer and non-palpable pulses bilaterally. There was no HbA1C reported. An x-ray of the right foot showed soft tissue gas throughout the foot without osteomyelitis. She underwent an arterial duplex, which did not demonstrate any arterial disease; thus, an angiogram was not performed. Despite extensive

debridement, she required a staged guillotine BKA and closure.

## Discussion

We describe ambulatory patients who underwent BKA/KA from a DFU at a tertiary care center in the Bronx, NY, USA to explore their medical history, indication, and management associated with a lower extremity amputation. Our patients were young, all were Black or Hispanic, and there was marked variation in their evaluation before surgery. In addition, there is a wide variance in the care they had received before the hospitalization.

There was not a standardized battery of tests/imaging for severe DFU, likely due to differences in presentation and variation in management approaches. Ideally, the vascular status in patients with a history of DFU and risk factors should be established earlier in the disease to allow intervention, which was not the case in many patients.

Here the DFU wounds are described using the Wagner classification system, which is widely utilized for assessing DFU. However, this classification falls short in fully capturing the complexities of diabetic limb conditions that are at risk for infection, ischemia, and amputation. In contrast, the University of Texas (UT) Staging System for DFU offers a robust framework for evaluating these ulcers by emphasizing factors such as ulcer depth and the presence of infection or ischemia (4). The Wound, Ischemia, and Foot Infection (WIFI) classification system provides an even more nuanced approach by stratifying amputation risk and guiding protocols of care (5). Staging wounds using the UT classification or WIFI system may be better suited to inform a comprehensive management strategy and enhance quality improvement initiatives.

There has been a global increase in DFU-associated lower extremity amputations, despite an increased understanding of the mechanisms of ulcers, improved diagnostic capabilities, and advances in glucose control management (6). Prevention of DFU is paramount, and risk factors for diabetes-related amputations are well known, and many of them can be addressed, such as smoking cessation, screening for foot deformities – including Charcot's arthropathy – and evaluation and management of peripheral vascular disease. In our cohort, glucose control was poor with a median HbA1c of 10.3, and insufficient glucose control increases risk of amputation in some studies (7). Screening of all patients with diabetes is an important aspect of DFU prevention. The American Diabetes Association recommends routine screening for evidence of loss of protective sensation, PAD, or foot deformity, and referral to vascular surgery if any are detected in patients with diabetes (1). Patients with a history of DFU should also



routinely be referred to podiatry or vascular medicine to provide intensive foot care and reduce the high rate of recurrent ulceration and risk for amputation (8). Some patients had a delay from the time of detection of the ulcer to presenting for care, at which time tissue loss and severity of the ulcer resulted in amputation. Use of foot monitoring devices that detect pre-ulcer changes and educating patients with diabetes to call their physician for any sign of ulcer could reduce amputations due to late clinical presentation (9).

Socioeconomic status (SES) is a critical factor influencing health outcomes, hindering access to healthcare and overall patient well-being. In our cohort, patients with lower SES may have experienced delayed care due to limited access to a primary care provider, low health literacy, and lack of regular care with a podiatrist. These challenges can also contribute to suboptimal glucose control and reduced access to early vascular intervention, ultimately increasing the risk of DFU-related amputation (4).

Amputation should not be the end of intensive care for patients with DFU. To prevent the high mortality following DFU lower extremity amputation, intensive and multidisciplinary care should be offered. Furthermore, healthcare systems where amputations are performed should track health outcomes after discharge from the hospital with the goal of achieving full restoration of patients to an ambulatory state through expert rehabilitation and physical therapy.

Limitations in our study included incomplete data on patient history, such as whether they had been educated and provided the technologies/interventions to reduce the known risk factors, and the extent of prior evaluation and management to maintain foot health. Prevention and management of DFU require expertise in many fields, and the use of multidisciplinary clinics for high-risk patients to provide efficient and comprehensive care has been shown to reduce amputations, and they should be more broadly implemented (10).

This study conveys the complexities associated with DFU and associated AKA/BKA in an ethnically diverse and young group of patients in our healthcare system. Further studies on patient knowledge, provider screening, and screening technologies are underway. Enhancement in patient outreach, provider education, and implementation of a multidisciplinary clinic for high-risk patients may allow for an increase in limb salvage for our population.

#### Declaration of interest

The authors declare that there is no conflict of interest that could be perceived as prejudicing the impartiality of the research reported.

#### Funding

This work was supported by the NY Regional Center for Diabetes Translational Research (grant number 342843) and the American Diabetes Association (grant number CDTR #5).

#### Patient consent

This retrospective case series study was approved by the Albert Einstein College of Medicine Office of Human Research Affairs (IRB number 2022-14264, approval number 115674).

#### Author contribution statement

All authors contributed to this case series through editing and writing.

## References

- 1 Boulton AJ, Armstrong DG, Albert SF, *et al.* Comprehensive foot examination and risk assessment: a report of the task force of the foot care interest group of the American Diabetes Association, with endorsement by the American Association of Clinical Endocrinologists. *Diabetes Care* 2008 **31** 1679–1685. (<https://doi.org/10.2337/dc08-9021>)
- 2 Senneville É, Albalawi Z, van Asten SA, *et al.* IWGDF/IDSA guidelines on the diagnosis and treatment of diabetes-related foot infections (IWGDF/IDSA 2023). *Diabetes Metab Res Rev* 2024 **40** e3687. (<https://doi.org/10.1002/dmrr.3687>)
- 3 Fisher DF & Phair J. Discussion. *J Vasc Surg* 2018 **67** 855–856. (<https://doi.org/10.1016/j.jvs.2017.08.087>)
- 4 Xu S, Herrera A, Schechter C, *et al.* The risk of and associated demographic and laboratory variables for amputations for inpatients with diabetic foot ulcers. *Endocr Pract* 2024 **30** 758–764. (<https://doi.org/10.1016/j.epr.2024.04.019>)
- 5 Rogers LC, Andros G, Caporusso J, *et al.* Toe and flow: essential components and structure of the amputation prevention team. *J Vasc Surg* 2010 **52** (Supplement 3) 235–275. (<https://doi.org/10.1016/j.jvs.2010.06.004>)
- 6 van Reijen NS, Ponchant K, Ubbink DT, *et al.* Editor's choice – the prognostic value of the Wifl classification in patients with chronic limb threatening ischaemia: a systematic review and meta-analysis. *Eur J Vasc Endovasc Surg* 2019 **58** 362–371. (<https://doi.org/10.1016/j.ejvs.2019.03.040>)
- 7 Adler AI, Erqou S, Lima TA, *et al.* Association between glycated haemoglobin and the risk of lower extremity amputation in patients with diabetes mellitus-review and meta-analysis. *Diabetologia* 2010 **53** 840–849. (<https://doi.org/10.1007/s00125-009-1638-7>)
- 8 Luo Y, Liu C, Li C, *et al.* The incidence of lower extremity amputation and its associated risk factors in patients with diabetic foot ulcers: a meta-analysis. *Int Wound J* 2024 **21** e14931. (<https://doi.org/10.1111/iwj.14931>)
- 9 Littman AJ, Timmons AK, Korpak A, *et al.* Evaluation of the effectiveness of remote foot temperature monitoring for prevention of amputation in a large integrated health care system. *Diabetes Care* 2023 **46** 1464–1468. (<https://doi.org/10.2337/dc22-1492>)
- 10 Musuuza J, Sutherland BL, Kurter S, *et al.* A systematic review of multidisciplinary teams to reduce major amputations for patients with diabetic foot ulcers. *J Vasc Surg* 2020 **71** 1433–1446.e3. (<https://doi.org/10.1016/j.jvs.2019.08.244>)