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Negative Pressure Wound Therapy as a Key Strategy in the Management of Severe Diabetic Foot Ulcers in Septic Frail Patients: A Case Series

Maria Ignacy Pirski[1] | Silvia Malerba[1,2,3] | Luigi Marano[1,2,4] | Martyna Kur[1] | Jaroslaw Skokowski[1,2] | Maciej Świerblewski[1]

[1]Department of General Surgery and Surgical Oncology, "Saint Wojciech" Hospital, "Nicolaus Copernicus" Health Center, Gdańsk, Poland | [2]Department of Medicine, Academy of Applied Medical and Social Sciences-AMiSNS (Akademia Medycznych I Spolecznych Nauk Stosowanych), Elbląg, Poland | [3]Department of Precision and Regenerative Medicine and Ionian Area, University of Bari "Aldo Moro", Bari, Italy | [4]Department of Surgery, Dnipro State Medical University, Dnipro, Ukraine

Correspondence: Luigi Marano (l.marano@amisns.edu.pl)

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ABSTRACT

Diabetes mellitus represents a major global health challenge, with over 537 million adults currently affected worldwide. Among its complications, diabetic foot ulcers remain a leading cause of morbidity, hospitalization and amputation, imposing a significant socioeconomic burden. Effective management requires a multidisciplinary approach integrating surgical, medical and rehabilitative expertise. Negative pressure wound therapy has demonstrated clinical efficacy in promoting granulation tissue formation, accelerating wound healing, and reducing infection rates compared with conventional dressings. This case series presents the management of four frail, septic patients with severe diabetic foot ulcers treated between 2023 and 2025 in an academic surgical department. All patients required surgical intervention, including debridement or partial amputation, combined with negative pressure wound therapy and, in selected cases, revascularization or skin grafting. One case utilized an electrospun nanofiber dressing which enhanced wound granulation and shortened healing time. Outcomes varied according to systemic comorbidities, vascular status and glycemic control; however, NPWT consistently supported wound stabilization and preparation for definitive closure. These findings reinforce the essential role of interdisciplinary collaboration and advanced wound technologies in the treatment of complex diabetic foot infections, particularly in frail or septic patients, and highlight the potential of nanofiber-based dressings as adjunctive therapies in comprehensive diabetic foot care.

1 | Background

Diabetes mellitus poses a significant global public health challenge, with its incidence having increased markedly over the past two decades. Currently, approximately 537 million adults worldwide are living with the condition. Among its various complications, diabetic foot ulcers are particularly prevalent and represent a major clinical concern [1]. These ulcers impose a substantial economic burden, contributing both to increased healthcare expenditures and losses in productivity. In 2017, diabetes-related costs in the United States were estimated at $237 billion, a 26% increase compared to 2012; approximately one-third of these direct costs were associated with the management of diabetic foot complications [2]. The diabetic foot is recognized as a clinical syndrome

Interdisciplinary management of frail patients with diabetic foot using negative pressure wound therapy to promote healing, control infection and support limb preservation through coordinated surgical and medical approaches.

Highlights

- Negative pressure wound therapy (NPWT) consistently supported wound stabilization and granulation in frail septic patients with severe diabetic foot ulcers.
- Multidisciplinary management, including surgical, vascular, and metabolic optimization, remains central to limb-salvage strategies in complex diabetic foot infections.
- Frailty, rather than chronological age, emerged as a critical determinant of clinical trajectory and healing potential in septic surgical patients.
- Electrospun nanofiber dressings may enhance wound healing dynamics, representing a promising adjunct in advanced diabetic foot care.

arising from multiple diabetes-related pathophysiological mechanisms, including peripheral arterial disease, microangiopathy, macroangiopathy and peripheral neuropathy. Collectively, these factors increase the risk of foot ulceration and contribute to impaired wound healing, a challenge that is particularly pronounced in frail patients with sepsis [3]. Foot infections, ulcerations and gangrene are major causes of hospital admission among individuals with diabetes; multidisciplinary management strategies, incorporating not only surgical but also medical specialists, have been shown to reduce both the incidence and severity of lower-limb amputations [4]. Lower-extremity amputations related to diabetes impose a considerable strain on healthcare systems and social resources worldwide, a burden that continues to rise in parallel with the global increase in diabetes prevalence [5]. Current evidence demonstrates the clinical value of negative pressure wound therapy (NPWT) in the management of chronic wounds, highlighting its effectiveness in accelerating healing and reducing wound-site infections [6]. Recent studies further report that NPWT promotes granulation tissue formation and complete closure of diabetic foot ulcers, whereas also shortening healing time and decreasing ulcer size compared with conventional dressings [7].

Frailty is particularly relevant in surgical patients, as individuals who are frail are more likely to experience perioperative and postoperative complications than those who are fitter for surgery. Importantly, frailty should not be considered synonymous with chronological age. Rather, it is a multidimensional condition characterized by physical and cognitive vulnerability, as well as a reduced ability to cope with physiological stressors. Nevertheless, frailty is often misunderstood, underdiagnosed and incorrectly regarded as an inevitable consequence of ageing. This misconception may contribute to the lower likelihood of older adults with cancer being referred for surgical treatment, despite evidence showing that postoperative recovery is not determined by age alone. Instead, surgical decision-making should be guided by a Comprehensive Geriatric Assessment (CGA), which offers a thorough evaluation of the patient's cognitive, functional, nutritional, socioeconomic and emotional status [8, 9].

We present our institutional case series involving complex diabetic foot cases, characterized by frail, septic patients requiring multidisciplinary management.

2 | Methods

Between 2023 and 2025, four cases of severe diabetic foot in frail patients were treated in our Academic Department of General and Emergency Surgery. We retrospectively reviewed their clinical presentation, diagnosis, management and follow-up.

3 | Results and Case Presentations

We examined four cases. The mean age was 58.2 (range: 48–78 years), all of them were male. Mean BMI (Body Mass Index) was 23.4 ± 4.99. CCI (Charleson Comorbidity Index) was 4.2 ± 2.02, CFS (Clinical Frailty Scale) was 3.9 ± 2.43. All patients' demographic data are described in Table 1.

3.1 | Case 1

A 48-year-old male was admitted in critical condition due to severe infection of the left foot, characterized by necrosis of the forefoot skin and systemic sepsis. The patient had previously been receiving oral clindamycin for 10 days. On admission, clinical examination revealed extensive plantar necrosis of the left forefoot involving the first to third metatarsal bones. Figure 1 illustrates the cases.

The patient presented with fever up to 39°C and uncontrolled hyperglycemia (glycemia 460 mg/dL). His past medical history included type 2 diabetes mellitus, hypertension and coronary artery disease with two previous myocardial infarctions. An implantable pacemaker had been placed 6 years earlier. Despite broad-spectrum antibiotic therapy (piperacillin/tazobactam, clindamycin and meropenem), the infection progressed from the forefoot along the tendon sheaths into the soft tissues of the lower leg. Doppler ultrasonography demonstrated normal arterial blood flow in the affected limb. Initial surgery included: dorsal incision at the base of the toes, drainage of a 3 cm liquefied necrotic area near the medial ankle with placement of rubber drains, amputation at the tarsometatarsal (Lisfranc) joint with bone debridement and preservation of a loose dorsal skin flap. Postoperatively, NPWT was applied

TABLE 1 | Patients demographics.

Number of patients	4
Age (years)	58.2 (range: 48–78 years)
Gender (male/female)	4/0
Body mass index (BMI)	23.4 ± 4.99
Charleson comorbidity index (CCI)	4.2 ± 2.02
Clinical frailty scale (CFS)	3.9 ± 2.43
American society of anesthesiologists (ASA)	III
Overall survival (OS)	100%
In-hospital mortality	0

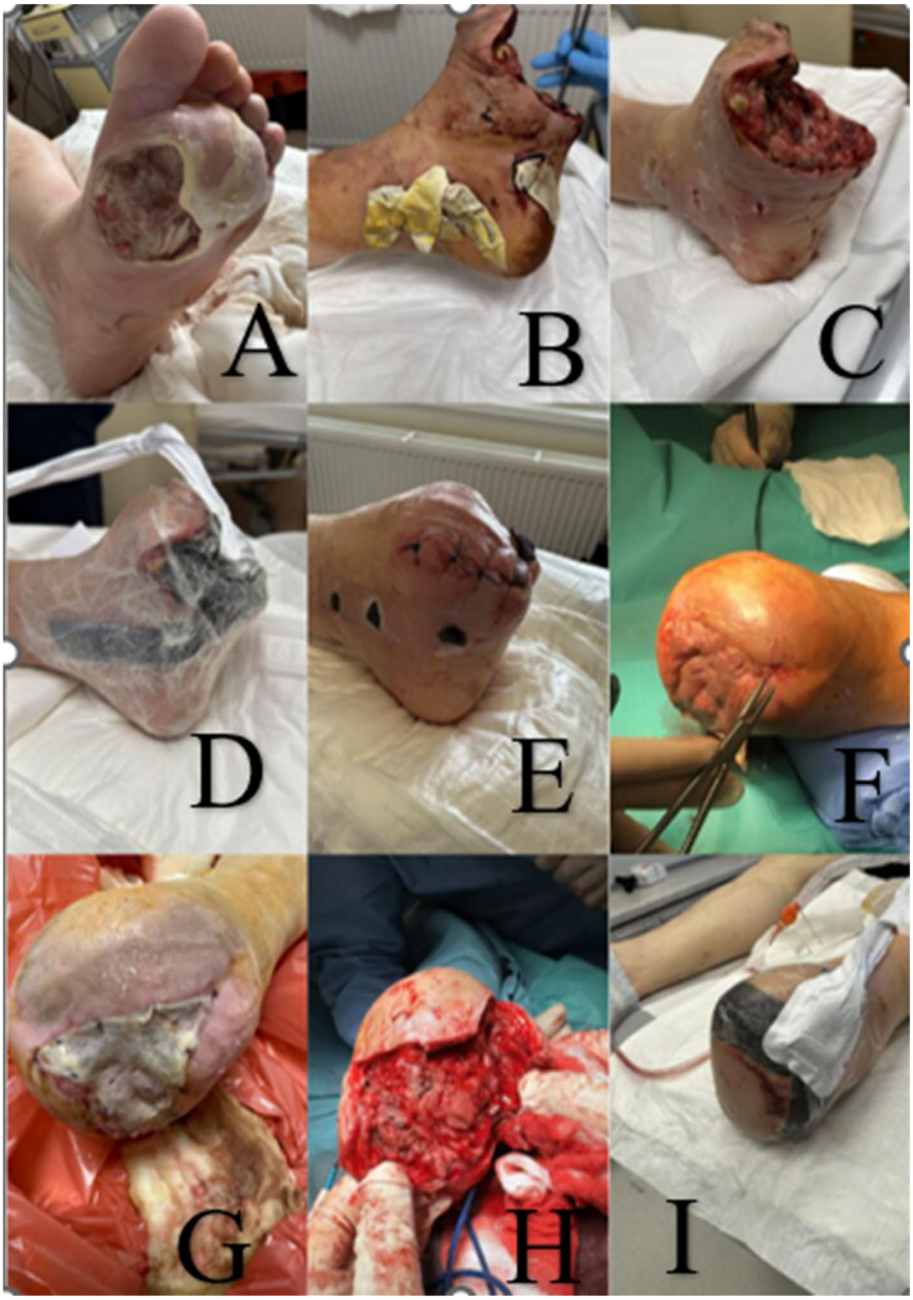

FIGURE 1 | Case 1. (A) On admission, physical examination demonstrated widespread plantar necrosis of the left forefoot, extending to involve the first through third metatarsal bones. (B) Incision and drainage of purulent lesions in the lower leg and medial ankle area. (C) Forefoot amputation at the tarsometatarsal joint (Lisfranc joint). (D) VAC negative pressure dressing applied to the forefoot stump and incisions for skin infection drainage. (E) Amputation at the transverse tarsal joint (Chopart's joint), suturing of skin flaps and VAC dressing. (F) Implantation of a split-thickness skin graft. (G) Skin graft rejection. (H) Mobilization of full-thickness skin flaps. (I) Reapplication of VAC therapy.

to the amputation site and incision areas. After 3 days, a re-amputation was performed at the transverse tarsal (Chopart) joint, with additional bone resection and preparation of two skin flaps to cover the residual bone; NPWT was reapplied and continued with dressing changes every 3 days. Granulation tissue subsequently developed, but the wound remained partially open. After 5 months, a partial-thickness skin graft (5 × 8 cm) harvested from the anterior thigh was placed with NPWT dressing. However, the graft necrosed and required removal. With continued local wound care, the defect reduced to approximately 3 cm. After 1 year from the initial procedure, a further reconstructive attempt was undertaken. This included excision of 1 cm of keratinized wound edge, mobilization of a medial plantar skin flap (4 cm incision), creation of a lateral U-shaped ankle incision (3 cm) to provide an additional flap, and bone smoothing. NPWT was applied for 5 days postoperatively, after which the patient was discharged and continued wound care in outpatient clinic (Figure 2).

3.2 | Case 2

A 49-year-old male was urgently admitted to our department from the Surgical Outpatient Clinic with suspected diabetic foot infection. His medical history included hypertension and obesity; however, he had not previously been diagnosed with or treated for diabetes mellitus. On admission, laboratory tests revealed elevated inflammatory markers: C-reactive protein (CRP) 349 mg/L, white blood cell count (WBC) $29.06 \times 10^3/\mu L$ and random blood glucose 372 mg/dL. Physical examination demonstrated inflammatory changes of both the dorsal and plantar aspects of the left foot. Microbiological swabs were obtained from the ulcer, and empirical intravenous antibiotic therapy with clindamycin 600 mg three times daily was initiated. Radiography of the left foot showed no evidence of osteomyelitis. CT-angiography revealed approximately 90% stenosis of the posterior tibial and dorsalis pedis arteries. Despite antibiotic therapy, inflammatory markers continued to rise, and progressive necrosis of the dorsal foot tissues was observed. Surgical debridement was performed, including amputation of the third toe, drainage of a foot phlegmon, and excision of necrotic tissues with exposure of the extensor tendons (Figure 3).

FIGURE 2 | Case 1: Final outcome of the limb-salvage procedure utilized a medial plantar skin flap in combination with a lateral U-shaped ankle incision to create an additional flap.

Intraoperative microbiological samples were collected. Cultures grew multisensitive strains of *Streptococcus agalactiae* and *Prevotella bivia*. Antibiotic therapy was subsequently changed to amoxicillin–clavulanic acid, resulting in gradual improvement of inflammatory markers. Due to persistent hyperglycemia, the patient underwent multiple internal medicine consultations and he was initiated on intensive insulin therapy; dietary and psychological counselling were also provided. A vascular surgery consultation led to qualification for revascularization, which was performed 7 days later via balloon angioplasty of the left dorsalis pedis artery. Twenty days later, the patient was readmitted due to persistent non-healing of the wound despite prior revascularization. A partial forefoot amputation was performed, and NPWT was applied immediately postoperatively for an additional 5 days. Subsequently, a split-thickness skin graft (STSG) was performed to cover the dorsal foot tissue defect. A

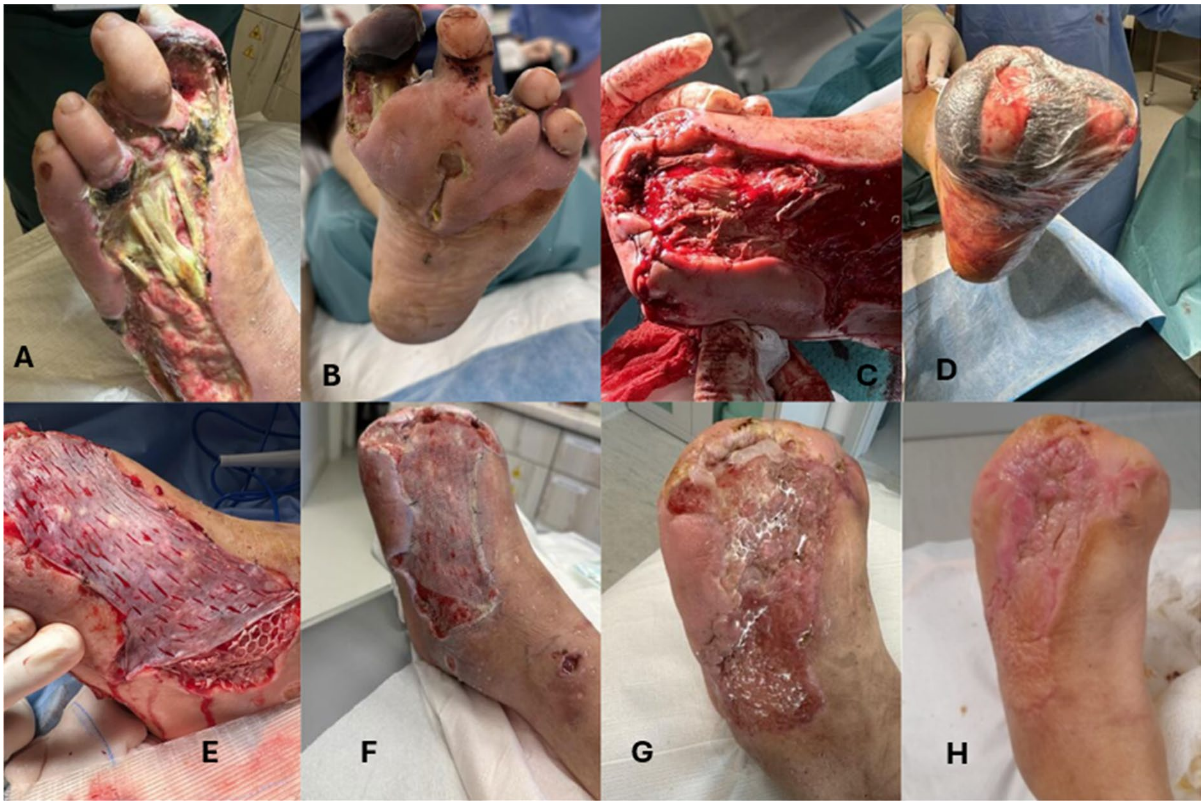

FIGURE 3 | Case 2. (A, B) Extensive debridement was performed, including amputation of the third toe, drainage of a foot phlegmon, and excision of necrotic tissue with subsequent exposure of the extensor tendons. (C) Forefoot amputation with skin flap reconstruction. (D) NPWT application. (E–G) The dorsal foot defect was covered with a split-thickness skin graft (STSG) as the final reconstructive step. (H) Fully healed left foot stump.

postoperative infection with *Pseudomonas aeruginosa* developed but was managed locally, given low inflammatory markers and the absence of systemic symptoms. The patient attended multiple outpatient follow-up visits, during which complete healing of the left foot wound was achieved. However, poor glycemic control contributed to a prolonged healing course.

3.3 | Case 3

A 78-year-old male was urgently admitted with left foot phlegmon and necrosis of the fifth toe, accompanied by markedly elevated inflammatory markers (CRP: 130 mg/dL, WBC: $19 \times 10^3/\mu L$), declining renal function (eGFR: $24.7\,mL/min/1.73\,m^2$) and mild anaemia (Hb: 10.9 g/dL). The patient had multiple comorbidities, including type 2 diabetes mellitus, hypertension, atrial fibrillation, a history of implantable cardioverter-defibrillator (ICD) placement, and previous amputation of the right first toe (2020). During hospitalization, the necrotic fifth toe was amputated, and the foot phlegmon was incised and drained. Microbiological cultures from the surgical site identified *Pseudomonas aeruginosa*, *Streptococcus anginosus*, *Bacteroides uniformis* and *Bacteroides thetaiotaomicron*. Targeted antibiotic therapy with piperacillin/tazobactam was initiated. Radiography of the left foot revealed inflammatory changes in the metatarsal heads and phalanges. Doppler ultrasonography and computed tomography angiography demonstrated significant bilateral narrowing of the anterior tibial and dorsalis pedis arteries. Due to progressive anaemia, the patient required transfusion of four units of red blood cells and underwent multiple debridements of necrotic tissue. After vascular surgery consultation, he was qualified for revascularization. Following angioplasty of the left anterior tibial artery, the amputation and phlegmon incision wounds failed to heal. Additional surgeries were performed, including amputation of the fifth metatarsal head, debridement of necrotic tissue and amputation of the second and fourth toes with application of NPWT. Blood cultures subsequently identified *Serratia marcescens* and urine cultures revealed *Pseudomonas aeruginosa*; targeted antibiotic therapy was administered. Despite these measures, the patient's condition deteriorated, progressing to septic shock requiring catecholamine support. Twenty days later, further amputation of the left first toe along with resection of the first and second metatarsal bones was performed, combined with partial plantar skin flap reconstruction and NPWT. After several NPWT sessions, definitive wound closure was achieved using a STSG harvested from the thigh. The graft healed successfully, and complete wound closure was obtained (Figure 4). During an abdominal ultrasonography, an incidental retroperitoneal mass was detected. Subsequent CT and MRI studies suggested a malignant lesion. Core-needle biopsy findings were consistent with a suspected liposarcoma. The tumour was deemed inoperable due to its extensive involvement and the patient's poor overall condition, which precluded survival following such an extensive surgical procedure. After more than 3 months of hospitalization, the patient was discharged home for further palliative hospice care.

3.4 | Case 4

A 58-year-old male was admitted due to necrosis of the wound bed following amputation of the first toe stump of the left foot and necrosis of the second toe of the same foot (Figure 5). He presents with a C-reactive protein (CRP) level of 256 mg/dL and a white blood cell count of $32 \times 10^3/\mu L$, along with a fever of 38.3°C.

The patient reported long-standing intermittent claudication, with pain occurring after walking approximately 300 m. His medical history also included hypertension and type 2 diabetes

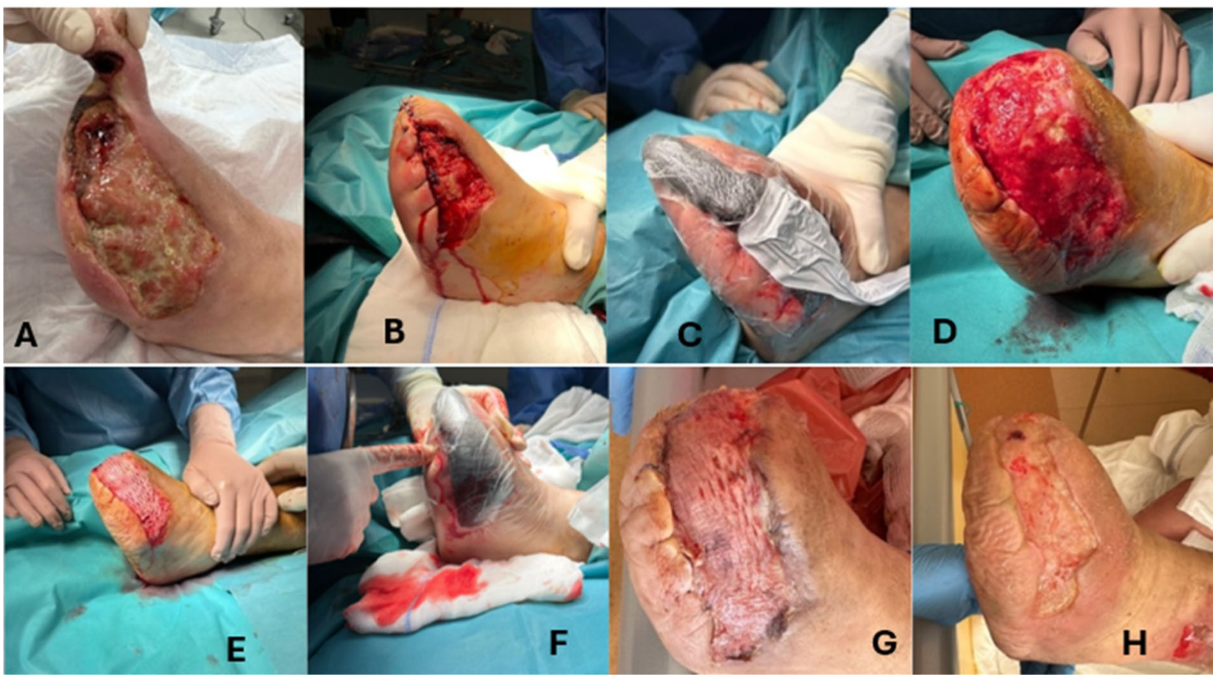

FIGURE 4 | Case 3. (A) Post-amputation of the 2nd–4th toes of the left foot. (B) Amputation of the hallux and forefoot. (C) Application of NPWT dressing. (D) Granulating wound prepared for grafting. (E) Split-thickness skin graft application. (F, G) NPWT dressing applied over the graft; healed skin graft. (H) Final wound healing post-amputation and grafting.

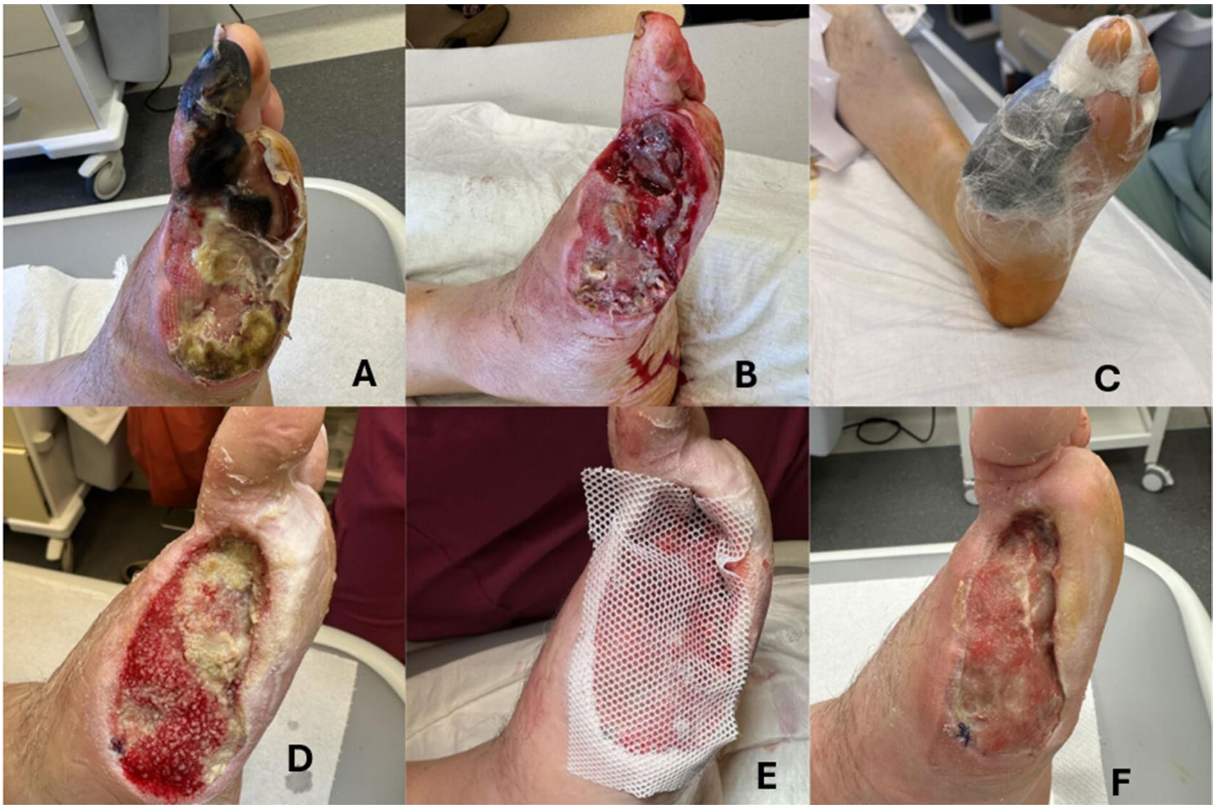

FIGURE 5 | Case 4. (A) At admission, physical examination revealed necrosis of the wound bed at the site of the first-toe stump amputation on the left foot, as well as necrosis of the second toe of the same foot. (B) Wound debridement and amputation of the second toe of the left foot. (C) NPWT application. (D) Healthy granulation tissue and reduction of infected tissue. (E) Application of non-adherent dressing over the synthetic mesh, and then putting NPWT for 5 days. (F) Clean wound with biofilm coverage.

mellitus. During hospitalization, the patient received intravenous antibiotic therapy with clindamycin, and the first metatarsal bone of the left foot was amputated. CT-angiography of the lower limbs revealed significant stenosis of the left tibial and fibular arteries, necessitating revascularization. Ten days later, the patient was readmitted to the Surgical Department, where wound debridement and amputation of the second toe of the left foot were performed, followed by application of NPWT. After 1 month, final debridement of necrotic tissue was performed, resulting in complete granulation of the wound bed. At this stage, a synthetic electrospun dressing (Spincare, Nanomedic Technologies Ltd., Global Park, 2 Yodfat St., Northern Industrial Zone, Lod, Israel 7129104) was applied (Figure 6). A non-adherent dressing was placed over the synthetic mesh, followed by reapplication of NPWT. Four days later, the NPWT dressing was removed, revealing a fully clean wound with biofilm coverage.

FIGURE 6 | Case 4. Outcome following the application of an electrospun dressing after debridement and repeated use of NPWT.

4 | Discussion

Diabetes mellitus represents an emerging global health concern, with diabetic foot complications constituting one of its most serious clinical challenges. These conditions require a multidisciplinary approach involving endocrinologists, nutritionists, specialized nurses, physiotherapists, psychologists and surgeons [10]. By 2035, the global prevalence of diabetes mellitus is projected to reach nearly 600 million individuals, with approximately 80% of affected persons residing in low- and middle-income countries [11]. Advanced surgical techniques for limb-salvage management of ischemic and inflammatory complications of the diabetic foot are currently essential to address this growing problem, which has reached pandemic proportions [12]. Specialized diabetic foot care has increasingly become the standard of care in regions with sufficient healthcare resources [13]. Evidence from clinical studies and systematic reviews indicates that multidisciplinary management can significantly shorten healing times, reduce amputation rates and minimize amputation severity. Although definitions of multidisciplinary diabetic foot care vary in the literature, such approaches typically include collaboration among surgeons (vascular, orthopaedic or general), podiatrists, diabetes specialists, physical therapists and wound care nurses [14]. To optimize the management of diabetic foot complications, clinical guidelines emphasize several key interventions. Diabetic foot ulcers may arise from arterial insufficiency, peripheral neuropathy or both; therefore, accurate etiological diagnosis is essential. In cases of significant arterial disease, revascularization or correction of the ischemic component is required to achieve successful healing [15]. According to the International Working Group on the Diabetic Foot (IWGDF), any diabetic foot ulcer that fails to show clear healing progress within 4–6 weeks should be evaluated for peripheral arterial disease. Similarly, the TransAtlantic Inter-Society Consensus (TASC) II and subsequent international vascular guidelines recommend revascularization—either endovascular or surgical—for all suitable patients with critical limb ischemia [16, 17]. In our case series, all patients were managed by a multidisciplinary team, including a vascular surgeon, diabetologist and general surgeon. Vascular assessment was routinely performed with ultrasonography, and treatment decisions were made collaboratively in order to determine the most appropriate management pathway for each patient.

The patients being treated are frail, meaning they have reduced adaptive capacity and limited resilience to stressors. Some individuals respond better than others to such stressors—even at more advanced ages—because frailty is not strictly dependent on chronological age. Instead, greater emphasis should be placed on biological age and overall physiological condition. Factors such as inflammatory processes and epigenomic alterations—including DNA methylation changes, telomere shortening and accumulated DNA damage—play important roles in determining an individual's vulnerability and adaptive capacity [8, 18]. Frail septic patients, particularly those treated in hospital settings, are at heightened risk of developing multidrug-resistant infections, a complication frequently observed in critically ill individuals [19]. Optimal management includes prompt treatment of active infections, avoidance of unnecessary antibiotic prescriptions in the absence of confirmed infection, and strict glycemic control as part of a comprehensive multidisciplinary strategy. Local wound care must be meticulous, incorporating surgical debridement or amputation, moisture-retentive dressings and effective offloading of pressure from the ulcer site [20].

A recent meta-analysis reported an amputation incidence of approximately 22% among patients with diabetic foot ulcers. Identified risk factors included body mass index, ulcer duration, lipid profile parameters, fasting blood glucose, white blood cell count, haemoglobin A1c, high-sensitivity C-reactive protein and uric acid levels. These findings strongly support a multidisciplinary rather than exclusively surgical approach to management [1]. Dorsal ulceration over a hammer toe or osteomyelitis involving a toe may necessitate digital amputation if prompt healing is not achieved. In neuropathic ulcers, digit–metatarsal amputation is often performed to redistribute plantar pressure across a broader surface area and is typically followed by custom orthotic footwear to prevent recurrence. More proximal amputations, such as transmetatarsal or transtarsal procedures, may be indicated in cases of advanced plantar space infection or following revascularization in patients with ischemic forefoot gangrene [4]. Candidates for transmetatarsal amputation are identified based on criteria including localized tissue loss or infection, adequate perfusion to support postoperative healing and preserved ambulatory capacity at the time of surgery [21].

Septic patients face additional challenges, as sepsis predisposes them not only to wound-related complications but also to secondary infections that may further compromise healing [19]. For these reasons, such patients may benefit from specialized dressings. A systematic review and meta-analysis demonstrated that NPWT enhances granulation tissue formation and complete ulcer closure while reducing healing time and ulcer dimensions compared with conventional dressings. NPWT provides an airtight barrier that minimizes external contamination while maintaining a moist environment conducive to healing. It is generally initiated following the first surgical debridement and may be continued until definitive reconstruction or closure by secondary intention is achieved. Its use has been associated with reductions in wound size and depth, along with the promotion of healthy granulation tissue suitable for subsequent coverage [22]. Post-amputation wounds are often characterized by greater depth, exposure of bone and tendons and pre-existing infection—factors that typically contribute to delayed healing. Prior studies have demonstrated that NPWT facilitates healing in such complex wounds by promoting granulation tissue formation and preparing an optimal wound bed for closure [23]. Additionally, NPWT can enable simpler reconstructive options; for instance, STSG is among the less complex coverage techniques, and NPWT applied over STSG has been shown to enhance graft adherence, reduce seroma formation and allow earlier mobilization [24]. This was the rationale for using NPWT in our case series. In these frail and septic patients, NPWT may promote wound healing and potentially shorten the healing time compared with conventional wound management alone. Its use appears particularly valuable in this population, as frail septic patients are at increased risk of wound dehiscence and impaired healing. In our case series, we successfully managed these patients by applying NPWT immediately after surgery and changing the dressing every 3–4 days.

In one of the cases included in this series, the use of electrospun nanofiber-based synthetic dressings significantly accelerated wound debridement and shortened healing time. Studies have documented growing interest in electrospun nanofibers for biomedical applications, largely due to their structural resemblance to the native extracellular matrix. These nanofibrous scaffolds provide a biomimetic environment that supports critical regenerative processes such as cellular adhesion, proliferation and migration. In wound healing, their high surface area and porosity facilitate moisture balance, oxygen exchange and exudate management, whereas serving as an effective barrier against microbial invasion [25]. In an observational study, treatment with Spincare was associated with faster wound healing, particularly during the epithelialization phase, along with significant improvements in pain scores and quality-of-life measures; this therapy was well tolerated and reduced hospital readmissions [26].

5 | Conclusion

In this case series, we examined frail septic patients with severe diabetic foot ulcers requiring amputation and advanced wound management, including NPWT. This work underscores the critical importance of interdisciplinary collaboration to achieve optimal healing outcomes and highlights the potential role of emerging technologies, such as electrospun nanofiber-based dressings, in managing these challenging wounds.

Conflicts of Interest

The authors declare no conflicts of interest.

Data Availability Statement

The data that support the findings of this study are available from the corresponding author upon reasonable request.

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