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Chapter

Current Perspective of Prevention and Management of Diabetic Foot

Deepikaa Ramakrishnan Ramesh, Faiz Ahmed Shaikh and Muhammad Ilyas Nadeem

Abstract

Diabetes-related foot infections and ulcers are frequent complications of the condition. These problems are also frequent, cause significant discomfort, frequently come back, and lead to morbidity and mortality, placing a huge financial burden on the patient and society. To start and direct treatment, it is crucial to comprehend the role of important contributing factors such as diabetic neuropathy, peripheral arterial disease, and immune system dysfunction. Beginning with a comprehensive physical examination and detailed history, diabetic foot disease is managed. A thorough medical examination should pay particular attention to any indication of diabetic foot ulcers or infection, as well as the symptoms of peripheral vascular disease and diabetic neuropathy. Analgesics and antibiotics should be used for pain management and infection control respectively. A multidisciplinary strategy focusing on patient education should be incorporated into prevention measures.

Keywords: diabetic foot ulcer, pain management, infection control, patient education

1. Introduction

According to the International Diabetes Federation, diabetes is one of the twenty-first century’s biggest global health emergencies and one of the top 10 causes of death worldwide [1]. Over the past 30 years, global prevalence has increased tremendously [2], and the trend is expected to continue to rise from the current 5.1 percent to 7.7 percent in 2030 [3]. Diabetes mellitus is a group of autoimmune, metabolic, and genetic illnesses that all have one thing in common which is hyperglycemia [4]. It is now becoming a major public health problem worldwide, putting unsustainable demands on individuals, caregivers, health systems, and society.

According to the WHO, officials throughout the world are concentrating their efforts on four non-communicable diseases (NCDs) that are recognized as being important public health issues. One of these diseases is diabetes. The prevalence of diabetes has considerably increased during the past few decades, as well as the number of cases [5].

Diabetes is becoming more and more prevalent, increasing the risk of complications. One of the most frightening effects of diabetes is foot disease. The term “Diabetic Foot” encompasses a number of conditions related to diabetes, including
diabetic neuropathy, peripheral vascular disease, Charcot’s neuroarthropathy, foot ulceration, osteomyelitis, and the possibility of limb amputation as a preventive outcome [6]. Diabetic foot is a terrible disability, requiring extended periods of time and is insurmountable, growing expenses, with the ever-present possibility of amputation. Diabetic foot ulcers, which are injuries to all layers of skin, necrosis, or gangrene that typically develop on the bottoms of the feet as a result of peripheral neuropathy or peripheral arterial disease, can occur in diabetic patients [7, 8].

1.1 Epidemiology of diabetic foot

Males and people over the age of 60 are more likely to develop diabetic foot problems. There is a dearth of reliable data on the prevalence and frequency of diabetic foot problems. According to current studies, the yearly happenings of diabetic foot ulcers in the generalized population is 1–4 percent, with a prevalence of 4–10 percent [6]. According to one study, diabetic foot problems account for 12% of all diabetes hospital admissions. In 2013, 11 percent of all diabetic patients admitted to a tertiary facility in East Coast Malaysia had significant limb amputation. Diabetics have a 12.3 times higher risk of amputation due to foot problems than the general population [9].

1.2 Etiology of diabetic foot

There are a few causes of diabetic foot ulcers.

1.2.1 Diabetic neuropathy

Diabetes neuropathy expresses itself through the motor, autonomic, and sensory components of the nervous system [10]. Diabetic neuropathy affects more than half of patients over the age of 60 and raises the risk of foot ulcers by sevenfold. Damage to the innervations of the intrinsic foot muscles leads to an imbalance in the foot’s flexion and extension of the directly impacted foot. Anatomic foot malformations lead to abnormal bone prominences and pressure points, which lead to skin breakdown and ulceration over time [11]. The patient may be unaware of the toxic nature of neuropathy, along with the significance of routine diabetic foot assessment. Motor neuropathy causes foot ulceration which is caused by muscle atrophy, foot deformity, altered foot biomechanics, and pressure redistribution [6].

1.2.2 Peripheral vascular disease

Peripheral vascular disease. Although the peripheral vascular disease can occur at any level of the arterial tree, atheroma appears to prefer specific locations, specifically bifurcations and bends in the artery where hemodynamic shear stress is low or flow separation occurs. In the lower limb, the aortoiliac segment and the superficial femoral artery (SFA) in the adductor canal are common sites. Diabetics often include more distal vessels underneath the trifurcation, for example, the peroneal, anterior, and posterior tibias. Unexpectedly, vessels in the feet, such as the dorsalis pedis, are frequently spared [11].

1.2.3 Infection or injury

Due to certain anatomical peculiarities, a profound infection inside a diabetic foot is indeed a limb-threatening condition. The foot has several compartments that
communicate with one another, enabling the infection to spread from one area to another and the patient's ability to continue ambulation, allowing the infection to spread even further [11]. On the other hand, patients with peripheral vascular disease who present with a minor injury may develop an excruciating and entirely ischaemic foot ulcer [12].

1.2.4 Immunopathy

Patients with type 2 diabetes have a significantly compromised immune system compared to otherwise healthy people. Diabetic foot infection is therefore a limb-threatening and debilitating disease. Increased blood glucose increases polymorphonuclear cell functions and hampers pro-inflammatory cytokines such as chemotaxis, adherence, phagocytosis, and intracellular killing [13]. The immune system is jeopardized by decreased leukocyte activity, an inappropriate inflammatory response, and disruption of cellular immunity [14].

1.2.5 Osteomyelitis

Osteomyelitis is caused by a profound soft tissue infection spreading continuously from the cortex towards the bone marrow. Osteomyelitis is related to the majority of deep, long-term foot infections. It can be difficult to diagnose osteomyelitis in a diabetic patient. It is difficult to distinguish soft tissue infectious disease from bone infection, as well as infectious diseases from non-infectious diseases [11].

2. Prevention and management of diabetic foot

2.1 Principles of management

The foremost is treating infections; secondly, to determine if any related ischaemia is revascularisable; thirdly, to limit exertion to the area of ulceration; The fourth focus is to enhance the wound or ulcer's situation through wound-bed preparation, topical treatments, and callus removal. The avoidance of ulcer recurrence can be the focus once the wound has healed.

2.1.1 Debridement

Diabetic feet develop calluses as a result of frequent sheer force [15]. Debridement is known as a wound treatment that removes slough or scar tissue. This necrotic tissue works as a barrier, preventing wound edges from coming together; eliminating it allows wound healing [16]. To accomplish this function, the base of abnormal injuries, wound edge tissue such as epidermal hyperkeratosis (callus) and necrotic dermal tissue, debris, and bacterial elements which can hinder wound healing are removed. According to multiple clinical trial studies, debridement promotes the growth of granulation tissue, which aids in the healing of wounds [17, 18].

According to Frank et al. theory, because there is fresh wound bleeding at the time of debridement in diabetic foot ulcers, debridement can raise VEGF levels [19]. Debridement of diabetic foot ulcers on a regular basis may speed up wound healing, however, there is little evidence to back up this claim [20].

Clinical trials have shown that only surgical debridement is effective out of the 5 methods of debridement: enzymatic, autolytic, mechanical, and biologic.
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Sharp debridement is used during surgery to remove all bone and dead tissue. Debridement's goal is to change the environment for chronic wound healing to one that is more conducive to acute wound healing. Enzymatic debridement uses enzymes that have been carefully formulated to break down proteins, including collagenase, trypsin, papain/urea from papaya, streptokinase as well as fibrinolytic/DNAse, and streptodornase combinations. Natural autolytic debridement occurs in ulcers that are healthy, moist, and perfused. Lavage, pressure irrigation, dry-wet dressing, and hydrotherapy are used for mechanical debridement. Utilizing the sterile Lucilia sericata fly larvae as the debridement method, in which the necrotic tissue is found to be able to be thinned out due to the proteolytic enzyme emitted by the larvae [21].

2.1.2 Offloading

‘Offloading’ solutions reduce pressure even more and redistribute weight-bearing load over a bigger region of the foot [15]. The most straightforward method is mandatory bed rest; however, this is ineffective due to poor compliance and the risk of consequences such as osteoporosis as well as deep vein thrombosis. Total contact casting (TCC) is evidence-based offloading as well as the best time-tested approach since it ensures compliance and reduces the bulk and weight of the cast. This relieves ulcer pressure and spreads throughout the foot, which causes wound healing to be faster [6]. This procedure enables the patient to move around while receiving therapy and is effective in reducing edema, which can impede wound healing. Even though difficult and time-consuming, TCC can alleviate the pressure upon that incision, as evidenced by 73–100% healing. The drawbacks of TCC include the need for time as well as skill, the potential for new injuries caused by plaster irritation, the difficulty of daily injury assessment, the increased usage of removable cast walkers, and the lack of daily wound examination, dressing changes, and infection detection. Additional techniques include bed rest, using wheelchairs, walkers, and shoes that are carefully made [22, 23].

2.1.3 Infection management

Patients’ self-education, improved diabetes knowledge and understanding, and self-management activities improved prescription adherence to oral diabetic drugs in a case-controlled trial. Duloxetine and pregabalin are recommended as first-line pain relievers by the National Institute of Clinical Excellence [15].

The three components of ulcer management are callus removal, infection destruction, as well as decrease of forces of weight bearing, which frequently necessitates foot elevated bed rest. To reveal the ulcer’s floor and enable effective drainage of the lesion, extra keratin should be removed using a scalpel blade. When there are lesions or an ulcer that is deep penetrating that does not heal or keeps coming back, a radiograph should be conducted to check for osteomyelitis [24].

After the callus has been removed, the bacterial swab has to be collected from the ulcer’s floor; the excised tissue may produce even more trustworthy results. Patients with superficial ulcers can receive suitable oral antibiotics until the ulcer heals and be treated as outpatients. Staphylococci, streptococci, and occasionally anaerobes are the most common pathogens that can infect a superficial ulcer. Amoxicillin, flucloxacillin, and metronidazole are therefore used to begin treatment and are changed once bacteriological culture findings are obtained. Considerable knowledge and laboratory assistance...
are required for the selection and duration of antibiotic treatment [24]. A wound culture-based antibiotic regimen has also been shown to benefit diabetic foot ulcers with superadded infection [15]. Microorganism resistance should be considered while choosing a treatment. Microorganism resistance should be considered while choosing a treatment. Oral antibiotics with Gram-positive germ activity for minor infections [25] as well as antibiotics active on Gram-positive as well as Gram-negative bacteria, which includes anaerobic bacteria, for moderate to terribly severe infections [16].

Patients who exhibit any of the risk factors stated on and in the box should be sent to the hospital right away for prompt care and assessment. They need to stay in bed and immediately begin receiving intravenous antibiotics. It could be necessary to use an intravenous insulin pump to regulate blood glucose levels.

Antibiotics: Bacteriological cultures require a broad spectrum of antibiotic coverage within the first 24 hours. Quadruple therapy may include amoxicillin, flucloxacillin, metronidazole (for anaerobes), and either ceftazidime 1 g three times daily or gentamicin (for Gram-negative organisms). When the outcomes of the bacteriological culture are available, this treatment can be modified. Multiple resistant Staphylococcus aureus (MRSA) is a severe issue because, first, it can cause sepsis’ devastating effects and, second, these individuals need isolation while in the hospital. Both intramuscular teicoplanin and intravenous vancomycin are available as therapies (Figure 1) [24].

Analgesics: Peripheral neuropathy, ischemia, and infection are the three main causes of pain in diabetic feet. With other painful conditions, the treatment is comparable. The WHO analgesic ladder suggests using straightforward analgesics for mild to moderate pain, for example, paracetamol or a non-steroidal anti-inflamatory drug.

**Figure 1.**
*Treatment algorithm for the diabetic foot. Note: From Ref. [26].*
In moderate pain, additional mild opioids such as dihydrocodeine or tramadol should be taken into consideration. Patients experiencing moderate to severe pain should be given potent opioids, such as morphine. In neuropathic pain, adjuvants are used at all levels of the analgesic ladder. Adjuvants include, for instance, antidepressants like amitriptyline and anticonvulsants like duloxetine (e.g. gabapentin or pregabalin) (Tables 1 and 2).

Surgical debridement is required to flush pus and abscess cavities as well as remove all gangrenous and contaminated tissue, such as osteomyelitis-related devitalized and infected bone. It is advised to send deep tissue swabs to the lab. If necrosis has occurred in the digit, a ray amputation to remove the toe and a portion of its accompanying metatarsal is required in the neuropathic foot with intact circulation. In some cases, skin grafting is required to hasten wound healing [24].

2.1.4 Negative therapy wound pressure

Another increasingly popular technique for treating diabetic foot ulcers involves targeted negative pressure wound therapy, which basically involves draining wound fluid through a vacuum seal. In comparison to treating ulcers with a typical gauze dressing, this often involves a shorter treatment period and is intended to improve the perfusion of tissues and encourage the creation of granulation tissue. However, there is no found statistically significant difference (p 1/4 0.15) in the amount of time needed for wound closure between negative pressure wound therapy and the usual wound care from a Canadian evidence-based study [28].

2.1.5 Growth factors and skin substitutes

In a meta-analysis of the research supporting the use of active skin replacements as well as the growth factors in the treatment of diabetic foot ulcers, Buchberger et al. found that the combination of these treatments did lead to a greater incidence and quicker time to complete wound healing [29].

Recent research has also indicated that the administration of granulocyte colony-stimulating factor can reduce the need for surgical procedures, as seen by a general decline in the risk of amputation for diabetic foot ulcers. Granulocyte colony-stimulating factor boosts neutrophil activity by increasing the release of neutrophil progenitors from the bone marrow. More research is still needed to support these findings and determine which patient populations may benefit from this therapy the most.

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**Analgesics**

<table>
<thead>
<tr>
<th>Category</th>
<th>Medication</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mild to moderate pain</td>
<td>Paracetamol or non-steroidal anti-inflammatory drugs, Ibuprofen</td>
</tr>
<tr>
<td>Moderate pain</td>
<td>Mild opioids such as dihydrocodeine or tramadol</td>
</tr>
<tr>
<td>Moderate to severe pain</td>
<td>Morphine</td>
</tr>
</tbody>
</table>

*Note: From Ref. [27].*

**Table 1.**

*Pain management in diabetic foot.*
2.1.6 Glycaemic control

In patients with insulin-dependent diabetes mellitus, increasing evidence shows that strict glycemic control prevents and slows the progression of diabetic retinopathy, nephropathy, and neuropathy. It is important for diabetic patients to maintain a proper glycemic index to avoid any further complications such as the diabetic foot.

2.1.7 Dressing

A dressing is a substance that is applied topically to the area to help the wound heal and protect it. Plaster serves as a barrier between the dressing and the wound, preventing direct dressing contact. Film, hydrogel, composite, alginate, hydrocolloid,
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foam, and other absorptive dressings including negative pressure wound therapy are some of the several types of dressings (NPWT) [18].

The primary function of a closed-clean wound or granulated wound is to create a moist healing environment that promotes cell migration and protects against dry sores. The type and quantity of exudate present in the wound determine the appropriate dressing. Cuts with a little amount of exudate are ideally suited for hydrogel dressing, film, and composite use. Hydrocolloids are utilized for wounds with exudate amounts, and alginate, foam, and NPWT are frequently used for wounds with exudate amounts. Before applying a dressing, injuries with significant necrotic tissue should be debrided [18].

A sponge which is put on the wound, covering it with a dressing which is airtight, and then installing a vacuum is known as negative pressure wound therapy or closure of wound with vacuum. Large lymphatic leaks and fistulas can be treated using negative pressure wound therapy. The primary goal of NPWT is to reduce edema; by removing lymphatic or interstitial fluid, it increases the passage of interstitial oxygen into cells. The MMP enzymes and collagenase, in which of levels rise in chronic wounds, are also eliminated by negative pressure wound therapy [18].

2.2 Prevention of diabetic foot

2.2.1 Primary prevention

Reduced cardiovascular risks make the foot less susceptible to ischemia caused by macrovascular disease, while improved blood-glucose control reduces microvascular consequences. Patients’ feet that are at risk will be identified by routine surveillance, and they should undergo specialized care.

2.2.1.1 Metabolic control

Hyperglycemia enhances the macrovascular and microvascular problems in diabetics. Foot ulcerations that can result in limb amputations are linked to this higher risk.

A systematic review comparing intense control (HbA1c (HbA1c) 6–7.5%) with less intensive glycemic control found a lower risk of amputees (RR = 0.65, 95% CI 0.45 to 0.94) and a delayed decline in sensory vibration cutoff point (MD = −8.27, 95% CI -9.75 to −6.79). Other neuropathic shifts (RR = 0.89, 95% CI 0.75 to 1.05) and ischemic changes (RR = 0.92, 95% CI 0.67 to1.26), on the other hand, were unaffected [30].

In a Cochrane literature review on the prevention of diabetes-related neuropathy, focused blood glucose control (HbA1c 7.0%) significantly reduced the risk of continuing to develop neuropathy in T1DM however not in T2DM at 12 months follow-up. However, including both T1DM and T2DM, this was associated with a higher risk of severe hypoglycemia, excess weight, hospital admissions, and deaths [32] (Figure 2).

2.2.1.2 Preventive footcare

Walking or having to stand while structurally trying to load the feet exemplifies stress on the plantar surface, exacerbating compression and shear stress. Foot abnormalities, such as hammer and claw toes, which are frequent in diabetic individuals, add to the pressure and tension. A systematic review of apparel and off-loading techniques throughout diabetics of neuropathy found that bespoke insoles reduced recurring metatarsal head ulcers at 15 months (p = 0.007) [33].
• When worn more frequently than 80% of the time, made-to-order shoes with the plantar pressure drop reduced the prevalence of foot ulcers markedly (25.7% vs. 47.8%).

• When compared to ready-made footwear, intensive footwear therapy for diabetic patients with neuropathy, deformity, prior ulceration, and mild amputation dramatically reduced the first or recurrent ulcer.

2.2.2 Secondary prevention

A past lesion is a very good indicator of future ulceration. To prevent aberrant pressure loading, efforts should be made. These efforts may include cushioning for weak and immobile persons and specifically fitting footwear for mobile people, but such interventions must be correctly targeted. Foot care, individualized examination, routine podiatry, and the availability of emergency contact information should all be emphasized in education. Education reduced recurrent ulceration and amputation by three times in under 13 months for one trial, whilst McCabe and colleagues discovered a decrease in amputees but no change in fresh ulceration. Education also increases knowledge and behavior connected to sickness. These results need to be verified. If education efforts were primarily directed at professionals, they might be more successful [34].

2.2.2.1 Patient education

Because their bodies do not respond to pain normally, patients with neuropathy frequently overlook signals of harm. The patient's adherence to self-care will be impacted by this. In order to decrease diabetic foot issues, extensive education on
adequate diabetic foot care is required. In preventing foot issues, knowledge of patients needs to be planned out and repeated at regular intervals. A doctor, podiatrist, or other trained healthcare professionals who dedicate time to explaining the fundamental care of the foot, callus, and nail can give patient education. Every year, this should be done [35].

The key to preventing ulcer formation is good foot care and management of minor foot injuries. The patient’s overall foot inspection is the basis for good foot care. Gentle washing with detergent and water, accompanied by the usage of topical creams, aids in the preservation of healthy skin that is greater resistant to breakdown and injury. Minimal foot injuries and infections, such as cuts, scrapes, ulcers, and athlete’s foot, can be unintentionally aggravated by home remedies that impede healing. Patients should be cautioned to avoid hot showers, heating pads, and harsh topical medications such as betadine, hydrogen peroxide, and iodine. Ulcers can be avoided by gently having to clean small cuts and applying a topical antibiotic to retain the site moist. In addition, any slight wound that does not heal quickly should be evaluated by a physician.

3. Conclusion

It takes careful coordination between numerous groups in primary care and hospital services to successfully manage diabetic foot ulcers, and this coordination may be difficult to develop if conventional boundaries between healthcare providers are still in place. When the patient is cared for by independent teams of professional caregivers, the frequent co-occurrence of social and medical issues complicates supervision. When making management decisions, it is critical to consider the patient’s (or his or her family’s) needs and preferences, and the patient should play an important role in the process by making well-informed decisions. Every step of the way, patients and caregivers should receive advice from qualified health care professionals and should have easy access to a second opinion [36].

Conflict of interest

There is no conflict of interest among the authors.
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References


[32] Callaghan BC, Little AA, Feldman EL, Hughes RA. Enhanced glucose control for preventing and


[34] Diabetic Foot Ulcer
