Lower Limb Amputation and Diabetes: An Urgent Call to Attention to This Medical Challenge

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Abstract:

The global prevalence of diabetes has reached epidemic proportions, leading to an increase in related complications, among which lower limb amputations stand out as a significant medical challenge. Diabetic patients often experience a wide range of vascular, neuropathic, and immune system abnormalities, resulting in impaired wound healing and heightened sensitivity to infections. The development of foot ulcers is a common cause of lower limb amputations in diabetic patients. Peripheral neuropathy and reduced blood circulation frequently lead to unnoticed injuries and delays in wound healing. These factors, combined with immune system dysfunction, create a conducive environment for infections, ultimately resulting in tissue necrosis and potentially amputation. Additionally, comorbid conditions such as peripheral arterial disease and renal dysfunction intensify the challenges of wound healing and postoperative recovery. Preventive and management strategies to address the crisis of limb amputation in diabetic patients are crucial. Educating patients about foot hygiene, appropriate footwear, and regular check-ups is vital for preventing diabetic foot ulcers. This article explores various aspects of amputation in patients with diabetic foot disease, including classification of amputation methods, identification of risk factors associated with lower limb amputation, implementation of effective medical management strategies for diabetic patients undergoing amputation, and more. The goal is to provide comprehensive and nuanced information aimed at enhancing treatment efficacy and improving the quality of life for these patients through care provided by healthcare professionals.

Keywords: ***Lower limb amputation, diabetic foot, foot complications, medical management, risk factors, infection prevention.***

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Background and Objective

Amputation is a serious and growing public health problem, especially in diabetic patients. Research shows that more than 50% of amputations occur in diabetic patients.[1-4] The risk of amputation in these patients is approximately 10 times higher than in non-diabetic individuals of the same age. This significant increase is due to several factors associated with diabetes.

A major factor is the reduced ability to perceive protective sensations. Diabetic patients commonly suffer from sensory neuropathy, which leads to loss of sensation in the extremities and increases the risk of unrecognized wounds and injuries. Estimates suggest that up to 80% of diabetic patients with trophic leg ulcers have a protective sensation deficit. Also, the immune response in these individuals is weak, making them more vulnerable to significant infections, which also increases the risk of developing distal arterial occlusive disease.

Unfortunately, many diabetic patients delay seeking medical attention until the foot infection or gangrene has reached an advanced stage. Abou-Zamzam's research[5] has shown that 25% of amputations are associated with a delay in treatment.

Fortunately, in recent years, the implementation of effective educational programs has led to a 50% reduction in the need for amputations in diabetic patients.[3,6] These programs include preventive interventions and management of diabetic foot ulcers. Treatment methods, such as the use of properly cushioned insoles and treatment of pinguth abrasion, are effective in reducing pressure on the foot and preventing ulcers.[7,8]

However, amputation, whether major or minor, is associated with significant medical risks. Up to 15% of transtibial below-the-knee amputations may result in above-the-knee amputations.[9]Complications associated with post-amputation wounds, including infections, are another major challenge that can occur due to inadequate perfusion and a reduced ability to respond to infections.[11,12] The progression of infection often coincides with worsening glycemic control. In this setting, wound drainage and debridement are paramount.[13] The use of wet-to-dry dressings is critical in wound healing, and the healing process can typically take two months or more.[14]

Studies have shown that vacuum-assisted wound closure devices are effective in accelerating the healing of infected wounds.[15-17] However, the occurrence of secondary infection at the amputation site does not always mean an increased risk of re-amputation.[18-20] Diabetic patients with severe neuropathy are commonly faced with recurrent or advanced foot ulcers.[21,22]

Reducing the extent of amputation as much as possible has become a key issue in the management of diabetic patients and the prevention of critical complications.[11,23,24] This approach offers patients a more comprehensive view of motor independence and the achievement of an independent lifestyle. Research shows that approximately 15% of patients who have undergone minor amputations require long-term care in nursing institutions, while this figure rises to 37% for those who have undergone major amputations.[17] This figure reflects the high prevalence of motor disorders among amputees. It is estimated that 30–50% of patients who have undergone major amputations are unable to walk independently, justifying the need for surgical procedures aimed at preserving the foot.

Psychological analyses show that the amputation process leads to feelings of fear in patients, as this procedure, as a transformative change, changes their self-perception and self-evaluation.[25,26] For this reason, resolving these psychological barriers requires an open and in-depth dialogue with the patient. Meanwhile, the vascular surgeon may perceive the occurrence of amputation as a sign of his/her professional limitations.[27,28] This perception can lead to a negative attitude towards the treatment process, while the patient may be more concerned with preserving the damaged limb rather than focusing on his/her overall well-being. Therefore, it is necessary to develop a

more positive perspective on amputation. Instead of seeing this procedure as a disappointment, it should be seen as a reconstructive procedure aimed at restoring the patient's ability to move independently. From this perspective, amputation can help to increase the patient's overall well-being and prevent serious complications in the long term.

The main goals of amputation, especially in diabetic patients, include four key areas: (1) complete removal of gangrene and necrotic tissue; (2) effective management of infection; (3) pain relief; and (4) restoration of mobility that allows patients to resume an independent lifestyle in the community. Therefore, it is essential to carefully examine factors that can help improve treatment outcomes and reduce the incidence of amputation and its associated wounds in people with diabetes. This article reviews the various dimensions of amputation in patients with diabetic foot disease, including the analysis of minor and major amputations, identification of risk factors associated with lower limb amputation, and successful implementation of medical management techniques for patients experiencing amputation. The aim of this study is to provide accurate information and a deeper understanding of treatment trends to improve treatment effectiveness and enhance patients' quality of life through the provision of specialized medical care by healthcare professionals.

Definitions

Diabetic foot issues are recognized as a significant challenge in the field of medicine, particularly among diabetic patients. Many scientific articles related to this topic typically begin with an introductory statement highlighting the serious nature of this problem and emphasizing statistics regarding the prevalence of diabetic foot ulcers (Figure 1), the annual amputation rates, and the associated financial burden.[29-31] However, some authors may exaggerate the prevalence of these problems by providing overly high estimates and paying less attention to median or more conservative data. This inaccuracy may be especially evident in the context of amputation statistics, as many articles may categorize both minor and major surgeries under lower limb amputations, while the motivations and outcomes for these two groups of surgeries are markedly different.[32-34]

Minor surgeries are generally performed with the goal of limb preservation and enabling the patient to achieve mobility independence, whereas major amputations are carried out when there is no reasonable chance of salvaging the limb. Such surgery severely impacts the patient's ability to stand and move. With the improvement in healthcare quality and an increased focus on limb preservation, one might expect to see an increase in the number of minor amputations alongside a reduction in the number of major amputations.

On the other hand, for more accurate analyses, a clearer definition of the terms "major" and "minor" is essential, as there is currently a lack of consensus in the medical community regarding these classifications. Generally, "major amputation" is recognized as a surgical procedure performed above the ankle and typically involves the removal of the lower leg (trans-tibial) or the whole foot (trans-femoral), although in rare cases, it may include disarticulation at the knee or hip joint as well.[35,36] This type of surgery usually cannot restore the patient's ability to stand independently. However, some surgeons classify procedures performed on the hindfoot and midfoot as "major amputations," which, although demanding a high level of surgical skill, do not significantly affect the patient's function and disability.

Consequently, the meaningfulness of comparisons made in various centers depends on the similarity and precision in the use of these terms. A more detailed examination of this issue will contribute to a deeper understanding of the current status of diabetic foot management and the need for the development of effective treatment protocols to prevent serious complications arising from diabetes and improve patients' quality of life.

Types of Amputation

1. Minor Amputation

Minor amputations can be categorized into various forms, such as complete digit amputations along with associated bones, toe amputations, and partial foot amputations.[37,38] To ensure a high likelihood of healing, surgeons should operate with a multidisciplinary team strategy that includes specialists such as vascular surgeons, internists, and rehabilitation experts.[39,40]

1.1. Assessment of Limb Perfusion

Prior to any minor amputation, a non-invasive assessment of limb perfusion is essential.[41] Neuropathic foot ulcers are typically characterized by palpable arteries in the foot with detectable pulsatile Doppler flow. To optimize wound healing, the segmental perfusion pressure should be maintained at 70 mmHg or higher. Additionally, ideally, transcutaneous oxygen measurement in the dorsum of the foot should be equal to or greater than 30 mmHg.[42] However, the immediate availability of an oximeter may be limited, and the obtained results may vary. Consequently, non-invasive methods such as photoplethysmography, transcutaneous oxygen tension measurement, and pulse wave recording may not fully assess wound healing capabilities. Thus, precise and informed clinical judgment in this context is vital, as over-reliance on non-invasive diagnostics could lead to unnecessary above-knee amputations.

1.2. Arterial Imaging and Preoperative Evaluation

If clinical data indicate the presence of an ischemic component, angiographic imaging, particularly MR angiography, is recommended as the preferred diagnostic method.[43,44] When necessary and feasible, re-establishing additional distal vascularization prior to performing minor amputations, toe amputations, or transmetatarsal amputations is essential.[11, 45-47]

1.3. Treatment Outcomes

A study conducted by Nehler et al.[42] indicates that heel amputation in diabetic patients with acceptable perfusion in the forefoot, provided no collateral vessels are utilized, results in a treatment failure rate of 50%. Additionally, Helstein et al.[48] reported the best outcomes in patients with exclusive neuropathic ulcers who had palpable pulses at the ankle, achieving an 86% limb preservation rate and a 68% survival rate after a two-year follow-up.

The outcomes for patients with non-reconstructible distal vascular disease are clearly inferior compared to those who undergo revascularization procedures. Specifically, the two-year limb preservation rate for the first group is recorded at 17%, while for the second group, it is 85%. Furthermore, the two-year survival rates for patients without reconstructible distal vascular disease are reported at 16%, compared to 55% for patients who had revascularization procedures.[45]

Figure 1. The present case illustrates the occurrence of necrosis at the wound margin following the amputation of the first toe in a patient with dysvascular diabetes. Ultimately, the foot was preserved using a popliteal-to-pedal bypass procedure, followed by the amputation of the first toe.

Evidence suggests that unsuccessful revascularization, which accounts for approximately 11% of all bypass surgeries, is one of the most significant predictors of non-

healing and major amputations.[49] Specifically, 30% of these patients required above-the-knee amputations. Concerns about the higher likelihood of amputation in patients undergoing failed revascularization procedures seem entirely reasonable.[50]

Based on scientific recommendations, toe amputations should be performed using an atraumatic technique to ensure complete preservation of the first phalanx base.[51,52]The use of large and appropriate flaps of skin from the dorsum and sole of the foot is crucial to facilitate tension-free closure. In this regard, the flexor tendon should be carefully released prior to transection to enhance the recovery of its function. Furthermore, preserving the joint between the metatarsophalangeal bones can improve movement and increase foot durability, especially in amputations of the first and fifth toes.[53,54]

To prevent inadvertent penetration into the adjacent metatarsophalangeal joint, performing a subperiosteal dissection with a precise scalpel is recommended as a standard procedure (Figure 2). In second toe amputations, a similar method to that of first-toe amputations or the Ray technique, which involves removing the metatarsal head, is typically employed.[13,55] This approach is particularly advised to prevent the development of hallux valgus, characterized by lateral displacement of the big toe due to a lack of lateral support from the second toe.

Conversely, detaching the fifth toe may increase its susceptibility to injury and subluxation. Accordingly, prophylactic surgery for the injured toe in relation to the neighboring fourth toe is recommended. In general post-amputation management, reducing load on the foot is crucial for enhancing spontaneous recovery, and emphasizing rest and elevation of the foot is very important.[56,57] These precautions are implemented to prevent the potential negative effects of pedal edema on the wound-healing process. In the early stages, implementing mechanical off-loading of the foot is seen as essential, especially as a preventive measure against wound enlargement. Skin sutures in this method should remain in place for three weeks.

Additionally, in the context of managing patients with foot cellulitis, it is advised to avoid performing minor amputations until the patient's infectious condition is stabilized.[57,58] At this stage, rest, intensive rehabilitation, and the use of broad-spectrum antibiotics (including intravenous antibiotics) should be considered. These measures are critical both for reducing the bacteriological load and for creating a favorable environment for potential future minor amputations.[39,59,60]

In cases where the patient continues to exhibit signs of cellulitis or localized deep infections, the selective approach may include maintaining the amputation incision.[61,62] The application of povidone-iodine mesh for recurrent wound packing can effectively assist in eliminating residual infections, and implementing a long-term regimen of specific antibiotics is necessary for preventing reinfection.[63]

In rare cases of untreated sepsis that rapidly disseminate (especially wet gangrene) or cause systemic toxicity, there may be a need for an open amputation at the level of the toe or ray.[64,65] This procedure is utilized to prevent the advancement and spreading of infection upwards. Furthermore, results from a study by Burchill et al. indicate that in patients with osteomyelitis associated with tenosynovitis, the use of open forefoot amputation resulted in a 70% limb salvage rate.[66]

In these cases, the surgical method for toe amputation involves the simultaneous removal of both toes and the adjacent metatarsal head.[13,67] This process begins with making a longitudinal incision on the dorsal aspect, which encompasses the base of the associated toe and exposes the distal shaft of the metatarsal. The metatarsal shaft is typically cut using an oscillating saw angled towards the sole of the foot, minimizing damage to the underlying muscular structures. It is particularly important to avoid incisions in the plantar region, which is subject to weight-bearing loads.

Ray amputation is generally employed to address recurrent destructive lesions in the sole of the foot and to manage complications arising from osteomyelitis.[68,69] The surgical techniques depicted in the related images represent a conservative approach to forefoot surgery, with the primary aim of preserving the balance and overall structure of the foot.[70,71] It is noteworthy that the occurrence of amputation at the ray level, particularly in the absence of internal support, may gradually lead to complications such as planovalgus deformity of the foot.[72]

The use of appropriate, customized footwear to provide necessary support to the medial arch of the foot in individuals with altered anatomy is of paramount importance. In cases where the toe is not directly affected, a unilateral resection of the metatarsal head can be performed, allowing for the removal of the problematic bone while suturing the existing wound in the plantar area. For example, a study by Wieman et al.[73]demonstrated that out of 101 consecutive metatarsal head resections, an 88% success rate was achieved in treating chronic plantar wounds that had been present for an average of 7 months.

Management of hallux valgus deformity and associated osteomyelitis at the first metatarsophalangeal joint also necessitates a separate incision at this joint, facilitating the removal of the underlying sesamoid bones.[74,75] This surgical technique aids in maintaining the natural position of the great toe and has a positive aesthetic impact on the surgical patient. In a study conducted by Murdoch, a re-infection rate of 8% was reported among 90 hallux amputations.[76]Over a three-year follow-up period, 52% of patients experienced new neuropathic wounds in the foot, primarily attributed to a lack of awareness or inadequate adherence to preventive measures. The implementation of protective footwear along with customized insoles has successfully reduced the recurrence rate of wounds to 26%.

Partial amputations in diabetic patients can lead to biomechanical disorders and foot deformities, which are caused by changes in the distribution of pressure in the plantar area. Biomechanical changes are necessary to create abnormal and additional pressure on adjacent areas, which is a serious threat for the development of transfer lesions. In a landmark study by Nehler et al., the incidence of new, non-adjacent ulcers was reported in 25% of patients within one year after toe amputation.[42] Also, another study led by Weiman showed that one year after metatarsal head amputation, approximately 43% of patients developed new ulcers in other areas of the same foot.[77]

Figure 2. The radiographic image shows the surgical removal of the first metatarsophalangeal joint for the treatment of osteomyelitis. Preservation of the first toe, sometimes referred to as the "flail" toe, is a potential outcome.

Research has shown that a significant proportion of patients (32%) who undergo forefoot surgery for neuropathic ulcers require further surgery during a two-year follow-up period.[78] In this regard, the most effective preventive measures to maintain the health of the pedal skin include the use of well-fitting, custom-made shoes. These shoes should be equipped with appropriate insoles that distribute pressure evenly across

the entire foot. The use of orthotic shoes is essential and patients should wear these types of shoes at all times, both at home and outdoors. Regular attendance at specialized diabetic foot clinics leads to better acceptance of preventive treatments to reduce the risk of skin ulcers in the amputation area as well as in the numb foot. Other factors can also contribute to the development of recurrent pressure ulcers on the corrected foot, including being overweight and not following medical advice.[79]

Management of chronic neuropathic ulcers may include pressure-relief procedures.[80] If bony prominences are present, these abnormalities can be removed by osteotomy using an oscillating saw.[81,82] In this procedure, incisions are made that avoid the weight-bearing area of the foot. Bony prominences that can be removed include bunions associated with hallux valgus and Charcot foot deformities, including calcaneocuboid or talonavicular dislocations. Ensuring adequate drainage with full-contact casts for at least 8 weeks is essential. In the case of Charcot foot deformities, some experts recommend repair of the bony structure of the foot by arthrodesis with screws and autologous iliac crest bone grafts, which helps to repair the gaps and promote bone union.[83] It is worth noting that the specific details of the surgical architecture of the foot in the context of Charcot foot deformities are beyond the scope of this review.

In cases where three or more toes need to be removed, a transmural metatarsal amputation is considered the preferred option.[84,85] This procedure significantly improves foot stability and can help maintain function and quality of life.

When performing a metatarsal amputation, the primary goal is to maintain the integrity of the medial and lateral arches of the foot. To this end, it is necessary to preserve the full length of the metatarsal shafts and to design metatarsal incisions that are obliquely directed from the proximal metatarsal heads toward the plantar surface.[86,87] Preservation of the plantar fascia and fat pad is also recommended to provide vascular supply to the plantar surface and to prevent circulatory complications in the foot. Studies show that diabetic patients account for approximately 70% of those who undergo transmetatarsal amputation.[77] The initial healing rate after this type of surgery is predicted to be 75%.[88] In approximately 50% of patients, secondary wound healing is possible with repeated debridement and moist wound dressings, and is ultimately completed with the use of a pressure-relieving dressing device.[89]

In addition, the use of negative pressure wound therapy (NPWT) in the management of complex foot ulcers in diabetic patients promotes the growth of granulation tissue in the wound bed, thereby accelerating the rate of wound healing.[90,91] The time required to achieve 75–100% granulation coverage in patients receiving negative pressure therapy has been estimated to be 42 days on average, compared with 84 days in conventional wound care.[16,91]

Studies have shown that negative pressure wound therapy specifically increases wound closure and reduces the risk of leg re-amputation compared with conventional wound care. In particular, a reduction in the re-amputation rate of 3% compared with 11% in conventional treatment has been reported, effectively underscoring the need to consider this approach in clinical protocols.[16]

Patients undergoing renal dialysis have a significantly reduced capacity for wound healing. In particular, evidence suggests that approximately 60% of these patients experience unsuccessful healing after forefoot amputation. As a result, of the patients who do not recover, approximately half will end up with below-knee amputation.[66]

In a study conducted by Griffith et al.[92], a significant correlation was identified between the duration of healing and serum creatinine levels, with an average healing time reported as 5 months. However, it is important to acknowledge the limitations of this study; the research included a small and heterogeneous sample of 40 diabetic foot

ulcers that were treated using techniques such as local debridement or heel amputation. Furthermore, the average creatinine clearance in these patients reached a maximum of 51 mL per minute, indicating better renal function compared to patients with end-stage renal disease.[92]

These findings underscore the importance of a thorough assessment of renal status and the associated risks of wound healing in diabetic patients undergoing dialysis. In other words, there is a need for greater attention to these medical challenges to prevent more serious complications, such as limb amputation.

In cases where gangrene has severely progressed in the forefoot, there is typically insufficient soft tissue available to cover the severed metatarsal bones in the sole.[93,94] In such situations, alternative approaches such as Lisfranc tarsometatarsal amputation are recommended.[95,96] Preserving the bases of the first, second, and fifth metatarsals is crucial due to the involvement of significant tendons, as these tendons play a vital role in maintaining the stability of the midfoot. The division of the tendons of the peroneal and tibialis anterior muscles during surgery can lead to a risk of muscular imbalance.[97]

Correction of equinovarus deformity is relatively achievable through stretching of the Achilles tendon. In the context of Chopart amputation (Figure 3), it is advised to surgically connect the anterior tibial tendon to the talus bone to prevent equinus contraction caused by the triceps surae muscle. In cases where gangrene or severe infection in the forefoot renders midfoot amputation unfeasible, Symes ankle amputation is proposed as an effective approach, allowing for the preservation of the posterior foot structures, including the heel pad and ankle.[57,98,99] In this technique, all bones of the foot, along with the calcaneus, are excised.

The use of a subperiosteal technique in amputation, while preserving the periosteum of the calcaneus, ensures the secure stabilization of the heel pad.[100] This stabilization is achieved by creating drill holes along the anterior border of the tibia and targeting the distal epiphysis of the tibia. This approach ensures that the heel pad remains securely affixed to its center, preventing any potential slippage. Attention to the prohibition of weight-bearing for 8 weeks postoperatively is crucial.[101] Proponents of this approach emphasize that maintaining the integrity of the heel pad, provided that there is no neuropathy and sensation in the heel is intact, preserves deep sensory feedback and allows for more normal function.[102]

Patients who undergo Symes amputation are capable of ambulating short distances without the need for a prosthesis.[103] The Pirogoff amputation technique is designed to preserve the calcaneus bone, which is positioned within the tibiofibular mortise after the talus is removed. To achieve bone stability, the use of osteosynthetic stabilizers is recommended. Patients are advised to use rigid and supportive ankle braces following surgeries such as Chopart, Lisfranc, Pirogoff, or Symes amputation to ensure adequate support and stability for the ankle.[95,104,105]

Figure 3. The subject of discussion is the Chopart midtarsal amputation. To prevent ankle instability, the use of a rigid ankle orthosis is essential.

In the existing reviews of amputation management in diabetic patients, researchers point to the importance of incorporating different strategies, including proximal foot amputation.[106,107] These include the metatarsal and Schupart techniques, in addition to ankle joint amputations, such as the Symes and Pirogoff techniques.[106-108] However, there is evidence that casts doubt on the effectiveness and appropriateness of these techniques in this patient population.[109] It has been established that the lack of sensory and proprioceptive protection in diabetic patients places them at particular risk of developing pressure ulcers.[39]

Wound management, especially after open forefoot amputations, typically involves the use of free muscle flap transfers, which aim to provide additional cushioning to pressure points in the altered foot.[109] However, it should be remembered that the possibility of pressure ulcer recurrence on insensitive muscle flaps remains a major challenge.[109]

Studies have shown that heel amputation has a limb healing rate of 70–80% at five years, allowing most patients to return to independent walking.[110, 111] These functional outcomes are much better than those seen with below-the-knee amputation. Studies also show that the perioperative mortality rate is less than 1% and the patient survival rate over a five-year period is approximately 43 percent.[42]

Therefore, continuous monitoring of patients in diabetic foot clinics seems essential. Evidence also suggests that minor foot amputations were commonly considered a prerequisite for larger amputations.[42,112] In other words, evidence suggests that within a three-year period, about one-third of people who undergo limited forefoot amputations progress to major amputations.[112] In this regard, the use of multidisciplinary wound healing units can effectively reduce the need for amputations at higher levels.

1.4. Diabetic osteomyelitis

Osteomyelitis in diabetic patients can be recognized as a dangerous and complex complication, especially in the metatarsal and interphalangeal joints of the foot. This complication is usually accompanied by joint destruction and its prevalence has been reported to be up to 60% percent.[60] The development of bone infections occurs following diabetic ulcers or interdigital infections and can involve the cortex and bone marrow.[113] In a study by Shone et al.[114], the prevalence of osteomyelitis in patients with leg ulcers and radiographic evidence of bone destruction was reported to be 23.5%.

Osteomyelitis is usually diagnosed using various methods, such as the probe-to-bone test, which has a positive predictive value of 53–89%.[115] In addition, MRI is considered the best method for detecting periosteal changes, bone marrow edema, and local cellulitis.[116] T2-weighted images with

gadolinium contrast enhancement can be used to detect histological changes.[117] In the early stages, osteomyelitis may not be easily detected on plain radiographs, and differential diagnosis with Charcot neuropathic osteoarthropathy is often difficult.[118]

Patients with osteomyelitis, particularly in the diabetic foot population, present unique challenges.[119] The conventional approach to managing these patients involves a variety of interventions, including drainage of the infection, administration of intravenous antibiotics, debridement to remove necrotic and infected tissue, and, if necessary, surgery to remove infected bone.[112,115] In patients with compromised foot circulation, vascular reconstruction is recommended to improve vascular status.[120]

Research suggests that increased blood flow to the foot arteries has a positive effect on antibiotic efficacy and facilitates tissue repair.[121,122] Another study reported that bone infections in diabetic patients can be very difficult due to the penetration of Gram-positive cocci, especially in the bone environment and their attachment to the glycocalyx layers, and the reinfection rate in these patients can reach 40%.[42] Effective control of hyperglycemia is a critical aspect of patient management, which in many cases requires a change to temporary insulin regimens.[123]

Dialysis patients who develop osteomyelitis in the forefoot usually have the worst prognosis, with approximately 32% of these patients resulting in amputation.[123] While bone biopsy, as the gold standard for diagnosing osteomyelitis, has limited utility, conservative treatment strategies have been proposed as an alternative option.[123] In many cases, infection can be successfully treated with a long-term regimen of 6 to 12 weeks of antibiotics and wound debridement, and this approach can lead to the eradication of the infection in 70% of cases.[123] This highlights the need for ongoing nursing care and close monitoring in the management of chronic leg ulcers.

2. Major amputation

The use of conservative approaches to amputation, in order to preserve foot function, is often not feasible in cases of complex and advanced infection and may not be generally effective.[124] The decision to salvage the limb or opt for primary amputation should be based on a comprehensive assessment of the patient's general health status and a balanced consideration of the potential risks and benefits.[125] For example, in patients with irreversible distal arterial occlusion who have developed gangrene of the foot, the use of short amputation methods may not only be unsuccessful but also require long-term wound care, which ultimately has a negative impact on the patient's quality of life.[126] In such cases, foot-sparing surgery can be potentially dangerous. Therefore, prioritizing primary below-the-knee amputation over repeated and ambitious attempts to preserve the foot, which often result in frustration, seems to be a better option.[127] In cases where distal bypass is unsuccessful, above-the-knee amputation may be required, which will result in reduced daily functioning.[127]

Palliative above-the-knee amputation is recommended as a recommended option for hospitalized patients at risk of health problems, especially those presenting with chronic foot infections or gangrene.[125] This intervention usually not only improves the patient's health but also reduces the length of stay in the hospital.[126] Additional factors that may lead to primary above-the-knee amputation include the presence of significant discoidity, irreversible complete occlusion of the infrapopliteal artery, popliteal artery occlusion, and flexion contractures of the knee.[127] This also includes the elderly with cognitive impairment who are unable to cooperate with treatment and those who are highly vulnerable due to age and acute conditions.[128]

The negative factors associated with limb-salvage procedures are significantly increased compared with the possible long-term benefits, especially in patients with advanced atherosclerosis.[127] The occurrence of major amputation is usually a significant

concern for patients who are struggling with a significant burden of underlying diseases.[129] According to research, approximately half of major amputations are associated with postoperative complications such as myocardial infarction, pneumonia, stroke, and urinary retention, which are attributed to the underlying diseases.[125,129] The mortality rate associated with major amputation procedures has been estimated to be 17% on average.[130] Specifically, mortality has been reported to be 14% for above-knee amputations and 6.6% for below-knee amputations.[131] In patients undergoing renal dialysis, the mortality rate is significantly increased, with a relative risk of 3.75.[132] Approximately 66.7% of postoperative deaths are attributed to cardiovascular causes. Furthermore, the life expectancy of patients after amputation is severely limited, with a reported five-year survival rate of 30% percent.[133]

Studies have shown that delayed wound healing is significantly more common after transtibial (below-the-knee) amputations, with rates ranging from 20% to 45%, compared with 10% to 25% for transfemoral (above-the-knee) amputations.[129,134] Interestingly, diabetic patients generally have a higher recovery rate than non-diabetic patients with end-stage peripheral arterial occlusive disease, with a recovery rate of 88% in diabetic patients and 70% in non-diabetic patients.[135] This difference is likely due to the predominant effect of diabetic occlusive disease on the sub popliteal region.

In addition, conversion to an above-knee amputation may be required in 15% of patients who initially undergo an amputation, increasing to 25% among patients on dialysis.[136] Other common causes of re-amputation at higher levels include stump necrosis and wound infection.[137] The Burgess procedure is recognized as a common technique for below-knee amputations, and it is recommended that surgeons use atheromatic techniques that involve gentle skin manipulation and removal of excess tissue from deep muscles and the sole of the foot to reduce wound complications.[138] This technique facilitates the application of sutures to the posterior myofasciocutaneous flap without unnecessary pressure. To avoid sharp edges, it is recommended to use an oscillating saw to cut the tibia, which should begin with a diagonal cut from the anterior proximal to the posterior distal.[138]

In the proposed technique, the fibula (peroneal bone) should be cut 2 cm closer to the body than the tibia. Cutting the fibula at higher levels results in a conical shape in the amputation, which reduces its suitability for prosthetic use. To reduce nerve-ending irritation and prevent neurinoma, proximal nerve cuts should be made under tension, away from the stump end. Suction drainage is usually maintained for 48 hours postoperatively, and skin sutures are typically maintained for three weeks.[139]

Amputation techniques, especially the Gritti-Stokes knee amputation, help preserve quadriceps function, and anatomically, the full length of the femur can provide optimal leverage for movement.[140] In the elderly, the skin over the patellar joint and femoral condyles atrophies, making it difficult to use a prosthesis.[141] Maintaining the integrity of the knee joint is of particular importance in rehabilitation processes and improving walking ability.[142] This has significant benefits for older patients who are unable to use a prosthesis and plays an important role in facilitating activities such as turning, sitting, and transferring.[143,144]

Research has shown that the patient's pre-amputation mobility status is a key factor influencing postoperative outcome and prosthetic use.[145,146] Patients who are unable to walk before a major amputation are more likely to not achieve the ability to walk with a prosthesis, even with postoperative pain relief.[146] A 2021 study by Nehler et al.[129] showed that the likelihood of postoperative mobility is reduced by up to 10-fold in patients with inadequate preoperative functional readiness compared with patients who can ambulate regularly preoperatively.

In addition, variables such as dementia, advanced age, and advanced renal disease

have been identified as important predictors of poor functional outcomes.[147] These variables are not only considered risk factors but also significantly influence the likelihood of not using a prosthesis. In fact, the relative risk (odds ratio) of these factors in this context is as high as 3. Also, the percentage of people who are able to regain independent walking with a prosthesis in their 80s is less than 10 percent.[148]

Amputation is usually performed with the aim of reducing pain and preventing deterioration of the patient's overall health. However, the presence of diabetes as a predicted risk factor for poor functional outcomes following lower limb amputation has not been emphasized in recent research and does not seem to have a direct impact on predicting postoperative outcomes.[148] In general, attention to the patient's preoperative ambulatory status and its associated variables can help improve motor outcomes and prosthesis use in amputees.

Risk factors for lower limb amputation

1. Peripheral vascular disease

Peripheral vascular disease (PVD) is more common in people with diabetes than in those without diabetes, independent of gender.[149] Studies have shown that in diabetic patients, the arteries below the knee are more commonly affected than other areas, which may be due to hemodynamic and metabolic changes caused by diabetes.[150]

In the epidemiological context, PVD is usually assessed using a measure called intermittent claudication, which refers to patients presenting with discomfort due to reduced blood flow to the leg muscles during activity.[151] This condition usually improves with rest. Another way to assess PVD is to check the arterial pulse and its presence or absence in the lower extremities, known as occlusive atherosclerosis.[151]

The Framingham studies[152,153] have shown that the relative risk of intermittent claudication in people with diabetes, after adjusting for confounding factors such as cholesterol levels, blood pressure, and smoking, is 4 to 5 times higher than in nondiabetics.[153] Furthermore, the occurrence of PVD in these individuals is clearly correlated with increasing age and duration of diabetes and is more common in men than in women. Studies conducted in Rochester, Minnesota, have shown that the prevalence of atherosclerotic plaque increases from 8% at the time of diagnosis of diabetes, to 15% after 10 years, and to 45% after 20 years.[154] Also, in the larger Framingham population,[155] smoking was associated with a two-fold increase in the risk of intermittent claudication in both sexes, and high blood pressure increased the risk by a factor of 2.5 for men and 4 for women.[156-159]

2. Infection

Infection is commonly seen in a significant proportion of foot ulcers and is often a frequent precursor to the need for amputation.[160] Among people hospitalized for infection and diabetes, the foot is the most common site of infection. Furthermore, foot infections contribute to a greater number of hospital days than other diabetes-related complications.[161,162] Foot infections can involve a variety of species, including anaerobic and aerobic microorganisms. The question of whether people with diabetes are more vulnerable to infection remains a matter of debate among the scientific community.

3. Peripheral Neuropathy

Peripheral neuropathy is one of the common complications of diabetes; however, its precise incidence remains unclear due to the lack of internationally validated classification systems.[163] According to research conducted in Brussels,[164] the overall prevalence of peripheral neuropathy at the time of initial diabetes diagnosis was reported to be 8%. However, this prevalence significantly increases to 50% after 25 years. The initial diagnosis of peripheral neuropathy is primarily based on the presence of decreased Achilles and patellar reflexes, as well as diminished vibratory sensation. The role of hyperglycemia in the pathogenesis of peripheral neuropathy is well documented.[165]

Prospective studies on newly diagnosed diabetic individuals in the Indian community have demonstrated that the absence of peripheral reflexes and reduced vibration sensation in the hallux is significantly associated with an increased need for limb amputation.[166] This association remained significant even after accounting for factors such as age, sex, and duration of diabetes.

Symmetrical distal polyneuropathy, which is common among individuals with diabetes, involves damage to motor, sensory, and autonomic nerve fibers.[167] The prominent symptoms of this type of neuropathy include decreased sensitivity to heat and pain, numbness, and severe paresthesia. This condition can impair individuals' ability to identify minor injuries, such as pressure, trauma from ill-fitting shoes, or thermal injury, ultimately leading to the development of ulcers, infections, and, eventually, gangrene.[168,169]

Moreover, motor nerve dysfunction may lead to muscle tissue atrophy, resulting in foot deformities and uneven pressure distribution on the foot surface.[168,170] Dysregulation of the autonomic nervous system is also associated with the formation of foot lesions. For example, a lack of sweating can lead to dryness and cracking of the skin. Vasomotor instability may also result in arteriovenous shunting in the foot, potentially attributed to abnormal sympathetic nerve activity, consequently leading to reduced tissue oxygenation.[171]

Peripheral neuropathy is considered a key factor in the development of foot ulcers. However, identifying and distinguishing the impacts of various risk factors can be challenging.[172] A study by Hall et al.[173] involving 239 individuals with diabetes and foot ulcers indicated that 62% of the observed wounds were classified as neuropathic ulcers, while the remaining 38% were identified as ischemic ulcers. Furthermore, 60% of those in the ischemic group also exhibited signs of neuropathy.[173] Hansen's disease, commonly known as leprosy, is characterized by persistent granulomatous infection, which can induce peripheral neuropathy and, in the presence of vascular diseases, lead to diabetic foot ulcers.[172]

4. Hyperglycemia

A study by Nelson et al.[166] on the Indian population found a significant positive correlation between hyperglycemia and the increased incidence of lower limb amputation. Hyperglycemia is identified as one of the major risk factors for the development of diabetic neuropathy and may potentially disrupt the body's immune response to infections.[174] Available information regarding the impact of hyperglycemia on accelerating the progression of large vessel disease is somewhat limited. However, evidence indicates that hyperglycemia is associated with a higher prevalence of small vessel diseases in peripheral regions, frequently observed in individuals with diabetes.[174]

5. Race

Numerous studies demonstrate significant differences in the risk of amputation among individuals with diabetes based on racial background.[175] Notably, a study in South Carolina indicated that the risk of amputation in Black individuals is 2.3 times higher than in White individuals.[176] Similarly, in New Jersey, the risk of amputation in non-White individuals was reported to be 1.4 times higher than in White individuals.[177] Additionally, research has shown that the amputation rate among Pima Indians with diabetes is 3.7 times greater than that of diabetic patients residing in six other states in the United States.[166] Nevertheless, it remains unclear to what extent the increased risk is associated with racial factors or lower socio-economic status. Recent evidence suggests that higher prevalence rates of smoking and hypertension among African Americans may significantly contribute to the increased risk of amputation.[178]

6. Foot Care

Given the increased sensitivity of individuals with diabetes to foot ulceration and accompanying lesions, the implementation of appropriate foot care

practices plays a crucial role in the timely identification of diseases and the reduction of amputation risks.[122] Occurrences of avoidable minor trauma, inappropriate footwear, and the inability to recognize and promptly address injuries can contribute to the progression of infection and gangrene, ultimately leading to the need for amputation.[179] Despite common recommendations for physicians to conduct regular foot examinations for individuals with diabetes who are at risk of foot complications during each clinic visit, research has shown that such assessments are performed in only 12.3% of visits to a specialized diabetes clinic.[178] Several studies (which will be discussed in more detail) have demonstrated that implementing appropriate foot care programs can lead to a significant reduction in the incidence of amputations.[180,181]

Foot ulcers or calluses often result from minor injuries caused by friction from inadequate footwear.[182] This is particularly prevalent among those who have a reduced ability to perceive and respond to potential injuries. Footwear modifications or the construction of specialized shoes that accommodate the foot are highly recommended, especially in cases of foot deformities. However, custom shoes can be relatively expensive, ranging from $100 to $400 per pair. Research has shown that replacing regular shoes with athletic running shoes has the potential to reduce the size of plantar calluses.[183]

7. Gender

Research indicates that the likelihood of lower limb amputation in men is 1.4 to 2.6 times greater than in women with diabetes. Individuals diagnosed with diabetes exhibit high sensitivity to PVD. However, it is important to note that smoking has been identified as a confounding variable in this relationship. Findings from the Framingham study demonstrated that the age-adjusted prevalence of intermittent claudication in men is 50% higher than in women with diabetes. Existing evidence regarding the incidence of neuropathy shows ambiguous findings, suggesting that it occurs slightly more frequently in men than in women.

8. Age and Duration of Diabetes

The risk of amputation in diabetic patients increases with age. Compared to individuals under 45 years of age with diabetes, those aged 45 to 64 years are at 2 to 3 times greater risk of amputation, while individuals aged 65 years and older face a risk that is seven times greater. Approximately 64% of all lower limb amputations occur in individuals aged 65 years or older, whereas 96% of all lower limb amputations are seen in those over 45 years old.[176] The likelihood of amputation appears to be correlated with the prevalence of neuropathy, which increases with the duration of diabetes. Furthermore, the occurrence of PVD is similarly associated with both the length of diabetes and age.[184,185]A study conducted on the Pima Indian population indicated that the duration of diabetes is a significant risk factor for amputation, even after adjusting for variables such as gender and age.[166] Therefore, it is essential to acknowledge that the length of time an individual has been diagnosed with diabetes should be considered an influential factor in the probability of amputation.

9. Type of Diabetes

Assessing the impact of diabetes type on the risk of amputation remains uncertain and challenging due to significant confounding effects related to age and duration of the disease [186]. Individuals with insulin-dependent diabetes mellitus (IDDM) show a slight increase in the incidence of PVD compared to those with non-insulin-dependent diabetes mellitus (NIDDM) after age adjustment.[187,188] The occurrence of foot ulcers is more prevalent among individuals diagnosed with diabetes before the age of 30 compared to those diagnosed at age 30 or later.[189] These changes may potentially correlate with the duration of the diabetes diagnosis. The incidence of amputation has a positive correlation with age, and the population diagnosed with NIDDM is both older and over ten times more prevalent

than the population diagnosed with IDDM. Consequently, the vast majority of amputations in diabetic patients are observed in those with NIDDM.

10. History of Previous Amputation and Foot Lesions

Individuals with diabetes who have undergone amputations, whether below or above the knee, face a significantly higher risk of contralateral amputation compared to the general diabetic population, with reported increases in risk ranging from 10 to 20 times over a three-year period.[176] According to one study, the incidence of contralateral amputation among individuals with diabetes was determined to be 53% within a four-year period following the initial amputation.[190] The likelihood of amputation is greater for patients with diabetes who have previously undergone minor amputations, such as toe amputation, compared to those who have not had prior surgical interventions.

Patients with diabetes experiencing foot lesions, which may include deformities, ulcers, or infections, are at significant risk for lesion progression and subsequent amputation. However, it is noteworthy that there is limited empirical evidence to substantiate this claim. Nonetheless, in optimal conditions within a specialized foot care clinic, an 86% success rate in the healing of neuropathic ulcers has been observed, whereas ischemic wounds demonstrate a healing rate of 72%.[191] Individuals with impaired healing abilities underwent a wide range of medical interventions, the majority of which necessitated amputation.[192] Those who have previously experienced ulcers tend to have ongoing foot issues and should be considered at high risk.[192]

Amputation and Infection Drainage in Diabetic Feet

There exists a strong association between foot problems and diabetes.[193] It is estimated that approximately 25% of individuals with diabetes may ultimately seek medical care from surgeons, physicians, or podiatrists due to manifestations of diabetic foot complications or related limb issues.[194] Medical management of diabetic foot infections requires significantly more hospital days compared to other diabetes-related complications. The likelihood of developing gangrene in individuals with diabetes is markedly higher, estimated to be nearly 17 times greater, emphasizing the need for sensitivity when discussing this condition with patients relative to those without diabetes.[160,195] Unfortunately, it is a regrettable reality that diabetic patients account for nearly two-thirds of major amputations performed in the United States.[196] Reducing this number depends on enhanced education and understanding among both patients and healthcare providers, as well as addressing misconceptions regarding the management of diabetic foot complications, particularly infections.

Diabetic patients exhibit a diminished resistance to infections. The presence of infection impacts diabetes management, while uncontrolled diabetes has a reciprocal effect on the occurrence and severity of infections.[162] Various disorders in host defense mechanisms result in a spectrum of deficiencies in neutrophil function, including impaired phagocytosis, chemotaxis, and bactericidal activity.[197] Furthermore, it is important to note that systemic signs and symptoms of a septic process often appear later, with uncontrolled and unexplained hyperglycemia serving as the only reliable indicator of a potentially severe infection that poses a risk to the limb.

Foot ulcer management

The treatment plan for an infected diabetic foot depends on the severity of the disease. Occasionally, patients may be hospitalized due to a life-threatening foot infection, which can be attributed to complications from hyperglycemia, edema, or cardiac failure.[198] The full extent of tissue damage and sepsis may not be readily apparent by visual examination of the callus or infected wound, especially in individuals who are constantly applying pressure to an area that is free of discomfort or who lack the visual acuity to detect the problem. It is

important to completely remove any covered area and perform a thorough wound examination to assess the extent of deep tissue damage and potential bone and joint involvement.

In cases of first superficial infections characterized by limited cellulitis, treatment in a home setting may be appropriate, provided there is no evidence of systemic toxicity and the patient demonstrates compliance, reliability, and a caring support network.[199] The effectiveness of outpatient treatment is dependent on the implementation of complete and absolute rest for the affected area. Neuropathy involves loss of sensory and proprioceptive perception, leading to a situation in which the patient may perceive partial weight-bearing as full weight-bearing, thus mistakenly believing that he is adhering to the prescribed treatment.[102,165] At the first debridement, cultures are taken from the wound surface and broad-spectrum oral antibiotics are initiated. The choice of antibiotic may be modified based on susceptibility tests and how the wound responds to treatment.[200] The dressings used in this setting are characterized by their simplicity. Specifically, they consist of sterile gauze sponges moistened with weak isotonic antiseptic solutions. These dressings are then applied to the exposed wound, often with a frequency of one to two times a day. It is recommended that hospitalization be considered if there is no significant improvement within 24 to 48 hours. Shoe modifications are necessary to protect sensitive and high-risk areas and to facilitate weight-bearing after the successful completion of the healing process. Acute clubfoot may occur when there is an excessive increase in weight-bearing progress.[201]

Immediate hospitalization is recommended for any patient presenting with an organ-threatening infection, with a prescription for complete bed rest. This group includes diabetic patients who are immunocompromised, including those suffering from renal failure or those undergoing immunosuppressive therapy after transplantation. It is recommended that patients presenting with gangrene or significant ischemia, as well as those who have no support system or are unable to adhere to prescribed treatment for superficial wounds, be admitted. Adopting a preventive strategy in hospitals for patients suffering from limb-threatening diseases is justified by statistical evidence that a significant proportion, i.e. one-quarter of these affected limbs, ultimately require amputation of the major limb, either below or above the knee.[202]

While ensuring the patient's medical stability is crucial, it is also important to avoid unnecessary delays in providing the necessary surgery.[203] Prompt management of blood glucose levels is essential, typically requiring insulin rather than oral medication. Implementation of appropriate antibiotic therapy and careful wound management are essential for limb preservation.[204,205] The issue of antibiotic therapy has been discussed elsewhere. However, it is important to recognize that people with diabetes already have compromised immune systems. Furthermore, it is worth noting that these infections are commonly caused by a variety of microorganisms, which are present in approximately two-thirds of anaerobic patients. Consequently, the appropriate use of broad-spectrum antibiotics administered via IV is essential.[206]

Surgical management of an organ-threatening infection is as essential as intravenous antibiotics.[207] In many cases, resolution of systemic toxicity or shock may not occur until the septic process has been effectively stopped. Immediate surgical intervention is necessary to remove all necrotic tissue and drain the affected areas of pus. Debridement of a deeply necrotic diabetic lesion cannot be effectively accomplished using small-bore incisions and drains.[208] Diabetics have a limited tolerance to unresolved infections, necessitating the use of debridement techniques regardless of circulatory status. Revascularization is not recommended in a diabetic patient who is currently experiencing an organ-threatening infection.

A routine radiographic examination, with the exception of a bone scan or gallium scan, can provide valuable insight. However, it may not always provide definitive evidence of the extent of tissue damage or bone and joint involvement.[61,209] While gas detection indicates the presence of anaerobic organisms, it should be noted that it does not always indicate the presence of clostridial organisms or the occurrence of guillotine dissection. Bacterial species, peptostreptococcus, and obligate anaerobes are often isolated microorganisms that require careful attention to recommended surgical care protocols.[210,211] Because of the presence of neuropathy, a significant number of debridement and drainage procedures can be performed with minimal or no anesthesia.[212,213]

Dressings are often initiated during the initial surgical procedure. Again, it is recommended to use uncomplicated dressings; that is, using basic gauze pads moistened with dilute isotonic antiseptic solutions and placed on the exposed wound two to three times over a 24-hour period.[75,214] The use of enzymatic debridement agents, full-strength solutions, or other astringents in diabetic patients is associated with more problems than desired results. The above statement is true for the use of warm compresses or soaking. Based on empirical observations, the process of soaking previously damaged tissue often leads to burns in the damaged areas and probably contributes to the spread of deep tissue microbes.[215]

In patients with ischemic limbs, the first method of debridement and drainage is rarely seen as a definitive treatment.[216] Once infection control is achieved, the next determination is whether further surgical intervention or amputation is necessary to restore function to the patient's leg. Based on empirical observations, it is clear that clinical judgment plays an important role in assessing the extent of vascular dysfunction in the lower extremities of individuals with diabetes. Noninvasive laboratory findings are only a complement to clinical judgment because of the unique characteristics of the diabetic peripheral vascular system. It is essential that diabetic patients are not mistakenly denied a less invasive distal amputation procedure simply because of negative noninvasive diagnostic results.[217]

The ultimate outcome of amputation will be influenced by factors such as the adequacy of circulation, the precise location of the wound, and the extent of infection and its management. In general, it is recommended that the physician attempt to preserve a significant portion of the weight-bearing surface. However, the greater the degree of ischemia at a given site, the more imperative it becomes to prioritize early closure of the amputated area.[218] In cases where the neuropathic foot demonstrates adequate circulation, infection may be managed and healing facilitated by performing an open amputation procedure targeting a single toe, with drainage.[219] In cases of ischemic foot infection, an optimal treatment approach may include an initial debridement procedure to effectively manage the infection.[213] Subsequently, subject to improvement in distal circulation, elective revascularization can be performed, followed by a closed transmetatarsal amputation. Successful completion of primary closure of a single toe or transmetatarsal amputation is often possible under certain conditions.[220] These conditions include effective management of any persistent infection, a venous filling time of less than twenty-five seconds, little or no associated scarring, and the absence of chronic rest discomfort in the area adjacent to the amputation site. Successful amputation outcome may also be predicted by factors such as preparation, approach, and care used during the procedure.[221]

After successful management of infection, patients with vascular insufficiency are evaluated and appropriate reparative interventions are performed. The findings of this study demonstrate a significant reduction in the risk of amputation, which reinforces the effectiveness of a revascularization strategy following the successful management of sepsis.[222] After the first surgical procedure, an additional

revision of the original incision can be performed or a distal amputation with a smaller amplitude can be chosen. This procedure can lead to successful wound healing and preservation of the affected limb.

It is essential to practice avoiding any weight and pressure on the affected area in cases of neuropathy until healing is confirmed.[223] It is very disappointing to see a patient experience the unfortunate consequence of losing a limb due to early weight bearing after an initial successful surgical intervention.[224] In order to maintain healing and reduce pressure on sensitive and high-risk areas, adaptations to footwear and equipment are recommended, if necessary.

When their treatment approaches fail, physicians should immediately seek the help of more experienced specialists.[59,225] It is not advisable for physicians who are not interested and encounter only rare cases of diabetic foot infection to treat severe, limb-threatening infections. Among the many complications experienced by people with diabetes, the possibility of a major amputation is particularly high.

Conclusion

It is recommended that physicians adhere to a program that prioritizes limb preservation whenever possible. The current approach includes a series of sequential steps for the treatment of wet gangrene infections in the forefoot. The prognosis for amputations related to diabetes—either major or minor—is influenced by several key aspects, including susceptibility to infection, impaired wound healing, diminished protective sensation, and limited tissue perfusion. Implementing specific safeguards can effectively reduce the likelihood of failure in managing these amputations. In cases where the potential for wound healing is diminished, such as in unreconstructable superficial femoral artery disease or when infection or gangrene extends beyond the midfoot, limb preservation surgery becomes impractical, and primary amputation is recommended. These guidelines are applicable to patients classified as non-ambulatory upon presentation, as foot preservation efforts in such cases are unlikely to lead to significant improvements in their quality of life. Understanding major amputations in the management of diabetic foot should be considered a failure rather than recognized as an acceptable treatment option, as it provides patients with opportunities to regain functional independence and mobility. It is essential for diabetic patients with major or minor amputations to actively engage in their diabetes treatment plan. This treatment program should include continuous participation in a diabetic foot clinic. Implementing preventive measures and foot care to prevent the occurrence of new pressure ulcers and skin deterioration in both the amputated and healthy foot is crucial. The importance of a well-organized multidisciplinary clinic for diabetic foot care, particularly in the post-amputation phase, should not be underestimated.

Furthermore, the presence of peripheral ischemia, neuropathy, and impaired host defense mechanisms places individuals with diabetes at a heightened risk for infected foot ulcers. Effective treatment should focus on addressing these three fundamental pathological conditions. Given the significant risk of severe limb amputation posed by threatening infections, timely and accurate identification of any foot-related issues is vital. Managing neuropathy necessitates complete cessation of activity in the affected area. Implementing a modified host defense requires a comprehensive understanding of the specific bacteria involved, as well as the appropriate use of antibiotics.

Careful attention to surgical principles is essential to ensure complete removal of all necrotic tissue and to establish adequate dependent drainage for the wound while preserving viable tissue and skin as much as possible for future revision or conservative amputation. Following sepsis treatment, revascularization of ischemic limbs may be performed. Due to the distinctive characteristics of vascular disease in individuals with diabetes, successful vascular interventions demand the utmost expertise and skill from vascular surgeons. After the

revascularization process, opportunities for revisions or more conservative distal amputations may arise.

There is an urgent need for comprehensive education and understanding among both patients and physicians as vital factors in the prevention and effective management of all complications associated with diabetic foot ulcers. Overall, amputation is considered when non-healing wounds or severe infections cannot be effectively managed. The key to reducing amputation risk in individuals with diabetes lies in proactive management of their condition and diligent foot care. Regular examinations and open communication with healthcare professionals can facilitate early detection and resolution of complications, potentially preventing the need for amputation. The decision for amputation is not straightforward and is often a last resort to save a person's life by preventing the spread of infection. Partial or complete amputation of toes, feet, or even parts of the lower leg may be necessary to remove infected or necrotic tissue.

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