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Diabetes and Amputation: Prevention and Care

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ABSTRACT

Diabetes mellitus is a major global public health challenge and a leading cause of non-traumatic lower-extremity amputations worldwide. The burden of diabetes-related amputation is driven primarily by preventable complications, notably diabetic foot ulcers arising from neuropathy, peripheral arterial disease, infection, and impaired wound healing. This review examines the epidemiology, pathophysiology, risk factors, prevention strategies, and management approaches linking diabetes to lower-limb amputation. Emphasis is placed on early detection through neuropathy screening and vascular assessment, effective glycaemic control, patient education, appropriate footwear, and multidisciplinary care. The paper also explores wound management, advanced therapies such as revascularization, surgical decision-making, rehabilitation, and psychosocial support following amputation. In addition, health system and policy implications are discussed, particularly in low- and middle-income settings where resource limitations exacerbate outcomes. Despite advances in diagnostics and treatment, diabetes-related amputations remain common, underscoring the need for integrated prevention programs, standardized care protocols, and strengthened health systems. A coordinated, patient-centred, and multidisciplinary approach remains essential to reducing the incidence of diabetic foot complications and improving quality of life for affected individuals.

Keywords: Diabetes Mellitus, Diabetic Foot Ulcer, Lower-Limb Amputation, Peripheral Neuropathy, Prevention and Foot Care.

INTRODUCTION

Diabetes mellitus affects an estimated 415 million people worldwide, and its prevalence is expected to rise to 642 million by 2040 [1-5]. The disease constitutes one of the leading causes of death globally and plays a major role in the development of lower-extremity complications [6-8]. The estimated worldwide incidence of leg amputation in diabetic patients is up to 22 times greater than in non-diabetic individuals: the World Health Organization estimates that one-leg amputation attributable to the condition occurs every 30 seconds. As many as 85% of lower limb amputations in diabetic patients follow the occurrence of a foot ulcer [9-13]. Most such amputations are preventable through the timely treatment of foot lesions and the amelioration of underlying biomechanical factors. A multi-faceted approach incorporating glucose control and foot-care education is required to maintain the foot health of patients with diabetes [14-19]. Diabetes-related foot lesions typically result from a combination of factors: neuropathy, ischemia, infection, and mechanical stress. The size and depth of the ulcer, the degree of surrounding ischemia and infection, and the patient's comorbidities play a central role in determining the treatment strategy. Wound healing is impaired in the presence of peripheral vascular disease, peripheral neuropathy, or osteomyelitis. Distal pedal and tibial pulses and non-invasive vascular studies are helpful in assessing circulatory status [20-25].

Epidemiology and Burden of Disease

Diabetes poses a significant health burden, particularly in sub-Saharan Africa, where the incidence of lower-limb amputations among diabetic patients is a key indicator of foot care quality [26-30]. Proper management and early recognition of foot complications can reduce amputation rates, but challenges in healthcare systems affect diabetes management and increase the risk of chronic complications [31-34]. Although diabetes is a well-known risk factor

for amputation, there is a lack of comprehensive public health literature addressing the condition [35-39]. Diabetic neuropathy significantly impacts patients' health and healthcare systems. Duration of diabetes, poor glycemic control, smoking, and hypertension are prominent risk factors [40-43]. Diagnostic methods such as monofilaments, DPN-Check, and SUDOSCAN devices aid in early detection of distal symmetrical polyneuropathy [44-47]. Despite advances in diagnostics, intensive treatment has not shown a significant effect on reducing neuropathy events or amputations. The burden of diabetic neuropathy includes increased risks of foot ulcers, amputations, and mortality, contributing to high healthcare costs and poor patient outcomes [48-50].

Pathophysiology Linking Diabetes to Amputation

Diabetes mellitus is a complex metabolic disorder characterized by either an absolute or a relative deficiency of insulin [51-54]. In the early twentieth century, amelioration of certain acute metabolic disturbances associated with diabetes was documented to prolong life [55-59]. Advances in therapy have extended this early "period of grace" for many individuals, but long-term complications of the disease usually appear at 8 to 10 years of age 5. Diabetes is the leading cause of new leg amputations in people aged 20 years or older and accounts for more than 56% of all nontraumatic lower extremity amputations, representing a profound personal, societal, and economic burden [60-63]. The association between diabetes and amputations lies primarily in the chronic, uncontrolled elevation of blood glucose levels, the emergence of pathophysiological changes (neuropathy, leading to lower limb deformities; macrovascular disease, hindering effective perfusion; and impaired wound healing) as well as superimposed infectious processes that would not otherwise occur [64-66]. Chronic elevation of blood glucose and the associated complications of diabetes result in an increased number of lower limb lesions, such as ulcers and abscesses, which frequently require amputation. Common identifiable factors (anaemia, obesity) may facilitate the progression to amputation [67-70]. In the absence of diabetes, the prince of the lower limbs could be identified as a "soft start." Otherwise, strictly pedo-pather of the lower limbs would manifest accordingly. Medical and surgical approaches could then be integrated, depending on the prevalent diabetic status and insulin sensitivity of each patient [71-73].

Risk Factors and Early Warning Signs

Amputation risk correlates with several interrelated patient and foot characteristics [74-77]. Systemic risk indicators include the presence or duration of diabetes, glycaemic control, chronic renal insufficiency, and prior foot ulceration, and renal disease, neuropathy with loss of protective sensation, foot deformity, and lower-limb vascular insufficiency [70-74]. Foot-related risk indicators include callus formation, foot deformities (such as hallux valgus, claw toes, and Charcot deformity), and history of prior ulceration or amputation, limited joint mobility, palmar plantar keratoderma, fissured skin, and fungal infection [75-77]. Foot problems that warrant close monitoring include changes in nail contour or growth; skin alterations on the heel or sole, palmoplantar keratosis, disruption of the skin–nail junction; recurrent infections; rapid progression of a diabetic foot or nail-related problems; and patient weight gain, especially in neuropathic diabetic foot cases [8].

Prevention Strategies in Primary Care

Amputation of the lower extremity is a significant socio-economic burden for both individuals and the community in terms of functional loss and the ability to work and perform usual daily activities. Furthermore, amputation remains a procedure that is avoided at most levels in the hospital [9]. Diabetic foot ulcers precede 85% of the amputations occurring in patients suffering from diabetes mellitus. Thus, prevention comes to the forefront as the urgent need. A comprehensive prevention strategy targeted at patients suffering from diabetes mellitus is required [11].

For diabetic patients, systemic glucose control supports other processes in optimization and prevention. Blood glucose levels should be checked diligently, and regular medication is important. Sustaining glucose levels also supports the action of further preventative measures [12]. Neuropathy screening is essential for diabetic patients, and screening for peripheral artery disease is necessary as it complements other risk factors. A thorough screening program, when combined with other stratification tools, can characterize and stratify risk levels [15]. A considerable amount of foot trauma and pressure derives from inappropriate footwear [10]. Education on the disease is crucial, and knowledge enables individuals to take care of themselves, reducing the risk of lower extremity amputation [10]. The Country Diabetes prevention programme highlights that foot care and foot wear is an essential strategy together with the neurological assessment, for the prevention of foot ulcers among diabetes patients. Management of round-the-clock monitoring of foot care [12]. Diabetics represent a group of patients with long life expectancy, but they have a higher risk of lower limb amputation, especially foot amputation, compared with non- diabetics [14].

Glucose Control and Metabolic Management

Diabetes mellitus is characterized by chronic hyperglycemia due to insulin deficiency or resistance. Proper glycemic control through effective treatment, diet, physical activity, and monitoring can prevent or slow the progression of complications [20]. Diabetes-related foot problems are responsible for more hospital admissions than any other complication and can ultimately lead to amputation of the lower limb. Both diabetic neuropathy and

peripheral arterial disease can lead to the development of leg ulcers, gangrene, and amputations. An estimated 25% of diabetic patients will develop a leg ulcer during their lifetime, and 15% of these cases will require amputation due to associated complications [21]. To counter the individual and collective burden of diabetes-related amputation, prevention constitutes a key priority. Active screening for diabetic foot lesions with neurological and vascular examinations can help in the early identification of lesions and in the detection of the first signs of neuropathy and peripheral arterial disease [2]. Prevention also involves effective management of major risk factors, such as blood glucose and cholesterol levels and smoking, as well as the prompt treatment of foot infections and peripheral artery disease [11]. Patient education and self-care have been consistently emphasized in generating awareness and compliance that underpin other preventive activities [6].

Foot Care and Footwear

Diabetic foot ulcers affect 15% of patients with diabetes during their lifetime and frequently result in amputations. Comprehensive diabetic education, foot care, and proper footwear minimize foot complications and lower amputation rates [3]. Approximately one-quarter of the diabetic population is at risk for foot-related complications [20].

Neuropathy Screening and Vascular Assessment

Incidence of diabetic foot ulceration and the risk of consequent infection or amputation can be drastically minimized through two straightforward primary care assessments: neuropathy screening and vascular assessment [5]. Neuropathy screening assists in identifying patients at risk of ulceration due to insensitivity and loss of mechanoreception[2]. The Michigan Neuropathy Screening Instrument (MNSI) is widely recommended for this purpose. Vascular assessment can be conducted with a simple pedal pulse examination or, for greater sensitivity, via measurement of ankle brachial indices [4]. Patients exhibiting abnormal findings or presenting with multiple ulceration risk factors should be prioritized for education on foot care and other preventive measures [12].

Patient Education and Self-Care

Diabetes management requires teaching patients the principles of self-care. This can be achieved by using patient education programs [5]. Education has an important role in the prevention of diabetic foot ulcers [13] and also provides a viable tool for reducing the incidence of diabetic foot ulcers [14]. Self-care is defined as the "capacity of individuals to undertake the activities that maintain life, health, and wellbeing". Educated patients adopt healthy lifestyles that help regulate blood sugar levels, keep their feet clean and dry, and prevent the development of foot lesions [16].

Management of Ulcerative Foot Lesions

Foot lesions can arise in people with diabetes as a result of inflammatory neuropathic, ischaemic, or combination causes [14]. Lesions limited to the epidermis typically do not progress to ulceration. Ulcerative foot lesions of a neuropathic or vascular origin, however, present a serious clinical problem that can require surgical amputation [15]. They often occur in conjunction with peripheral arterial disease (PAD), which is four to ten times more common in people with diabetes. Adequate peripheral blood supply is needed for ulcer healing, and vascular surgery procedures such as percutaneous transluminal angioplasty may be needed before specialist wound healing therapy can begin [1]. Thus, an assessment of foot perfusion in consultation with a vascular surgeon is advisable at the earliest sign of an ulcer if PAD is suspected [5].

Wound Care and Infection Control

Management of diabetic foot ulcers involves addressing the global burden and underlying pathophysiology. Optimal wound care prioritizes infection prevention, healing facilitation, and correction of neuropathic and pressure-associated factors [23]. Complicating infections, including methicillin-resistant Staphylococcus aureus (MRSA), require appropriate antibiotic therapy [22]. Advanced dressings, such as silver-impregnated materials, may enhance healing but necessitate caution due to potential toxicity [21]. Effective management also demands optimization of wound-bed preparation and attention to biomechanical contributors to diabetic foot injuries [15].

Diabetic wound healing is compromised by systemic and local factors, fostering chronicity and elevating risks of infection and amputation [19]. Diabetes induces biochemical and cellular derangements that obstruct tissue-repair processes, including cell migration and proliferation. Innate-immunity deficiencies further impair healing: hyperglycemia diminishes neutrophil function and exacerbates inflammation through reactive-oxygen-species production [18]. Peripheral-arterial disease aggravates prognosis by inducing ischaemia, delaying recovery, and increasing amputation susceptibility [11]. Toxic hyperglycaemic effects on fibroblasts and endothelial cells disrupt granulation-tissue organization and hinder re-epithelialization, impeding wound-closure and healing [5].

Advanced Therapies and Revascularization

Vascular reestablishment in diseased arteries remains a key intervention in advanced therapies for critical limb ischemia [16]. Revascularization addresses the anatomic obstacles imposed by occlusive disease and restores the physiologic perfusion that favors healing of foot ulcers. Recent large series on surgical revascularization with contemporary techniques, patient cohort definition, and limb classification indicate lower rates of amputation compared with historical data [17]. In the absence of other systemic or local conditions that enforce amputation,

limb salvage, when strictly aligned with these entities, can be achieved in more than 70% of patients. Revascularization and limb salvage form separate therapeutic concepts that in many circumstances correlate and combine in common overall strategies, yet not uncommonly are applied independently and separately [18]. Wound healing, prevention strategies, and the underlying pathophysiology of diabetic foot ulceration are well recognized. Implementation of revascularization procedures in anticipation of more advanced and established ulcerations remains debated [21]. Foot ulcers, which often lead to amputation of the limb, initiate a spiraling course that usually includes nonhealing or recurrent ulceration, severe infection, and ultimately amputation despite extensive and multiple reconstruction efforts[13]. In chronic ulcers, inflammation dominates the local healing process and interferes with the reparative response. Material addressed at this stage involves a comprehensive treatment approach that rests on revascularization, infection eradication, and control of associated comorbidities and risk factors [15].

Surgical Considerations and Amputation Timing

Diabetes substantially contributes to the morbidity associated with foot pathologies. Neuropathy is often the major underlying factor responsible for the initiation and progression to clinical disease, resulting in ulceration, osteomyelitis, and/or ultimately amputation [6]. Pathologies directly attributable to diabetes have a significant potential to progress to above-the-ankle amputation, albeit amputations at more distal levels are most frequent. Various factors are important influences in determining the likelihood of disease progression and, therefore, amputation risk [7]. The foot pathologies that can lead to amputation in the diabetic population include infection, ulceration, and vascular event [9]. Critical to the design of public health prevention and management programs is an acute awareness of the disease process and predominant societal risk factors in the geographical area of interest. As with many other chronic complications, precise timing of the intervention to remove the contributing factor is often critical in determining a more distal surgical solution: revascularisation must precede, and is often sufficient to prevent, more distal surgery [18].

Indications for Amputation

Progressing infection in patients with diabetic foot ulcers often leads to limb amputation. The common site for the surgical intervention is above the ankle [14]. Once amputation has occurred, outcomes are poor: five-year mortality may reach 60%, and around half of those affected will incur further contralateral amputation within four years. Approximately 50% of the individuals who undergo major amputation post-ulcer die within five years from the onset of foot lesions [15]. Infected ulcers also warrant amputation when life-threatening infection escalates, diabetes remains poorly controlled amid chronic ischemia, or revascularization has failed [16]. Deceased patients usually feature pre-amputation risk factors such as long-term systemic illness, malignancies, micro- and macroangiopathies, renal failure, and foot deformities [17]. Regular examination by specialist units is recommended for those at elevated ulceration risk or with previous amputation 6. Despite innovation and increased conservative management, amputation and consequent mortality rates remain high due to case complexity and reduced rates of pre-amputation revascularization [1].

Levels of Amputation and Rehabilitation

Diabetes-related lower extremity amputation (LEA) generally involves either the toe, the forefoot (i.e., amputation of the first or second metatarsal), or a distal transmetatarsal amputation [3]. When the foot is compromised, a key decision is whether to retain the foot and the option of footwear. In the absence of significant ischemia, the amputation of the foot, the Chopart amputation, preserves limb length and thereby has a more favourable outcome than forefoot amputation [3]. A Chopart amputation may nevertheless become insufficient, and patients who receive it often also undergo a second amputation, at what is generally considered a more distal femoral or knee. Compared to the Chopart amputation, a more proximal foot preservation, at the level of the major vasculature (i.e., femoral- popliteal), such as the Syme amputation, is extremely rare [19].

Rehabilitation, Prosthetics, and Quality of Life

Three clinical priorities significantly affect long-term outcomes after lower-extremity amputation: rehabilitation, prosthetics, and psychosocial support [18]. A multifaceted rehabilitation program should begin within 48 to 72 hours after surgery and include functional assessment, physical and occupational therapy training, community reintegration planning, and vocational counseling [19]. Early intervention with a prosthetic limb is crucial for maximizing mobility regardless of surgery type, level of amputation, or preoperative ambulation. Fortunately, several excellent, durable prosthetic options are available today. Psychological, social, and spiritual support is also critical throughout recovery [21]. Supportive counseling, educational programs, sharing of experiences, and emotional management can help amputees and family members cope with the inevitable life adjustments and proactive self-care required. Addressing the psychosocial aspect early in the rehabilitation process enhances motivation, encourages healthy behaviors, and improves quality of life [20]. The clinical outlook after amputation depends primarily on the underlying pathology [19]. People with diabetes and peripheral vascular disease have poorer prognoses. Even in these cases, however, survival rates after transfemoral amputation exceed 75 percent at 5 years. Addressing psychosocial challenges further enhances motivation and ensures more proactive self-care;

hence, life can remain fulfilling and purposeful even with a limb loss [20]. Costs associated with artificial limbs and fitting procedures can be major concerns for patients after amputation, especially in developing countries. Negotiating the prosthetic–rehabilitation phase with the provider consistently emerges as a key learning point of adjustment [11]. Amputees face myriad challenges, yet quality of life outcomes can be good despite the loss. Unlike many surgical procedures, limb amputation leads to a permanent change in body image and might evoke considerable psychological distress [12]. Continued social connection and ongoing self-care remain vital components of a healthy lifestyle and disease management; therefore, rehabilitation after amputation requires a collaborative and coordinated effort among multiple trained professionals, including physicians and nurses, physiotherapists, occupational therapists, and dieticians [2].

Health Systems and Policy Implications

Diabetes and its complications continue to be a major problem in India, with significant socioeconomic implications. The burden of diabetes-related foot disease and the stigma associated with lower-limb amputation indicate a need for better preventive care and disease management strategies [21]. Studies conducted in the Indian setting revealed major gaps in care delivery across the entire continuum of diabetes and its complications. As the elderly population with diabetes continues to grow in India, studies from Ireland highlight the primary role of early recognition of diabetic foot complications in the prevention of amputation. Effective management of the diabetic foot requires a multidisciplinary system of care that combines screening, education, surveillance, timely referral, and treatment [9]. Currently, such a comprehensive system does not exist in India. Consequently, there is a need to establish a countrywide diabetic foot program that provides the desired mix of centrally planned and locally flexible arrangements to facilitate implementation at a national level. The elderly population with diabetes is growing rapidly in India. In 1990, the number of elderly people aged 60 years or older was 61.89 million, which is projected to reach 119.48 million by 2030 and 194.81 million by 2050[6]. There has been a smaller relative increase in the elderly population in urban areas than in rural areas during the same period of analysis. The rate of increase in the diabetes population due to increased life expectancy and ageing of the population in India is projected to reach an estimated 64.38 million by 2010, 86.00 million by 2025, and an alarming 134.64 million by 2040 [10].

Future Directions and Research Gaps

Diabetes-related foot disease ranks as the foremost cause of potentially avoidable amputation in the United States and globally [22]. Despite significant medical progress to mitigate its risk factors, mobilize patient self-care, and tackle lower extremity ulcers, the burden of diabetes-related amputation continues to rise. Although various diabetic foot care guidelines exist, information about standardised care protocols is scant, and ample knowledge gaps persist [21-25]. Rigorous multi-faceted research and systematic prioritisation are necessary to establish guidelines for collaborative multidisciplinary approaches, cycle, target foot care, assess healthcare systems, and deploy interoperable community-wide solutions [9]. Collaboration between foot care and vascular sub-disciplines, allied health professions, and policy-makers remains equally pivotal, and emphasis must also extend to prevention and risk-reduction strategies [26-30].

CONCLUSION

Diabetes-related lower-extremity amputation represents one of the most severe yet largely preventable complications of diabetes mellitus. The progression from neuropathy and vascular insufficiency to foot ulceration, infection, and eventual amputation reflects gaps in early detection, patient education, and coordinated care. Evidence consistently shows that timely intervention through effective glycaemic control, routine neuropathy and vascular screening, appropriate footwear, and patient-centred self-care can substantially reduce the incidence of diabetic foot ulcers and subsequent amputations. Management of established foot lesions requires a multidisciplinary approach that integrates wound care, infection control, revascularization where indicated, and judicious surgical decision-making aimed at limb preservation whenever possible. When amputation becomes unavoidable, early rehabilitation, access to prosthetics, and psychosocial support are critical to improving functional outcomes and quality of life. However, mortality and morbidity rates following major amputation remain high, highlighting the importance of prevention as the cornerstone of care. At the health-system level, the burden of diabetes-related amputation underscores the urgent need for standardized foot-care programs, improved access to specialized services, and supportive public health policies, particularly in resource-constrained settings. Future research should prioritize the development of evidence-based, context-specific care models and strengthen collaboration among clinicians, allied health professionals, and policymakers. Ultimately, reducing diabetes-related amputations requires sustained commitment to prevention, early intervention, and comprehensive, multidisciplinary management.

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