

# Diabetic foot – the need for comprehensive multidisciplinary approach

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## Abstract

Diabetes mellitus is considered to be civilization disease development of which is influenced by environmental changes. Diabetic foot (ulceration, infection, gangrene) is one of the most disabling complication of diabetes mellitus. It contributes to the increased mortality and cardiovascular death.

It also frequently leads to depression, social exclusion and physical impairment.

Risk factors of diabetic foot are as follows: age, race, sex, duration of diabetes, biomechanical factors, level of glycemia, smoking habits.

According to international standards diabetic foot can be successfully treated only by the multidisciplinary team which can provide more comprehensive and integrated care as compared to ordinary medical team or single specialist.

*Multidisciplinary team consists of: diabetologist, shoemaker, orthopedist, psychologist, surgeons both vascular and general, podologists, radiologists, educators, nurses and rehabilitation team.*

Such coordinated attitude to a patient may be the future solution for any civilization and environment-related disease requiring treatment which cannot be successfully provided by any ordinary medical team.

## Key words

diabetic foot, ulceration, infection, ischemia, amputation, multidisciplinary foot clinics, environmental factors

## INTRODUCTION

Diabetes is reaching epidemic proportions. Due to better methods of treatment, the life expectancy for patients with diabetes has improved, but as a result, the risk of developing chronic complications has increased. Disease of the foot is among one of the most common and feared complications of diabetes. Diabetic foot, manifesting as ulceration, infection, and gangrene is the leading cause of hospitalization in patients with diabetes mellitus [1]. Despite better knowledge about the pathogenesis of this complication and efforts to improve prevention, the prevalence of foot ulcers still ranges from 4% - 10% among persons diagnosed with diabetes, and the lifetime risk of developing foot ulceration is estimated to be as high as 25% [2]. Foot ulcers precede about 85% of all diabetes related lower-extremity amputations [3]. Diabetic foot poses not only a financial challenge to healthcare systems all over the world, but it may have significant psychosocial effects on the patient's quality of life because of impaired mobility and substantial loss of productivity [4]. The treatment of diabetic foot ulcers is costly and the highest costs are generated by the need for lengthy hospitalization [5,6]. According to data from the 2011 National Diabetes Fact Sheet (released 26 January 2011), more than 60% of non-traumatic lower-limb amputations occur in people with diabetes, and in 2006 the number still reached about 65,700 [7]. It has been calculated that worldwide one foot amputation due to diabetes is performed every 30 seconds [8]. According to USA data, 50% of amputees die

within five years of amputation, and mortality in the group of diabetic patients with foot complications is comparable to the mortality in some types of cancer [9,10].

The ratio of amputees among diabetic is even higher than among soldiers taking active part in military conflicts which comprise 2.3% of all battle injuries and 7.4% of major limb injuries [11].

The reason for such global burden is mixture of risk factors including environmental, metabolic, and socio-economical factors associated with development of diabetes alone [12-14], its complications (neuropathy) resulting from unbalanced glycemia level [15,16] and occurrence of other diseases associated with diabetes such as depression and atherosclerosis (ischemia) [17,18].

The most common type of diabetes mellitus is type 2 diabetes which is strongly associated with environmental factors among females [13] and in populations where sudden changes of life style took place (both genders) [14].

The same factors which may influence the development of type 2 diabetes (such as lack of exercise, dietary habits, smoking) may influence life expectancy [19]. Moreover in type 1 diabetes some environmental factor such as viral infections, early infant diet, toxins and even vaccinations may influence the prevalence of diabetes mellitus [14].

Some of the risk factors for diabetic foot such as, biomechanical factors, level of glycemia, smoking habits are strongly associated with environmental factors [20].

In certain societies factors such as average monthly household income, education levels, racial distribution may contribute to diabetic foot prevalence [21] but it did not matter in more egalitarian societies [22] where a significant increase in the age-specific incidence of amputations was observed [23].

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## OBJECTIVE

The article presents a review of current literature concerning the global problem of diabetic foot with particular consideration of those affected by environmental factors.

Medical literature was analyzed with the use of the PubMed database, from the aspect of reports containing the key words: diabetic foot, environmental factors, diabetes mellitus, and complications of diabetes mellitus available in English. The studies carried out on an underage population and concerning diabetes during pregnancy were excluded. Due to the large number of reports which fulfilled the above-mentioned criteria, the articles which comprehensively describe the scope of problems of interest were selected.

## PATHOGENESIS OF DIABETIC FOOT

Pathogenesis of diabetic foot is multi-factorial:

### Neuropathy

The key contributor to the foot problem in a patient with diabetes is peripheral neuropathy affecting both motor and sensory as well as autonomic nerve fibers in patients with type 1 and type 2 diabetes – it is considered to be one of the most underdiagnosed complication. In evaluation by Herman et al. (2005) non-endocrinologists correctly identified mild/moderate and severe neuropathy in 31 and 64% of patients, endocrinologists – in 36 and 74% of patients respectively [24]. In case of primary health physicians less than 15% of patients undergo proper foot examination and neuropathy screening [25].

The risk of ulceration in patients with diabetes and neuropathy is several-fold higher than in patients without this complication [26]. Neuropathies are among the most common of all long-term complications of diabetes, affecting up to 50% of patients [27]. Dysfunction of the motor nerve fibers results in deformity of the foot, altered weight bearing, and callus formation. Calluses may cause ulceration underneath and their regular removal is one of the key measures in the prevention of foot ulceration. Lack of protective pain sensation in a foot affected by sensory neuropathy results in the inability to feel any discomfort in a foot area, unawareness of trauma, delayed presentation of a patient with developing ulceration and/or infection to the medical team, and increased risk of amputation. Any patient who fails to recognize the pressure of a 10-g Semmes-Weinstein monofilament applied to the skin until it bends (6-8 selected and chosen by the examiner areas on the sole of the foot, avoiding calluses and hard skin) should be considered to have lost the protective sensation. More tests for sensory neuropathy may be performed, such as vibration or temperature perception. Other factors contributing to diabetic foot problems are deformities (such as claw toes and prominent metatarsal heads or hallux valgus), trauma and ill-fitted footwear. Proper evaluation of patient's feet and simple screening for diabetic neuropathy is one of the most effective ways of diabetic foot prevention [25,26], using of therapeutic footwear in case of existing deformities appears to be less effective [28].

### Ischemia

Ischemia due to the peripheral vascular disease of the lower limbs is another contributory factor in the pathogenesis of the diabetic foot problems. Peripheral vascular disease impairs healing and increases the risk of amputation. According to the EURODIALE study, peripheral vascular disease is present in nearly 50% of diabetic patients, the ulcer healing rate in this population is significantly reduced, and mortality is increased [29].

Diabetes is characterized by the predilection for occlusion in the arteries below the knees. The data reported in the studies suggest a higher prevalence of amputations in ischemic patients, and the prevalence of amputation may increase up to 100% in the presence of ischemia and infection in non-revascularised patients [30,31].

Screening for PVD in diabetic patients includes inspection of the foot (decrease in hair growth, red-bluish discoloration of the skin are typical of ischemia), palpating the pedal pulses, measuring the ankle-brachial index or transcutaneous oxygen pressure. Pain of intermittent claudication in patients with diabetes may be absent due to neuropathy; therefore assessing the severity of ischemia solely on the basis and symptoms may be misleading. Any patient with clinical signs of ischemia should be referred to a vascular team for assessment and possible revascularization procedure.

### Ulceration

Every break of the skin on the foot of a diabetic patient is potentially dangerous and may lead to amputation. Formation of an ulcer is a critical moment for a patient with diabetes and potentially the first step on the pathway to amputation. The risk of a leg amputation is 15-40 times greater in patient with diabetes than in the general population [3].

Ulcers occur most often on the forefoot (at the level of metatarsal heads); those occurring on the sides of the foot are characteristic of ischemic foot. Ulcers in diabetic patients with neuropathy are usually painless (those in ischemic patients are painful even in the presence of neuropathy) and can be debrided without any anesthesia. Debridement (removal of dead tissue forming around the ulcer) should be performed on a regular basis as it leads to the lowering of pressure around the ulcer, makes assessment of the true ulcer size possible, and speeds up the healing process.

### Infection

Approximately 56% of diabetic foot ulcerations become infected [32]. Signs of infection involve – cellulitis (redness), oedema, increase in local temperature, unpleasant smell, abscess formation. Pain is usually absent due to neuropathy. In about 50% of diabetic patients, leukocytosis or fever may not be present [33]. Infection can be caused by Gram-positive, Gram-negative aerobic, and also by anaerobic bacteria. Ulcers of short term duration are usually infected by a single Gram positive organism, but cultures from long term ulcers may yield mixed flora – both Gram-positive and Gram-negative organisms may be present together with anaerobes. The team treating patients with diabetic foot infection should be aware of the local bacteriological profile and the prevalence of resistant organisms, and should stay in close contact with microbiologists. For each infected patient, serial plain radiographs should be performed to detect possible osteomyelitis, and in many cases, magnetic resonance imaging (MRI) may be necessary. Any patient with serious

infection and systemic toxicity should be hospitalized. Other indications for hospitalization comprise - low socioeconomic status of a patient and inability to self care.

### Charcot osteoarthropathy

Charcot osteoarthropathy, occurring in some diabetic and neuropathic patients, is characterized by progressive destruction of bones and joints of the diabetic foot, with accompanying osteopenia. The incidence of this complication is reported in various population-based studies to be in the range between 0.1% up to nearly 30% [34]. Due to the lack of specific markers of Charcot osteoarthropathy, according to some authors, as many as 25% of cases can be missed or the diagnosis may be delayed which may result in significant deformity, ulceration and amputation of the foot [35]. The pathogenesis of Charcot syndrome is obscure - it is not known why some patients with neuropathy will develop Charcot osteoarthropathy and some will remain free of this complication. Management of the acute phase consists of immobilization (ideally in a total contact cast which should be removed every week for foot inspection) and non-weight-bearing.

Diagnosis of Charcot osteoarthropathy must be considered in every diabetic patient presenting with neuropathy, oedema, erythema, and increased temperature of the foot. Such an individual should be immediately referred to the diabetic foot clinic.

## PREVENTION AND TREATMENT:

### Amputation

Lower extremity amputation, the most feared and devastating consequence of diabetes, is a still too common outcome of diabetic foot complications. Indeed, in many cases amputation should be seen as a treatment option which, with proper rehabilitation, should help patients return to their normal activities. However, in countries like Poland where the supporting mechanisms for amputees are not well developed, amputation should be considered only in very limited situations. One of the definite indication for amputation is a serious infection of the foot, placing the patient at risk for life-threatening sepsis. Amputation should also be considered in individuals with ischemic limb not suitable for revascularization and significant rest pain which is not manageable with analgesics.

In making the decision to amputate, one must bear in mind the subsequent outcome which in the case of major amputations is poor – a 5-year mortality rate may be as high as 40% to 70% [36].

### Multidisciplinary team

The gold standard of care for a person with diabetic foot is in the setting of a multidisciplinary clinic. The multidisciplinary team approach to diabetic foot care has been shown to result in a major reduction in amputation incidence [37]. The podiatrist (specialist in foot care), together with the diabetologist, play a coordinating role in the team, but the podiatry service is currently available in only 20 countries around the world. In some other countries, including Poland, trained nurses or doctors perform their job which is mainly debridement and care of the wound.

Other specialists of the multidisciplinary team include: general and vascular surgeons, radiologist, microbiologist,

orthotist (specialist in footwear production), and an orthopedic surgeon. All of them should have knowledge of the unique aspects of diabetic foot treatment and should work in close cooperation. This cooperation does not mean the presence of all the specialists at a patient's bedside at the same time, but as a shared experience in diabetic foot management and the possibility of immediate communication and consultation when needed.

## CONCLUSIONS

Patients who attend multidisciplinary diabetic foot clinics have an increased limb survival rate. The key aspects of the diabetic foot ulcer treatment involve relief of high plantar pressures, frequent debridement as well as management of infection and revascularization of the ischemic foot (angioplasty and by-pass), which can be very successful. Infection in the diabetic foot is often difficult to detect and may lead to amputation, and once infection is present, oral or parenteral antibiotic therapy must be started immediately.

Paul Brand, pioneering surgeon and professor of orthopedics recommended simple measures to reduce foot amputation – make physicians and nurses remove patients' shoes and socks and examine the feet [38].

Simple measures such as foot examination, neuropathy screening with monofilament or tuning – fork does not mean that is not time consuming. An average time for screening one patient is almost 5 minutes (independently of performed method) [39].

It is beneficial in terms of risk-reduction, but in ordinary practice it means additional 50 minutes for every 10 patients. Therefore annual examination of feet and neuropathy screening once per year should perhaps be treated and rewarded by National Health Insurance as additional skill beyond routine medical evaluation.

Although the awareness and knowledge about diabetic foot is increasing and the number of papers published is reaching 3% of all diabetic publications, the number of amputations in many countries, including Poland, is still high [40]. In order to reduce the number of legs lost due to diabetes, effective systems for prevention and treatment of foot ulcers have to be developed. Those must be based on multidisciplinary foot clinics and introducing educational programs for clinicians and patients with risk factors. As shown by Swedish authors, this can lead to a significant reduction in this devastating complication – amputation of the leg [41]. Treatment in the setting of the multidisciplinary foot clinic is also less costly as compared to the costs of hospitalization [42]. In Poland, the number of people diagnosed with diabetes is reaching 2 million and there are only 5 multidisciplinary foot clinics in our country – if amputations are to be reduced there is an urgent need to change the existing situation by organizing appropriately structured foot care by multidisciplinary teams which will be available to all patients with a diabetic foot problem.

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