

The Diabetic Foot

Elroy Patrick Weledji* and Pius Fokam

Department of Surgery, Faculty of Health Sciences, University of Buea, Cameroon

Corresponding author: E.P. Weledji, Department of Surgery, Faculty of Health Sciences, University of Buea, Cameroon; Tel: 00 237 699 92 21 44; Email: elroyapat@yahoo.co.uk

Received date: Aug 25, 2014, **Accepted date:** Mar 05, 2015, **Published date:** Mar 12, 2015

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Abstract

Diabetic foot infections are a frequent clinical problem. About 50% of diabetic foot infections who have foot amputations die within five years. Properly managed most can be cured, but many patients needlessly undergo amputations because of improper diagnostic and therapeutic approaches. This approach along with vascular assessment help clinical decisions about which patients to hospitalize, which to send for imaging procedures or for whom to recommend surgical interventions. This paper reviewed the natural history of the diabetic foot and assessed the surgical impact of the Infectious Diseases Society of America clinical practice guideline- based care of diabetic foot infections.

Keywords: Diabetic foot infection; Neuropathic foot; Ischaemic foot; Risk factors; Medical and surgical management; Prevention

Methods

Electronic searches of the medline (PubMed) database, Cochrane library, and science citation index were performed to identify original published studies on the natural history and current management of the diabetic foot. Relevant articles were searched from relevant chapters in specialized texts and all were included.

Introduction

Diabetes is common, affecting some 30 million people world-wide [1]. Its causes are incompletely understood, but it is clear that the disease is often multifactorial and that both genetic and environmental factors are involved [2]. Approximately 90% of diabetics have type 2 diabetes (non- insulin dependent -NIDDM) and most complications of diabetes are related to vascular impairment [1-4]. Diabetics are at increased risk of developing infections, peripheral neuropathy, retinopathy and renal impairment or failure. There is no evidence that diabetic patients with good glycaemic control are more prone to infection than normal subjects [1-3]. However, poorly controlled diabetes entails increased susceptibility to skin, urinary tract and lung infections. Foot ulcers affect 1 in 10 diabetics during the entirety of their condition and do have a male predominance [1,5]. Ischaemia, infection and neuropathy combine to produce tissue necrosis in diabetes mellitus [6] High blood glucose dampens white blood cell function mostly by impairing chemotaxis and phagocytosis by neutrophils and more importantly, damages the vascular endothelium. Accelerating atherosclerosis, results in poor macro- and micro-circulation. The microangiopathy causes restricted capillary perfusion and arterio-venous shunting. The impaired tissue metabolism and glucose-rich environment favour bacterial growth. Many organisms alone or in combinations can cause diabetic foot infections, but aerobic gram-positive cocci, especially Staphylococci, are the most common [7]. Aerobic gram-negative bacilli are frequently co-pathogens in infections that are chronic or follow antibiotic treatment, and additionally obligate anaerobes may be co-pathogens in ischaemic

or necrotic wounds. In countries with warm climates, gram- negative isolates especially *Pseudomonas aeruginosa* are more prevalent [7]. Although wounds without evidence of soft tissue or bone infection do not require antibiotic therapy; definitive therapy for infected wounds should be based on cultures of infected tissue [8]. Imaging is especially helpful when seeking evidence of an underlying osteomyelitis, which is often difficult to diagnose and treat [9]. As diabetes is usually irreversible, many amputations in diabetes should be delayed or prevented by more effective patient education and medical supervision. Surgical interventions of various types are often needed and proper wound care is important for successful cure of the infection and healing of the wound. Prompt and adequate surgical debridement, including limited resections or amputations, may decrease the likelihood that a more extensive amputation is required [10-12]. Patients with a foot infection should be evaluated for an ischaemic foot and consideration for revascularization [13,14]. Once tissue damage has occurred in the form of ulceration or gangrene, the aim is preservation of viable tissue, but the two main threats are infection and ischaemia. The progressive development of an abscess in the presence of ischaemia leads to irreparable tissue damage and amputation [3].

Risk Factors of Diabetic Foot

Soft tissue infection (bacteria /fungi) of ingrown toe nails for example are inadequately treated with antibiotics due to the poor circulation and may lead to a gangrenous limb [8]. Walking barefoot in poorly developed countries is a risk factor for diabetic foot disease. The prevalence of web space and nail infections is higher among barefoot diabetics [15]. Blisters and cuts from poorly fitting foot wear may become infected [8]. As a result of peripheral neuropathy lesions may appear after minor trauma and if left unnoticed, then severe lesions may appear [6]. Smoking increases atherosclerosis and vasoconstriction of peripheral circulation leading to poor circulation and poor wound healing [2].

Clinical Features and Diagnosis

Clinicians should evaluate a diabetic patient presenting with a foot wound at three levels- the patient as a whole, the affected limb and foot, and the infected wound [16]. The affected limb and foot should be assessed for arterial ischaemia, venous insufficiency, presence of protective sensation, and biomechanical problems. There may be an obvious large wound or ulcer associated with erythema and pyrexia. The presence of any exposed bone and ulcer larger than 2 cm² increases the likelihood of osteomyelitis [17]. Osteomyelitis should be suspected in a patient with an adequate blood supply to the affected foot that has a deep ulcer which would not heal after 6 weeks of appropriate wound care and off-loading [17]. It is important to distinguish between the ischaemic and the neuropathic foot although these factors may co-exist [2,6]. The neuropathic foot is characterized by warm, dry, bounding pulses present as a result of peripheral vasodilatation, callosities, painless penetrating ulcers at pressure points and sites of minor injury, painless necrosis of toes, spreading infection along plantar spaces, general loss of pain and thermal sensation, decrease ankle jerk reflex, tone and power [1,2,18]. The ischaemic foot is characterized by cold, absent pulses, dependent rubor, trophic changes, absent callosities, painful ulcers around heels and toes, claudication and rest pain [1,2,13]. Diabetic foot infections typically begin in a wound, most often a neuropathic ulceration. While all wounds are colonized with microorganisms, the presence of infection is defined by ≥ 2 classic findings of inflammation or purulence [19,7]. Infections are then classified into mild (superficial and limited in size and depth), moderate (deeper or more extensive), or severe (accompanied by systemic signs or metabolic perturbations) [16]. This classification system, along with a vascular assessment, helps determine which patients should be hospitalized, which may require special imaging procedures or surgical interventions, and which will require amputation [1,2,16,20,21,14].

Symptoms and Signs

There may be pain due to claudication on exercise (arterial diagnosis) or persistent pain from underlying infection. A palpable distal peripheral pulse would exclude an ischaemic foot. There may be limp or difficulty in walking due to infection, ill-fitting shoes or Charcot's joints (neuropathic). A warm erythema and migrating erythema indicate a spreading cellulitis due to infection. This should not be confused with dependent hyperaemia in ischaemic limbs. Discharging pus which is foul-smelling is due to anaerobic infection and often associated with persistent pain and erythema. A swelling is as a result of infection or poor venous return; crepitus indicate gas in soft tissue and pyrexia, rigors, confusion from bacteraemia [1,2]. Sepsis from infection may result in diabetic ketoacidosis requiring urgent medical treatment in hospital. Infections in diabetics lead to loss of glycaemic control and are a common cause of ketoacidosis. Insulin-treated patients may need to increase their dose by up to 25% in the face of infection, and non-insulin-treated patients may need insulin cover while the infection lasts [22,23].

Investigations

The first step is to determine if the diabetic foot is infected, which is likely if there are at least two of the following signs: redness, warmth, tenderness, pain or swelling [14]. The basic investigations would include a complete blood count- increased white blood cell count indicating infection, creatinine or proteinuria, (renal function), random glucose (as may need to treat hyperglycaemia in sepsis) and

C- reactive protein representing inflammatory marker [1,24]. A foot x-ray would exclude soft tissue gas (gas gangrene), osteomyelitis and Charcot's joints. Isotope bone scan confirms osteomyelitis. Although plain radiographs may be sufficient, magnetic resonance imaging (MRI) being far more sensitive and specific is useful if soft-tissue abscess is suspected or the diagnosis of osteomyelitis is uncertain. Osteomyelitis may be optimally defined by bone culture and histology [9,25,26]. A Duplex ultrasound scan (USS) would assess blood flow to the foot [1,4,14].

Treatment and Management

The main emphasis is on prevention and early recognition as well as treatment. Prevention entails controlling diabetes, smoking, obesity; daily foot checks, removing callosities (neuropathic foot); daily moisturizing; regular toenail cutting, and well fitted footwear [8]. Patients with infection should be told never to omit their insulin dose, even if they are nauseated and unable to eat; instead they should seek urgent medical advice [16]. It is vital that the diabetic condition is urgently controlled; otherwise the vicious circle of infection leading to the instability of the diabetes and ketosis allows the spread of infection. Patients with a severe infection should be hospitalized immediately as these are often imminently limb threatening and, in some cases life-threatening. Most diabetic foot infections require some surgical intervention, ranging from minor (debridement) to major interventions [22,23]. Wounds must also be properly dressed and off-loaded of pressure, and patients need regular follow-up [10,16,27].

Treatment

Neuropathic Foot

Infection is treated with intra-venous antibiotics in hospital and, antiseptics and dressings for ulcers. Necrotic tissue is removed and conservative digital amputations or filleting as required. The surgical approach should optimize the likelihood for healing while attempting to preserve the integrity of the walking surface of the foot. Specialised footwear is used to reduce weight bearing [18].

Ischaemic Foot

Infection is treated by debridement (cleaning the wound, removing pus, dead necrotic tissue and infected bone) [11,12]. Osteomyelitis often require surgical debridement or resection and/or prolonged antibiotic therapy for at least 4 weeks, based on the culture and sensitivity of biopsied bone tissue or curettage of deep tissues [28]. Swab specimens, especially of incompletely debrided wounds provide less accurate results [1,26,28]. In a drier dressing or granuflex promotes granulation. If wound is not easily debrided varidase dressing is used initially [27,29]. As there are usually complex infections, a broad-spectrum intra- venous antibiotic and metronidazole for anaerobes are recommended. Antibiotics can usually be discontinued once the clinical signs and symptoms of infection have resolved usually 1-2 weeks for mild infection and 2-3 weeks for moderate to severe infection, and not until the wound has healed to avoid resistance [19,28]. Skin grafting when no infection is present may be required [10].

Revascularisation

An angiogram and angioplasty or arterial reconstruction to improve blood flow would aid healing [1,13,30]. Because in most cases

ischaemia is secondary to larger vessel atherosclerosis rather than to 'small vessel disease', vessels above the knee and below the ankle tend to be relatively spared [4,5]. Thus lower extremity atherosclerosis can be amenable to angioplasty or vascular bypass [30]. Patients with non-critical ischaemia (ankle/brachial pressure index 0.4-0.9) can in some cases be successfully treated without a vascular procedure [30]. Many centres have reported successful use of both aggressive endovascular interventions and distal bypass procedures for more severe vascular disease of the foot [31]. There is some evidence that failed bypasses result in a higher level of amputations and the combined mortality rate of a failed reconstruction followed by amputation may be higher than a primary amputation. A graft should if possible prevent limb loss for at least 2 years if it is to be considered a success. The 2 year patency rate of distal vascular grafts for experienced vascular units should be in the region of 75%. However, careful debridement of necrotic, infected diabetic foot wound should not be delayed while awaiting revascularization [11,12].

Amputation

Peripheral arterial disease is an independent baseline predictor of the non-healing foot ulcer and along with progressing infection continues to be the main reason for lower extremity amputation [3]. Pre-operative arteriographic studies and ankle pressures are usually unhelpful in the diabetic foot. Transcutaneous oxygen measurements have been found to be very helpful in some units but the apparatus is expensive and the results are not infallible. The patient's symptoms, clinical and radiological (Duplex USS) findings would dictate the need and level of amputation, for example in the poorly - controlled diabetic patient with chronic ischaemia who has failed angioplasty to improve the circulation to the lower limb [13,30,31]. In practice, most surgeons inspect and palpate the ischaemic limb pre-operatively and observe the intraoperative bleeding from the severed blood vessels at the time of surgery. Major amputations are usually below knee. Below- knee amputation is the gold standard and should be attempted if there is a reasonable chance that it will succeed, and that the patient will subsequently learn to walk again. Preserving the knee joint limits disability and facilitates the use of a prosthesis [32,33]. The posterior reconstructive transtibial flap method is frequently used but its disadvantage over the equilateral (skew) flap is the risk of ischaemia in the longer posterior flap [30]. The major problem is stump infection, and so a swab should therefore be taken from infected lesions in the foot so that appropriate antibiotics can be administered. Patients who have a good blood supply down to the foot, but who have either infection or small vessel disease and gangrenous toes simply require a local amputation of the toes, as do those who have had a successful bypass. However, digital amputations are rarely successful [34]. When all or part of a foot has dry gangrene, it may be preferable (especially for a patient who is a poor surgical candidate) to let the necrotic portions auto-amputate. It may also be best to leave adherent eschar in place, especially on the heel, until it softens enough to be more easily removed, provided that there is no underlying focus of infection [33].

Prognosis

The prognosis depends on the problem. Smokers, older patients with longer history of uncontrolled diabetes, and those with gangrenous infections and large ulcers have poorer outcome [35-37]. About 50% of diabetic foot infections who have foot amputations die within five years i.e. a mortality rate similar to some of the most deadly

cancers [38]. It would be interesting to ascertain what proportion is related to the progression of their disease or to the sequelae of the amputation and resulting disability. About half of these amputations can, however, be prevented by proper care [39,40].

Conclusions

Many diabetic foot problems are avoidable. Good glycaemic control and patient's need to learn the principles of foot care, advised concerning appropriate footwear and risks of smoking are essential. Ulcers should not be automatically treated with antibiotics since about half are not infected, and, thus avoid super-infection and development of antibiotic resistance. The main determinant of which patients with a diabetic foot infection need to be hospitalized is the clinical severity of the infection. It is desirable that a vascular surgeon should assess or perform amputations for diabetic foot as the possibility of revascularization must always be considered and the correct sub-group are selected for amputation. The patient should be seen by the rehabilitation team pre-operatively so as to encourage a positive attitude towards remaining mobile and independent if at all possible. Guideline-based care for diabetic foot infections and the employment of multidisciplinary teams improve outcomes, prevent amputations and mortality.

Competing Interests

The authors declare no competing interests

Author's Contributions

Dr Elroy Patrick Weledji is the main author and contributor to the article.

Dr Pius Fokam, an orthopaedic surgeon contributed to the tropical and orthopaedic aspects of the paper.

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