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Complications and risk management of diabetic foot ulcer: A review

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Abstract

The rise in the cases of people affected by Diabetes is exponential in the last decade the disease can be controlled but not completely treated. One of the micro vascular complication of the disease is diabetic foot ulcer. Patients affected with diabetes have foot problems because of damage in nerve and blood vessel. In severe cases or unmanaged conditions these skin ulcers do not mend, or become complicated leading to the extreme cases of amputation of the affected limb. This mini review covers comprehensive but concise topics about the clinical manifestations symptoms, demographics of the disease basic strategies of risk management of diabetic foot ulcer.

Keywords: Diabetic foot ulcer, Risk management, Complications.

Introduction

Diabetes is a very serious disease with numerous health problems. If left unchecked, it can bring serious consequences including death. Fortunately, it is a disease that can be managed but same time most of the people who have diabetes do not know that they have it and hence do not treat it till it becomes very late. It is very important to get prompt professional attention for the determination of the disease and its complications in particular. Diabetes mellitus, often simply referred to as diabetes, is a group of metabolic diseases in which a person has high blood sugar, either because the body does not produce enough insulin, or because cells do not respond to the insulin that is produced. This high blood sugar produces the classical symptoms of polyuria, polydipsia and polyphagia.[1,2] It is a chronic disease with long-term complications, including diabetic macro vascular and micro vascular complications including nephropathy, neuropathy, and retinopathy. One of such longstanding complications involve foot ulcers.[2,3]

People with diabetes are more likely to have foot problems because of nerve and blood vessel damage. Small sores or breaks in the skin may turn into deep skin ulcers if not treated properly. If these skin ulcers do not improve, or become larger or go deeper, amputation of the affected limb may be needed.[4] Diabetic neuropathy is a common complication of diabetes, in which nerves are damaged as a result of hyperglycaemia.

Etiological factors

People with diabetes commonly develop temporary or permanent damage to nerve

tissue. Decreased blood flow and high blood sugar levels becomes the main reasons for nerve injuries and are more likely to develop if blood sugar levels shoot up .Not all affected will develop nerve damage, in a few the symptoms appears early.A symptom usually begins 10 to 20 years after the diabetes diagnosis. Damage to nerve usually occurs in 50% of affected population. Peripheral nerve injuries may affect cranial nerves or nerves from the spinal column and their branches. This type of nerve injury tends to develop in stages.Autonomic neuropathies affect the nerves that regulate vital functions, including the heart muscle and smooth muscles.Not only the nerve injury any mechanical stress on the fringe of the foot, may also cause the rapid tension leading to a sore spot or ulcer. In some cases, the poorly fitting shoes are a common cause of diabetic foot problems. If the patient has red spots, sore spots, blisters, corns, calluses, or consistent pain associated with wearing shoes, new properly fitting footwear must be obtained as soon as possible. If the patient has common foot abnormalities such as flat feet, bunions, or hammertoes, prescription shoes or shoe inserts may be necessary.If poorly controlled, diabetes can lead to accelerated hardening of the arteries or atherosclerosis. When blood flow to injured tissues is poor, healing does not occur properly. Any trauma to the foot can increase the risk for a more serious problem to develop.

Athlete's foot, a fungal infection of the skin or toenails, can lead to more serious bacterial infections and should be treated promptly. Ingrown toenails should be handled right away by a foot specialist. Toenail fungus should also be treated. Smoking any form of tobacco causes damage to the small blood vessels in the feet and legs. This damage can disrupt the healing process and is a major risk factor for infections and amputations. The importance of smoking cessation cannot be overemphasized.[5]

Clinical Manifestation

The General Symptoms[6, 7] that help in the prediction of the appearance of late phase of the diabetic foot ulcer include In Legs and arms: Deep pain, most commonly in the feet and legs; Loss of the sense of warm or cold; Muscle cramps; Numbness (if the nerves are severely damaged); Tingling or burning sensation in the extremities, particularly the feet; General Weakness.

Other symptoms which are common for diabetics include: Dizziness; Drooping eyelid; Drooping face; Drooping mouth; Impotence; Light-headedness when standing up (orthostatic hypotension); Loss of bladder control; Rapid heart rate; Speech impairment; Vision changes. As discussed above specific symptoms cannot be predicted immediately .The symptoms vary depending on the nerves affected and usually develop gradually over years and may include symptoms other than those mentioned earlier. The condition where there is an abnormal and decreased sensation of pain or touch is often termed as diabetic neuropathy, usually it has a 'glove and stocking' distribution starting in the feet later on it affects the fingers and hands. The condition is much more worsened with damaged blood vessels and can lead to diabetic foot. Mon neuritis or autonomic neuropathy is the other forms of diabetic neuropathy. Diabetic amyotrophy on the other hand is muscle weakness due to neuropathy.8

Thus Diabetic foot is a complication often due to a combination of sensory neuropathy (numbness or insensitivity) and vascular damage. It increases the risks of skin ulcers (diabetic foot ulcers) and infection and, in worse cases, it causes necrosis and gangrene. The main reason why diabetics take a longer time to heal wounds is As a result of this, in this developed world it becomes the underlying cause of non-traumatic adult amputation, usually of toes and or feet.

Epidemiology

Globally, diabetic foot infections are the most common skeletal and soft-tissue infections in patients with diabetes. The incidence of diabetic foot infections is similar to that of diabetes in various ethnic groups and most frequently affect elderly patients. There are no significant differences between the sexes.Mortality is not common, except in unusual circumstances. The mortality risk is highest in patients with chronic osteomyelitis and in those with acute necrotizing soft-tissue infections.

Diabetes affects approximately 170 million people worldwide, including 20.8 million in the USA[9], and by 2030 these numbers are projected to double.[10] The foot ulcer is a leading cause of hospital admissions for people with diabetes in the developed world and is a major morbidity associated with diabetes[11], often leading to pain, suffering, and a poor quality of life for patients. Diabetic foot ulcers (DFUs) are estimated to occur in 15% of all patients with diabetes11 and precede 84% of all diabetes-related lower-leg amputations.[12]

Despite the existence of protocols to standardize care, the physiological impairments that can result in a DFU complicate the healing process. Currently, the only FDA-approved growth factor and cell therapies for DFUs are not

routinely used during treatment, preventing professionals from implementing evidence-based protocols.[13]

On a population basis diabetic foot ulcers are a relative rare disease: the prevalence in cross-sectional studies in theUK was 1-2% of the diabetic patient's screened[14, 15] this incidence rises to 5-7% in patients with risk-factors, such as loss of sensation or foot deformities. Foot ulcers and their consequences are associated with major health care consumption and high costs. The costs of amputation and its consequences are even higher, because of the rehabilitation, care in nursing homes, etc. On the longer term costs are probably much higher as diabetic foot ulcers are a recurrent disease, with recurrence rates up to 70% in centres of excellence, resulting in repeated interventions and progressive disability.[16]

Table 1: General facts regarding the Diabetic foot ulcer complications[17]

One in every six people with diabetes will have a foot ulcer during their lifetime
Every year 4 million people with diabetes will develop a foot ulcer
Every 30 seconds a leg is lost due to diabetes somewhere in the world
Foot problems are the most common cause of admission to hospital for people with diabetes
In developing countries foot problems may account up to 40% of health care resources
The direct cost of an amputation is estimated to be between US$ 30,000 and US$ 60,000.
Ulcers can be prevented and up to 85% of amputations can be avoided.

In developing countries it is recognized as a sweeping epidemic. In the Asian sub-continent affecting nearly 25 million in India alone. Recent studies are being conducted to evaluate the clinical and the bacteriological profiles concerning with diabetic foot ulcer different studies assume the context in India where the disease itself is detected late where there is a little awareness of foot care in patient and thus significant delay in pursuing the treatment.

In Indian scenario substantial population being rural, engaged in the field work barefoot leading to amplified chances of further ancillary infections.

In such cases physician will be left with no option than giving an empirical treatment till the cultural reports are ready and available hence further delaying definite treatment

Etiology

Diabetes mellitus is a disorder that primarily affects the micro vascular circulation. In the extremities, micro vascular disease due to "sugar-coated capillaries" limits[18] the blood supply to the superficial and deep structures. Pressure due to ill-fitting shoes or trauma further compromises the local blood supply at the micro vascular level, predisposing the patient to infection, which may involve the skin, soft tissues, bone, or all of these combined.Diabetes also accelerates macro vascular disease, which is evident clinically as accelerating atherosclerosis and/or peripheral vascular disease. Most diabetic foot infections occur in the setting of good dorsalis pedis pulses; this finding indicates that the primary problem in diabetic foot infections is microvascular compromise.Impaired microvascular circulation hinders white blood cell migration into the area of infection and limits the ability of antibiotics to reach the site of infection in an effective concentration. Diabetic neuropathy may be encountered in conjunction with vasculopathy. This may allow for incidental trauma that goes unrecognized (eg, blistering, penetrating foreign body.

Microbial characteristics

The microbiologic features of diabetic foot infections vary according tothe tissue infected. In patients with diabetes, superficial skin infections, such as cellulitis, are caused by the same organisms as those in healthy hosts, namely group a *Streptococci* and *Staphylococcus aureus*. In unusual epidemiologic circumstances, however, organisms such as *Pasteurella multocida* (eg, from dog or cat bites or scratches) may be noted and should always be considered. Group B *Streptococcal cellulitis* is uncommon in healthy hosts but not uncommon in patients with diabetes. In diabetic individuals, group B *Streptococci* may cause urinary tract infections and catheter-associated bacteriuria in addition to cellulitis, skin and/or soft-tissue infections, and chronic osteomyelitis. Such infections may be complicated by bacteremia.

Furthermore, as previously mentioned, deep soft-tissue infections in diabetic persons can be associated with gas-producing, gram-negative bacilli. Clinically, these infections appear as necrotizing fasciitis, compartment syndrome, or myositis. Gas gangrene is uncommon in persons with diabetes. Acute osteomyelitis usually occurs as a result of foot trauma in an individual with diabetes. The distribution of organisms is the same as that in an individual without diabetes who has acute osteomyelitis. In chronic osteomyelitis, however, the pathogens include group A and group B streptococci, aerobic gram-negative bacilli, and Bacteroides fragilis. Other pathogens implicated in chronic osteomyelitis in patients with diabetes include *B. fragilis*, *Escherichia coli*, *Proteus mirabilis*, and *Klebsiella pneumoniae*. *Pseudomonas aeruginosa* is generally not a pathogen in chronic osteomyelitis in these individuals. Although *P. aeruginosa* is frequently cultured from samples obtained from a draining sinus tract or deep penetrating ulcers in patients with diabetes, these organisms are superficial colonizers and are generally not the cause of the bone infection. Because *Pseudomonas* organisms are water-borne, superficial ulcers may be contaminated by bacteria in wet socks or dressings. Fetid foot represents a combined deep-skin and soft-tissue infection caused by pathogens involved in chronic osteomyelitis.

Diabetic Foot Care Symptoms

Persistent pain can be a symptom of sprain, strain, bruise, overuse, improperly fitting shoes, or underlying infection. Redness can be a sign of infection, especially when surrounding a wound, or of abnormal rubbing of shoes or socks. Swelling of the feet or legs can be a sign of underlying inflammation or infection, improperly fitting shoes, or poor venous circulation. Other signs of poor circulation include the following:

Pain in the legs or buttocks that increases with walking but improves with rest (claudication) Hair no longer growing on the lower legs and feet hard shiny skin on the legs

Localized warmth can be a sign of infection or inflammation, perhaps from wounds that won't heal or that heal slowly. Any break in the skin is serious and can result from abnormal wear and tear, injury, or infection. Calluses and corns may be a sign of chronic trauma to the foot. Toenail fungus, athlete's foot, and ingrown toenails may lead to more serious bacterial infections. Drainage of pus from a wound is usually a sign of infection. Persistent bloody drainage is also a sign of a potentially serious foot problem. A limp or difficulty walking can be sign of joint problems, serious infection, or improperly fitting shoes. Fever or chills in association with a wound on the foot can be a sign of a limb-threatening or life-threatening infection.Red streaking away from a wound or redness spreading out from a wound is a sign of a progressively worsening infection. New or lasting numbness in the feet or legs can be a sign of nerve damage from diabetes, which increases a person’s risk for leg and foot problems.

Biomechanics

Complications in the Diabetic foot and foot-ankle complex are wider and more destructive than expected, and function of several systems: vascular, nervous, somatosensory, musculoskeletal. Thus, a deeper comprehension of the alteration of gait and foot biomechanics in the Diabetic foot is of great interest, and may play a role in the design and onset of preventive as well as therapeutic actions effect of diabetes on the main structures of foot-ankle complex can be summarised in general category as following

Effects on skin: skin – and the soft tissues immediately underneath the skin - undergoes to greater compressive and shear loading than usual, thus explaining from a mechanically point of view the onset of tissue damages so deeply correlated to traumatic ulceration processes. Besides this, skin of the Diabetic foot suffers from loss of autonomic control and a consequent reduced hydration, which renders it less elastic and thus more vulnerable to the action of increased mechanical stress.[19, 20]

Effects on tendons and ligaments: protein glycosylation and the consequent collagen abnormalities entail greater transversal section – i.e. thickening - of tendons and ligaments, and, reasonably, greater coefficient of elasticity. Particularly interested by this process are Plantar Fascia and Achilles tendon. Both causes lead to an increased stiffness of those structures.

Effects on cartilage: similar to what happens to tendons and ligaments, cartilage changes its composition mainly due to the modification of collagen fibres; this increases its stiffness and represents an obstacle in the performance of physiological range of motion of each and every foot and ankle joint.

Effects on muscles: Diabetes mellitus entails a severe damage to nerve conduction, thus causing a worsening in the management of the related muscle fibres; as a consequence, both intrinsic and extrinsic muscles of the

foot-ankle complex are damaged as for structure (reduction of muscle volume) and function (reduction of muscle strength).[21, 22]

Effects on peripheral sensory system: nerve conduction degeneration has a dramatic effect on the peripheral sensory system, since it leads to loss of protective sensation under the sole of the foot. This exposes the Diabetic foot to thermal or mechanical trauma, and to the late detection of infection processes or tissue breakdown.

Effects on foot morphology (deformities): due to most of the above alterations, a significant imbalance of peripheral musculature and soft tissue does have place in the foot which seriously alters its morphology and determines the onset of foot deformities; most common deformities of the Diabetic foot are represented by a high longitudinal arch (rigid cavus foot), hammer toes and hallux valgus. A completely different morphologic degeneration is represented by the Charcot foot, whose analysis is not part of this discussion.[23, 24]

Diagnostics of Diabetic foot ulcer

There are certain general as well as confirmatory tests for Diabetic foot ulcer just like any other disease. The Medical evaluation[24] should include a thorough history and physical examination and may also include laboratory tests, x-ray studies of circulation in the legs, and consultation with specialists.

History and physical examination: First, the physician enquire patient about their symptoms and will examine them. This examination should include the patient's vital signs (temperature, pulse, blood pressure, and respiratory rate), examination of the sensation in the feet and legs, an examination of the circulation in the feet and legs, a thorough examination of any problem areas. For a lower extremity wound or ulcer, this may involve probing the wound with a blunt probe to determine its depth. Minor surgical debridement of the wound (cleaning or cutting away of tissue) may be necessary to determine the seriousness of the wound.

Laboratory tests: A complete blood cell count, or CBC, which will assist in determining the presence and severity of infection. A very high or very low white blood cell count suggests serious infection.Checking of the patient's blood sugar either by finger stick or by a laboratory test. Depending on the severity of the problem, kidney function tests, blood chemistry studies (electrolytes), liver enzyme tests, and heart enzyme tests to assess whether other body systems are working properly in the face of serious infection.

X-rays: X-rays studies of the feet or legs to assess for signs of damage to the bones or arthritis, damage from infection, foreign bodies in the soft tissues. Gas in the soft tissues, indicates gangrene - a very serious, potentially life-threatening or limb-threatening infection.

Ultrasound: Doppler ultrasound to see the blood flow through the arteries and veins in the lower extremities. The test is not painful and involves the technician moving a non-invasive probe over the blood vessels of the lower extremities.

Consultation: Vascular surgeon, orthopedic surgeon, or both to examine the patient. These specialists are skilled in dealing with diabetic lower extremity infections, bone problems, or circulatory problems.

Angiogram: If the vascular surgeon determines that the patient has poor circulation in the lower extremities, an angiogram may be performed in preparation for surgery to improve circulation.With an angiogram, a catheter is inserted through the artery in the groin and dye is injected while x-rays are taken.

This allows the surgeon to see where the blockages are and plan an operation to bypass the blockages. This procedure is usually performed with local anaesthesia and a light sedative given through a tube inserted in the patient's vein (an intravenous or IV line).

Table 2: Clinical Manifestations of Infection

Clinical Manifestations of Infection	IDSA severity	Pedis Grade
No signs of infection	Uninfected	1
Presence of >2 manifestations of inflammation (purulence, or erythema, pain, tenderness, warmth, or induration), But any cellulitis/erythema extends <2 cm around the ulcer, and infection is limited to the skin or superficial subcutaneous tissues; no other local complications or systemic illness.	Mild	2
Infection (as above) in a patient who is systemically well and metabolically stable but which has >1 of the following characteristics: cellulitis extending >2 cm, lymphangitic streaking, spread beneath the superficial fascia, deep-tissue abscess, gangrene, and involvement of muscle, tendon, joint or bone	Moderate	3
Infection in a patient with systemic toxicity or metabolic instability (e.g., fever, chills, tachycardia, hypotension, confusion, vomiting, leukocytosis, acidosis, severe hyperglycemia, or azotemia)	Severe	4

Diabetic foot ulcer management

Treatment of foot ulcer involves close monitoring of several conditions that may be causing it. The oxygen levels in the skin of patients with peripheral vascular disease, for example, are closely observed. Diabetics are urged to quickly consult a physician at the first sign of abnormality in the feet. Patients with foot ulcer may also be required to quit smoking (if they are smokers) and change lifestyle habits that contribute to the condition. Most physician advice patients to exercise not only to improve circulation of blood in the feet, but also to help decrease cholesterol levels in the blood and control blood sugar levels. Patients are also advised to switch to cushioned shoes or other prescription footwear.

People who have had foot pressure ulcers are at a high risk of more skin breakdown in the future, possibly throughout his or her lifetime. Healthcare professionals usually extend self-care training to such patients. They are taught how to prevent and manage foot ulcer, monitor their blood sugar levels, inspect their feet at a regular basis, and also control.

Recently advances in management include bio surgery. Biosurgery[25] uses the larvae of the green bottle fly (*Lucilia sericata*) to debride selectively any sloughy tissue without attacking healthy granulation tissue.

Patients with diabetes must be careful to avoid foot trauma and to properly care for their feet to minimize the possibility of infection. In addition, they must understand that chronic osteomyelitis cannot be cured with antibiotics alone and that adequate surgical debridement is necessary.

Patients who are unwilling to undergo the surgical procedure must understand the long-term complications of chronic osteomyelitis. They should be advised that if the infection is not adequately treated with sufficient surgical debridement and/or amputation, systemic complications, including bacteremia and/or systemic infection, amyloidosis, and squamous cell carcinoma at the affected site, may occur over time.

Long-term suppressive therapy may decrease the incidence of septic complications, but it does not affect the long-term complications, which may include amyloidosis or squamous cell carcinoma at the drainage site.

Diabetic foot infections require attention to local (foot) and systemic (metabolic) issues and coordinated management, preferably by a multidisciplinary foot-care team the team managing these infections should include, or have ready access to, an infectious diseases specialist or a medical microbiologist and competent pharmacist.

Algorithmic approach to treating a diabetic patient with foot ulcer (Figure 1-3).[26]

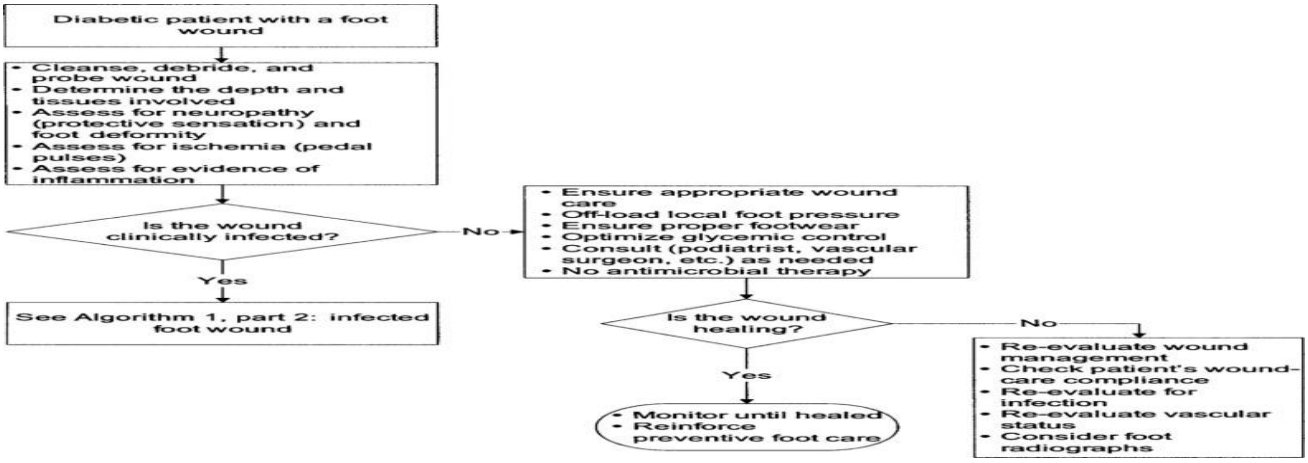

Figure 1: Depicts approach treating a patient with foot ulcer

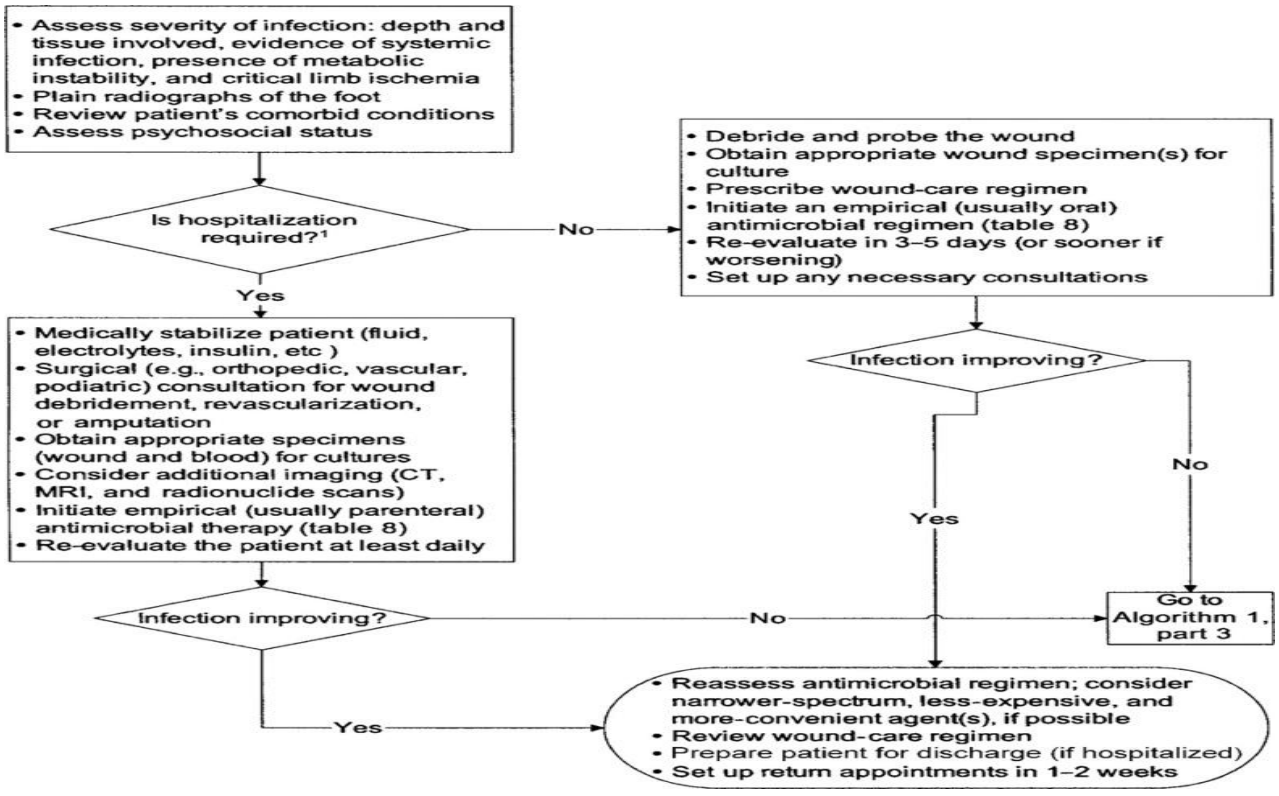

Figure 2: Depicts considering hospitalization

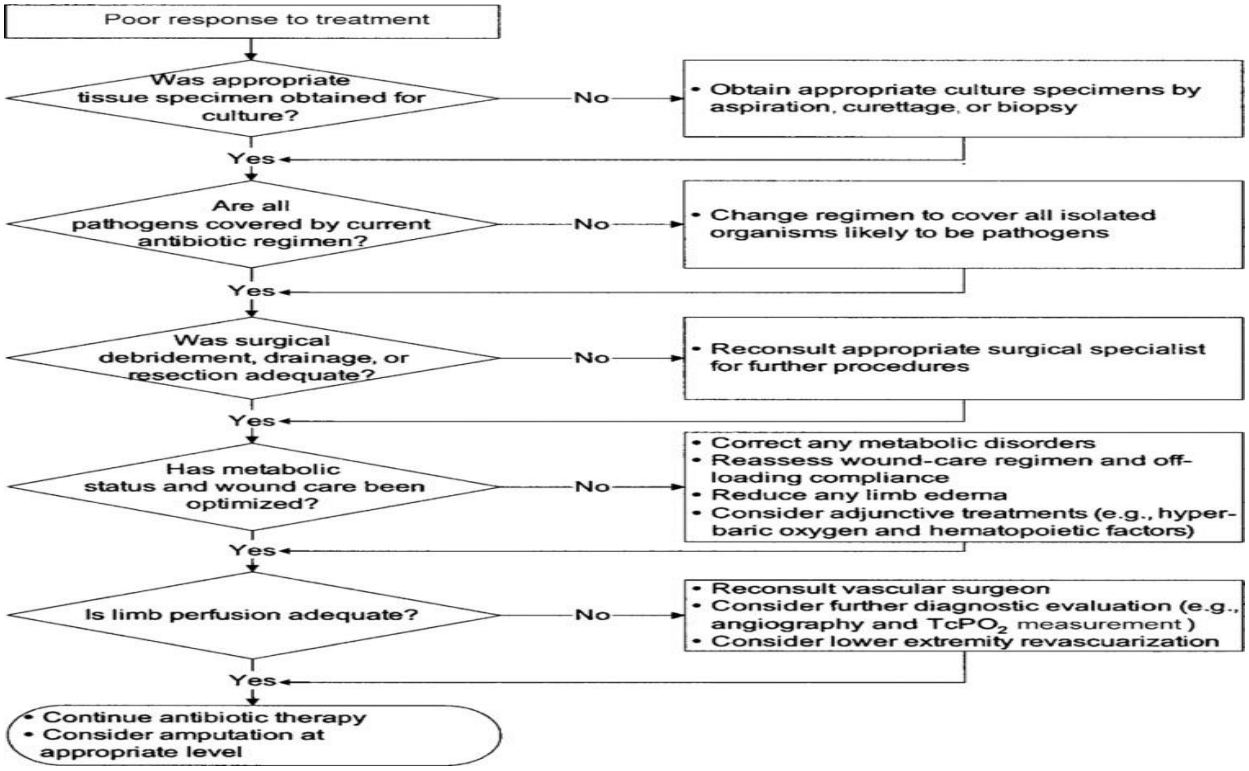

Figure 3: Depicts diabetic patient with a foot infection who is not responding well to treatment

Conclusion

Diabetes is a condition that can be sustained such that the effect can be minimized by management. The future prospective in the therapy can be in personalization of medicine required for an individual patient which in turn controls the problem of foot ulcer by variant therapies and life style modification increasing health related quality of life thus by preventing the severity of diabetic foot ulcer.

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