DIAGNOSTIC AND THERAPEUTIC CHARACTERISTICS IN THE APPROACH OF DIABETIC FOOT IN THE ELDERLY.

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Abstract

This article systematically evaluates the most used diagnostic measures for the management of diabetic foot in the elderly, the decision making in the surgical approach, the tertiary prevention of the disease and the microbiological behavior. The initial diagnostic study for musculoskeletal infections and alterations is conventional radiography (sensitivity 40-75%, specificity 60-90%), computed tomography is more useful in the approach to chronic infection, assessing bone abductions and deformities. Magnetic resonance (sensitivity 100%, specificity 40%) is useful to assess the formation of abscesses and bone compromises.

Decision-making in the surgical approach is due to sensory, motor or mixed neuropathy; which predispose to ulcers, fractures, deformities and fissures of the skin; lesions that are overinfected and must be operated on. Infections in elderly people with diabetic foot show that *Staphylococcus Aureus* is the main pathogen causing osteomyelitis. Beta-hemolytic Streptococci / *S. Aureus*, in patients with cellulitis, without open cutaneous wound, except in repeated mono microbial cultures, immunosuppressed patients or ulcers that do not respond to treatments. The diagnosis and treatment of diabetic foot continues to be a challenge for the health system; it is important that health institutions form interdisciplinary groups aimed at improving patient conditions, who must perform

timely, adequate treatment, with routine monitoring and follow-up; using diagnostic methods throughout the course of the disease in order to reduce the need for amputations of the extremities.

Keywords: Therapeutic approach, Diabetic Foot, osteomyelitis.

Introduction:

Diabetes mellitus (DM), is nowadays understood as a set of diseases characterized by chronic hyperglycemia, resulting from defects in insulin secretion, insulin action or both, and in other cases multihormonal defects as a cause of epigenetic effects (DNA methylation, histone modification, and microRNAs) (1). DM is a public health problem worldwide, with a worldwide prevalence of 8.3% (2). In Colombia, the prevalence is 7, 2%, with approximately 29,989,290 inhabitants between 20 and 79 years, generating 15 deaths per 100,000 inhabitants, where it represents the fifth cause of death for 2010 (3).

Among the major complications of DM, which generate more disability in patients, is the diabetic foot (4). The prevalence of this complication is between 8% and 13%; The most affected population is between 45-65 years old and the incidence of amputations in diabetic patients is between 2.5-6.0 per 1000 patients per year (3). Diabetic neuropathy is one of the most destructive complications that can affect up to 60% of diabetics; if it is not detected early, it will be a risk factor for the production of ulcers, infections or amputations (4). The risk of death in patients with diabetic foot is 2.5 times more than the diabetic who does not develop diabetic foot in the course of their disease. Approximately 20% of patients who develop recurrent infections reach some degree of amputation. This type of complications leads to mortality of patients after an amputation is greater than 70% in the following 5 years (5).

In the integral therapy of diabetic foot patients in developed countries, diabetic foot without complications can be achieved up to 77% in the first year. Despite this; Recurrence is very common, reaching 40% in the first year, 60% at 3 years and up to 65% in the first 5 years. Determining these changes early generates a

significant impact factor in reducing the development of ulcers and the risk of amputation. A large number of these factors are associated with deterioration of the blood flow of the extremities, either by the development of glycozilation products that generate alteration of the vasa vasorum and vasa nervorum or by the formation of neovascularization of poor quality by hypoxia. To develop early diagnosis measures in addition to a clinical history focused on the patient with diabetic complications, causes a more cost-effective intervention impact by reducing the number of recurrences in the development of ulcers and improves the effect of adherence to the integral treatment of these patients and their inclusion in activities of daily life.

DM and its vascular complications increase with the passage of time of its natural history, being of greater incidence in the older adult. Due to the above, it is necessary to diagnose earlier changes in the skin of patients and vascular damage through diagnostic tests to develop better intervention programs, decreasing recurrence of ulcers and amputation in the elderly. In the systematic search of the literature, there are no publications that show what are the diagnostic and therapeutic characteristics that lead to the decision making of specialists in the therapeutic approach of these patients; likewise, neither the surgical characteristics that determines the management for the short and long term control of diabetic foot complications. This article systematically evaluates which diagnostic measures are most used for the treatment of this disease in the elderly. Likewise, it evaluates what is the microbiological behavior in this disease and the decision making in the surgical approach in the tertiary prevention of the disease

Methodology

A systematic search was carried out with the following search engine and Boléan operators: ("Diabetic Foot / classification" [Mesh] OR "Diabetic Foot / Problems" [Mesh] OR "Diabetic Foot / diagnostic imaging" [Mesh] OR "Diabetic Foot / diet therapy "[Mesh] OR" Diabetic Foot / drug therapy "[Mesh] OR" Diabetic Foot / epidemiology "[Mesh] OR" Diabetic Foot / mortality "[Mesh] OR" Diabetic Foot / prevention and control "[Mesh] OR "Diabetic Foot / statistics and numerical data" [Mesh] OR "Diabetic Foot / surgery" [Mesh] OR "Diabetic Foot / therapy" [Mesh]). Articles were excluded in languages other than English and Spanish, research on persons under 18 years of age, and where the published topic did not take into account the objectives of this article. A critical analysis of the available evidence was carried out both in indexed databases and in gray literature.

Pathophysiology

Osteomyelitis in the elderly can be acute, subacute or chronic, being the acute in less than 2 weeks, the subacute between 2 weeks and 3 months, and the chronic greater than 3 months. The bone could be compromised in several ways.

Hematogenous spread, soft tissue extension and direct inoculation by trauma. The mechanism by which the hematogenous spread develops a predominant active phase, is due to the prominent vascularization of the metaphysis, which in the older adult that develops alteration in the vasa vasorum is generally interrupted. Reason for which, generates that this type of patients develop a more subacute and chronic period with greater bone and vascular complications. Within these periods, if the patient presents an adequate glycemic control they generate a localized infection inside the bone called Brodie's abscess. However, when the infectious process is located in a portion of the bone and is separated from normal bone it is known as bone sequestration, requiring surgical management. The sclerotic cavity surrounding the bony sequestration is called osseous implication. If the latter communicates with the soft tissues, it is recognized as a cloaca and worsens the prognosis of elderly patients with diabetic foot (6). All these alterations are related to the structural pathology that is triggered in Charcot's osteopathy. However, it has a different anatomical predilection (Diagram).

Diagram. Pathophysiology of osteomyelitis.

1. Brodie's abscess 2. Bone sequestration 3. Osseous implication 4. Cloaca. Charcot osteopathy with greater commitment in shaded area (midfoot). Osteomyelitis with greater involvement in Talus, metatarsal # 1 and # 5, Distal phalanges. Diagram made by William A. Prada M.

Diagnostic characteristics

In order to develop an adequate diagnostic approach, a patient-centered clinical history focused on the duration of the disease, glycemic control and the evaluation of other complications that may be related to diabetic foot should be taken into account. Also, the clinical history should be directed towards the affected foot, focused on the evaluation of the wounds, the skin and the musculoskeletal

system. In the vascular evaluation, the examination directed to the most affected system (femoro-popliteo-tibial) is crucial for the diagnosis, and a non-invasive and / or invasive vascular study is mandatory.

The diagnostic approach can be divided into the study of infection, osteomuscular alteration and vascular evaluation for an adequate diagnostic approach of Charcot neuroarthropathy according to the Eichenholtz classification (Table 1).

Table 1: Classification of Eichenholtz

Stage	Presentation
0: patient at risk	Diabetic neuropathy and acute injury. Image: normal
I: fragmentation	Erythema, edema. Image: bone fragmentation.
II: coalescence	Improvement of erythema and edema. Image: Coalescence of the fragments.
III: consolidation	No erythema or edema. Image: Consolidated fractures

Source: Eichenholz. S.N. Charcot joints. Charles C. Thomas, (1966). (6,7)

For the study of the first two entities, conventional radiography is established as the first measurement, where the earliest sign of osteomyelitis is bone demineralization. Generally, accompanied by thickening of the soft tissues and alteration of the fatty planes (figure 1a, 1b) (7). The computed tomography has greater utility in the approach of chronic infection, evidencing classically the bone sequestration, additionally, it has utility in the assessment of the bone deformity. In acute disease, tomography has greater limitation in the assessment of initial edema, because most diabetic elderly patients have established kidney disease, the risk of the use of contrast means that the use is increasingly limited (8, 9).

Figure 1a: Anteroposterior radiograph of the left foot with evidence of decreased interphalangeal space of finger 2 and 3, with presence of soft tissue edema and alteration of the fatty plane.

Figure 1b: Lateral radiograph of the left foot with evidence of extensive proximal and distal vascular calcifications.

Magnetic resonance imaging is the modality with the highest diagnostic performance, because it allows categorizing the disease in initial stages, where other modalities are limited (10, 11). The use of contrast improves diagnostic performance in the evaluation of T1-weighted sequences. However, it can cause systemic nephrogenic fibrosis with greater probability in the elderly (12). The most recommended additional sequence to images enhanced in T1 and T2 is the STIR or Fat Sat sequence (fat saturation), which allows the evaluation of abscess formation and bone involvement (Figure 2a, 2b) (13). The use of imaging techniques by nuclear medicine allows obtaining an accurate diagnosis for the metabolically active area where the infection is occurring (table 2). Its clearest indication due to its high cost is when the magnetic resonance is contraindicated (7).

Figure 2: Magnetic resonance imaging.

Figure 2a, 2b, 2c: Magnetic Resonance Imaging with paramagnetic contrast medium. T1-weighted images with fat suppression evidenced in axial, coronal and sagittal sections of the left foot, bone edema of the proximal and distal phalanges of the second finger.

Table 2: Accuracy of the different diagnostic modalities

Diagnostic test	Sensitivity (reference)	Specificity (reference)	Positive Predictive Value (reference)	Predictive value Negative (reference)
X Ray	40-75% (15)	60-90% (11)	60% (16)	88% (16)
Magnetic resonance imaging	100% (10)	40% (17)	56% (16)	97% (16)
Nuclear medicine	97,6% (18)	92,6% (18)	60% (16)	88% (16)
Doppler	80-90% (19)	97-100% (19)	94-100% (19)	83-93% (19)

The peripheral vascular assessment of the diabetic patient allows us to assess in a better way what is the real risk status of the diabetic foot. Although 50% of patients with foot ulcers have arterial alterations, knowing the state of peripheral vascular perfusion in asymptomatic patients allows improving the therapeutic

approach in the elderly, since in them the risk and the arterial alteration is much greater (14). Ultrasound with Doppler assessment allows assessing the anatomy and vascular flow of the circulation of the lower limb, being easier due to accessibility for the patient, relatively more accessible cost than angiotomography or angioresonance and the real-time assessment of

the flow and its alterations. It is established that in the Doppler assessment, a peak flow velocity ratio greater 2 indicates a stenosis > 50%. The main drawback of ultrasound will always remain the dependence of the operator and the anatomical alterations of the patients as in the case of obese patients (Diabesity) (14).

Despite the excellent accuracy presented by the different imaging modalities, the reference standard for vascular diagnosis continues to be invasive methods with digital subtraction by angiography, which allows us to assess arterial circulation completely with 3D reconstruction with contrast administration (14).

Therapeutic characteristics

According to the above, a general concept of some therapeutic characteristics of the diabetic foot will be given where ulcers arise as a first physical appearance, which can be of neuropathic origin representing 70%, vasculopathic 20% and of mixed origin 10%; About 85% of diabetics are amputees after presenting ulcers (20-23). Some of the clinical characteristics of these patients show in their vascular signs: cold feet, intermittent claudication, pain at rest, cooling, acrocyanosis, absence of pulses in the pedis or tibial artery; neurological disorders such as paresthesias, anhidrosis, muscular weakness, loss of tactile, vibratory and thermal sensibility, decrease of the aquiline reflex, and muscular atrophy. Some patients present biomechanical variations of the foot such as dig foot, claw toes, or Charcot arthropathy.

There are three important classifications for diagnosis and treatment of diabetic foot ulcers, the Meggitt-Wagner scale defines the ulcer as superficial, deep, with abscess or gangrene; the Classification of the University of Texas that classifies it in pre ulcers, ulcers with infection, ischemia or ischemia and infection; and pedis classification, which measures perfusion, extension, depth, infection and sensitivity (20). In our country, the most known and used is the Magita-Wagner classification.

The risk factors associated with amputation have a higher incidence in men older than 60 years without glycemic control and the prolonged duration of DM. Minor surgery procedures that include nail ablations, debridement of abscesses, and surgical cleanings are defined as conservative treatment. The amputation is the radical surgical treatment which depends on the extension of the necrosis, inflammation or infection; also, of the assessment of the vascular status of the lower limbs of the patient (22).

There are two basic types of amputation: the minor amputation that corresponds to those performed below the ankle and the larger amputation that belongs to those performed above it. Sometimes a major amputation is performed as a result of infection of the lower limb to control general sepsis or abscesses of the deep compartments with extensive gangrene of the forefoot or loss of soft tissues impossible to reconstruct. The increase of morbidity and mortality in major amputations in the diabetic foot has as a choice the conservative procedures that preserve the limb, although patients with critical ischemia or gangrenous with failure in the antibiotic treatment are made angiographies and hemodynamic measurements to determine if it is possible to revascularize them (22,24).

Treatment of diabetic foot

Establishing an appropriate and timely treatment plan for this type of complication usually becomes a therapeutic challenge; in a plantar ulcer, the total contact plaster is the discharge method that has demonstrated the rapid healing of plantar ulcers by diabetic neuropathy, is indicated in the treatment of plantar ulcers with Meggitt-Wagner I-II classification (25,26). The therapeutic objective is to reduce excessive mechanical stress on the plantar surface at the site of the ulcer at the time of walking by 84% to 92% (27,28).

In this treatment an immobilization is performed with an adequately padded and molded plaster, protecting the areas of bony prominence and including in the immobilization the joints, allowing the support of the involved limb once

the plaster has set; Indications include grade I-II foot ulcers in the presence of sensitivity alterations and acute or subacute Charcot osteoarthropathy. Absolute contraindications include deep ulcers with active infection or grade III, IV or V ulcers (29, 30).

The skin lesions of the diabetic foot are susceptible to colonization and infection, an adequate physical examination allows to establish if it is a local or systemic process and if the commitment is superficial or deep, as well as the commitment of bony structures (31). The infection is usually located in the forefoot and plantar ulcers.

The treatment in this condition is directed to the control of the infectious process, and the initial treatment will be a debridement of the lesion, to remove the total thickness of necrotic tissue, foreign material and the hyperkeratosis that can surround the ulcer, until obtaining clean tissue with greater healing potential.

Deeper lesions with purulent collections require more extensive debridement with drainage from the collection and in fulminating soft tissue infections such as gas gangrene, which requires urgent debridement with resection of all the involved tissue. While performing surgical procedures for the control of the infectious process, the patient must receive intravenous antibiotic treatment.

Other therapies that may be useful in the control of infection in the diabetic foot are the recombinant factor of granulocyte colony stimulation (27), which has been shown to reduce the rates of amputation or other surgical procedures; with hyperbaric oxygen, what is sought is to increase the availability of oxygen in the ischemic tissue, favoring the control of infection, the healing of ulcers and revascularization (angioplasty - bypass) (33).

Taking into account deformities of the tissues as a predisposing factor so that pressure ulcers appear and these in turn can be over infected, once these are identified, different surgical procedures can be performed such as correction

of hallux valgus, correction of claw joints , to improve the anatomy, the alignment of the foot and improve these areas of pressure. (30), these treatments are accompanied in recent years by negative pressure therapies (vac therapy) such as drainage systems that aid in the granulation and control of infections (37, 38).

Microbiological behavior

The cutaneous affection is the first manifestation of diabetes, they express biochemical imbalances such as glycozilation of proteins, vascular, neurological and immune alterations. (39-41) Diabetic foot occurs as a set of syndromes in which due to the existence of neuropathy, ischemia and infection tissue alterations or ulcers secondary to micro trauma occur, leading to a high morbidity that may conclude in amputations (42). With the breaking of the protective layer of the skin, the deep tissues are exposed to bacterial infection progressing rapidly (43). It is important to clarify that the presence of microorganisms does not necessarily mean infection which can be defined when at least the presence of a purulent exudate and two signs or symptoms of inflammation: tumor, blush, heat and pain, hence the difference between colonization and infection. Given that the first would not require treatment, it is necessary to obtain the sample properly, which is sent to the microbiology laboratory (44).

Diabetic foot infection is the most common cause of amputation of the lower limb in the general population and of decreased quality of life in diabetics. 15% of diabetics will suffer a foot infection throughout their lives, which in 80% of cases is preceded by an ulcer on the foot. Foot infections are also one of the fundamental causes in the hospitalization of elderly diabetic patients; the "superficial infection" is conditioned to the skin and subcutaneous tissue, while the "deep infection" involves invasion of the fascia, muscle, joint or bone. Currently, the management of this type of infection is conditioned by the antimicrobial resistance and the different surgical procedures that can be carried out during its treatment (38).

According to studies on infections in older adults with diabetic foot show that *Staphylococcus Aureus*, is the main pathogen causing osteomyelitis, if this microorganism occurs in an ulcer, this has a 25% chance of infecting soft tissues and adjacent bone structures, which can trigger an amputation. On the other hand, Beta-haemolytic *Streptococci* / *S. Aureus* are found when the patient presents cellulitis, without open cutaneous wound, except in repeated mono microbial cultures or immunosuppressed patients or ulcers that do not respond to treatments. *Pseudomonas aeruginosa* is one of the five most common pathogens, sometimes

accompanied by other microorganisms. Finally, Microbial Poly ulcers are colonized by Gram-positive cocci, Gram-negative and anaerobic bacilli, evidencing signs such as foul-smelling foot, bad smell, necrosis and gangrene. It is concluded that the most frequent microorganisms in elderly patients with diabetic foot are Beta-hemolytic *Streptococcus*, *S. Aureus*, Enterobacteria and *Pseudomonas*. Each of the microorganisms that were identified presents different signs and symptoms that, according to their complexity, range from cellulitis to gangrene (Table 3) (39, 46, 47)

Table 3: Microorganisms and consequences.

S. Aureus	One of the main causes of osteomyelitis, if there is ulceration and there is this microorganism, can reach an amputation.
Beta-hemolytic streptococci / S. Aureus	Cellulitis, without open cutaneous wound.
Beta-hemolytic streptococci / S. aureus / Enterobacteria	They are usually found in chronic ulcers or ulcers previously treated.
<i>Pseudomonas Aeruginosa</i>	They are present in macerated ulcers.
Microbial Poly Ulcers: Gram-positive cocci, gram-negative and anaerobic bacilli	Foul foot, bad smell, extensive necrosis and in some cases gangrene.

Source: Valderrama KG. Infectious Microorganisms in Patients with Diabetic Foot. Current Research Seedbed.2017.

Mycotic infections are common in the diabetic patient: chronic candidiasis paronychia, intertrigo by candida, interdigital infections especially in the third and fourth space that is favored by humidity, another affected area is the nail plate of the toes, infections by dermatophytes are given by low immunity or by favoring environmental conditions. In ulcers that do not heal or in surgical wounds, infections with phycomycetes occur. (41) Acute infectious comorbidity also increases with age in patients with diabetes mellitus and diabetic foot, affecting the skin and soft tissues, among the most frequent injuries are: cellulitis, necrotizing fasciitis and impetigo. (48). The choice of

antibiotics depends mainly on causal pathogens. However, in most cases antibiotic treatment must be started before having laboratory results that indicate against which microorganism we are facing. For this reason, initial therapy is usually empirical and is based on local epidemiological information. The choice of antibiotic and the route of administration should reflect the severity of the infection (49, 50).

Conclusions

The incidence of diabetic foot and its complications in the elderly continues to increase every year despite the diagnostic and therapeutic measures currently being proposed. Therefore, the therapeutic approach of the elderly with diabetic foot continues to be a great challenge for the health system in Latin America. It is important for health institutions to form

multidisciplinary groups that allow patients with risk factors to be recognized and generate public health measures for the comprehensive care of these patients. Within the primary prevention approach, the participation of trained primary care physicians means that these patients can have non-invasive diagnostic studies and can be intervened early by the attending physician, generating fewer and fewer complications and improving the quality of life of these patients. Finally, it is important to know the epidemiology of the bacterial flora of each institution, so that the antibiotic treatment is directed. Likewise, knowing the diagnostic and therapeutic tools for this type of population that has a higher life expectancy will be able to generate primary and secondary prevention policies.

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