Trends in Medical Research, 2010
ISSN 1819-3587

Different Procedures in Management of Diabetic Foot Infections

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Abstract: This study was conducted to evaluate different procedures in management of diabetic foot infection. Once infection is suspected, aggressive medical and surgical management is instituted. Patients eligible for the study were outpatients followed in the period from January 2003 to the end of 2009. The 776 patients, those included in the study, were followed for a median of 3.3 years (0-6 years). Study subjects were predominantly men (78.2%) and with a median age of 65 years (range of 28-91 years). A total of 93% of patients had type II diabetes and 47% of those were treated with insulin. The median duration of diabetes was 9 years. There were no lower-extremity amputations of any level in stage A (non-infected-non-ischemic) and stage B wounds, regardless of depth. Patients presented in stages C and D had significantly lower Ankle\Brachial Indices (ABIs) than those in non-ischemic stages A and B. Furthermore, significantly more of the patients in ischemic stages had non-palpable pulses. Conservative measures, in a group of patients; were successful without amputation. Present study has confirmed the effectiveness of existing interventions in the management of diabetic foot complications. Each of these interventions, when used appropriately results in excellent outcome and reduce the risk of foot ulceration and with it the risk of amputation.

Key words: Diabetic foot, surgical management, ankle, foot-sparing amputation, magnetic resonance imaging

INTRODUCTION

Diabetes is a systemic disease that may affect numerous organ systems and anatomic sites. In the foot and ankle vascular disease, tendinopathy, neuropathic disease and infection are common sequellae (Morrison and Ledermann, 2002).

Diabetic foot disease has a significant economic impact; (Holzer *et al.*, 1998; Reiber *et al.*, 1998). Diabetes affects approximately 15 million people in the United States alone (Boulton and Vileikyte, 2000). Of these, an estimated 15 to 20% suffer a foot-related complication requiring hospitalization (predominantly for ischemia or infection) at some point in their lives (Smith *et al.*, 1987). These complications may necessitate amputation; diabetes is the main reason for non-traumatic lower extremity amputation, which is 15 to 40 times more common than in non-diabetics; (Humphrey *et al.*, 1994; Most and Sinnock, 1983). In addition to decreased quality of life; (Pell *et al.*, 1993). It has been shown that after pedal amputation

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there is a 50% incidence of serious complication involving the contra-lateral foot within 2 years, resulting in a 50 to 66% (Goldner, 1960; Hoar and Torres, 1962), incidence of amputation within 5 years. As a result, over the past decade there has been increasing emphasis on managing these patients earlier in their disease course; (Apelqvist and Larsson, 2000) these interventions include ulcer prevention (Lavery and Gazewood, 2000; Sumpio, 2000) and care and revascularization procedures.

Epidemiologic studies have demonstrated that foot and ankle injuries account for 25% of athletic injuries (Berquist, 1992) and that ankle injury alone account for 26.5% of all sports injuries in school-aged children (Backx *et al*., 1989). Sports-related foot injuries have also become an increasingly recognized problem.

Once infection is suspected, aggressive medical and surgical management is instituted (Holstein and Sorensen, 1999; Karchmer and Gibbons, 1994; Pinzur, 1999; Tan *et al*., 1996). MRI facilitates the surgical approach used, not only to diagnose infection but also to determine preoperatively the extent of osseous and soft tissue infection (Durham *et al*., 1991; Horowitz *et al*., 1993; Morrison *et al*., 1995; Nigro *et al*., 1992). Surgical care includes debridement of devascularized tissue and partial, foot-sparing amputation intended to preserve functionality. The manifestations often prompt referral for imaging evaluation. Over the past decade MRI has been used with increasing frequency for evaluation of the diabetic foot and associated complications. It is important for radiologists to be familiar with the MRI appearance of these processes (Morrison and Ledermann, 2002).

Magnetic Resonance Imaging (MRI) is often the primary diagnostic tool in the evaluation of musculo-skeletal disease. In addition, the evaluation of the musculo-skeletal system is the second most common clinical application for MRI, after neuro-vascular imaging, because the diagnostic information provided by the study has become a mainstay of clinical evaluation for many orthopedic and vascular specialisty aids.

The MRI, with its excellent specificity, is helpful in distinguishing bone tumor or infarction from osteomyelitis. Furthermore, MRI is particularly reliable in distinguishing normal areas from abnormal areas when surgery is being planned for diabetic patients with osteomyelitis. Metallic prostheses exclude the use of MRI and distort image reflection on CT, thereby obscuring early changes of infection (Gentry, 1993); so those patients also were excluded from the study.

Tan and The (2007) aimed of their review to illustrate the MRI features that can help differentiate osteomyelitis from neuropathic osteoarthropathy in the foot.

Researchers provided how his group at Yale uses MRI to image musculo-skeletal disorders by highlighting its utility in diagnosing the etiology of chronic ankle pain.

The agic angle effect that is often visible in tendons that are oriented 55°C to the main magnetic field. This effect results in increased proton density signal and can be mistaken for tendon degeneration or tear. Understanding the etiology of this effect helps radiologists recognize its presence as a normal variation rather than a pathologic change necessitating intervention. The medial and lateral flexor tendons of the ankle are the most common sites of tendon injuries and can be imaged with MRI. Three types of tears may be recognized: hypertrophic tendons that often occur with internal splits, atrophic tendons that are small and subsequently rupture and acute tendon rupture of a normal tendon. Besides tendon injuries, injuries to the ligaments of ankle can also be observed on MRI. Ligament damage often occurs at the lateral aspect of the ankle. At the heel of the foot, plantaris fasciitis is best depicted by MRI on sagittal inversion recovery images of the ankle. These images are also useful in depicting the bone marrow edema associated with fractures. Patients with inflammatory changes around the os trigonum often have plantar flexion pain and fluid between the os trigonum and the talus. Dr. McCauley noted that in his practice, MRI of the ankle has become a valuable tool because of its influence on clinical management decisions and its impaction on the intervention procedures and upcoming results.

It is to evaluate different procedures in management of diabetic foot infections, depending on wound classification and pre-interventions clinical, laboratory and radiological assessments especially MRI scans.

MATERIALS AND METHODS

This study is designed to assess the incidence of and risk factors for lower extremity complications with diabetes. Diabetes was defined by physician diagnosis or current treatment with hypoglycemic medication. Diabetes type was based on an algorithm that incorporated treatment type, age at onset, family history of diabetes, BMI and history of keto-acidosis. Patients eligible for the study were outpatients followed in the general internal medicine and general surgery (and Plastic and vascular surgery units) clinics of Al-azher university hospitals (New Domiatte) and of Ministry of Health Hospital and Health Insurance in Kafer El-Sheikh, Zagazeik and Mansourah Clinics in the period from January 2004 to the end of 2009, of 4,211 total outpatients diabetics, 1,040 (25%) had diabetes complications; 264 (6.27%) excluded from the study (patients who were too ill to participate or who could not walk or have previous amputations for diabetic or vascular causes). The remaining 776 patients were included in the study. Patients were followed for a median of 3.3 years (0-6 years).

The diagnosis of diabetes was verified for all patients using the criteria, which include treatment with insulin or an oral hypoglycemic agent, two random glucose measurements 200 mg dL^{-1}, or a fasting glucose 140 mg dL^{-1} (Morrison *et al*., 1995). Sensory neuropathy was evaluated with a 10 g Semmes-Weinstein monofilament wire (Nigro *et al*., 1992; Arora and LoGerfo, 1997).

The diagnosis of infection was made using clinical criteria. Wounds with frank purulence and/or two or more of the following local signs were classified as infected. These signs include warmth erythema, lymphangitis, lymphadenopathy, edema, pain and loss of function. For all wounds, depth was evaluated using (Probe-to-bone Test) a sterile blunt nasal probe (Ierardi and Shuman, 1998). If a wound probed to bone or joint, with the presence of local or systemic infection, a sample and bone biopsy were performed with both microbiologic and histologic analysis to diagnose or exclude esteomyelitis. Plain x-ray of foot was taken both in A\P and lateral views to diagnose bone infection and presence or absence of esteomyelitis. A working diagnosis of lower-extremity ischemia was made by a combination of clinical and noninvasive vascular studies. Clinical signs were based on the absence of one or more foot pulses of the involved foot. Noninvasive criteria included an Ankle-Brachial Index (ABI) of 0.80 (Tan *et al*., 1996; Tooke, 1995). Duplex Doppler study for the lower extremities vascular tree is an essential diagnostic tool in our study. Clinical signs and/or the presence of abnormal noninvasive values provided a diagnosis of lower-extremity vascular insufficiency.

Subsequently, we reviewed the lower extremity duplex results and established a final treatment plan based on the history, physical examination and duplex results. Treatment was labeled as either: (1) Aggressive (Amputation), (2) tunneling with antibiotics soiling and drainage, (3) the patient was considered to have a peripheral vascular disease (vascular

Table 1: Demographic data

Items	Comments
Total No. of patients	776 patients
Gender	607 patients (78.2%) male 169 patients (21.8%) female
Median age	45 years (median 28-61 years)
Type of diabetes	721 patients (93%) Type II (339 patients of them) treated by Insulin
Median duration of DM	9 years (range of 5-31 years)

procedures); or (4) Conservative measures (culture-guided antibiotics with daily dressing). MRI scan were employed in many cases of high risk group of patients for diagnosis of musculo-skeletal and neuro-vascular disorders in addition to detection and evaluation of deep infections.

The classification uses a matrix of wound grade on horizontal axis and wound stage on the vertical axis to categorize wounds by severity. Wounds were graded by depth according to the following criteria: grade 0, a pre-or post-ulcerative site that had healed; grade 1, superficial wounds through the epidermis or epidermis and dermis that did not penetrate to tendon, capsule, or bone; grade 2, wounds that penetrated to tendon or capsule and grade 3, wounds that penetrated to bone or into the joint. Within each wound grade there are four stages: clean wounds (A), non-ischemic infected wounds (B), ischemic non-infected wounds (C) and infected ischemic wounds (D) (Wagner, 1979; Lavery *et al*., 1996).

Data Collection

At entry into the study, participants underwent an interview for careful history, a physical examination and laboratory testing. The history included past and present symptoms, signs and physician diagnoses of diabetes, foot conditions and vascular complications.

Analysis of blood included measurements of glycosylated hemoglobin A1c, albumin, leukocytes, hematocrit and creatinine.

Physical examination included assessment of peripheral sensory neuropathy, palpation of Posterior Tibialis (PT) and Dorsalis Pedis (DP) pulses, observation of stance and gait, examination of edema and ulcers.

All patients at high risk groups (neurovascular diseases and deep infections), were examined by MRI scan for detection of soft tissue infections and osteomyelitis.

Characteristics of Study Population

Study subjects (776 patients) were predominantly men, 607 patients (78.2%), 169 women (21.8%) and with a median age of 45 years (range of 28-61 years); 721 of patients (93%) had type II diabetes and 339 of those patients (47%) were treated with insulin. The median duration of diabetes was 9 years (range of 5-31years) (Table 1).

RESULTS

The prevalence of wound severity by wound stage and grade as stated by Wagner (1979) and Lavery *et al*. (1996) and outlined in Table 2. There were 342 patients of stage A (grade 0: 34 patients, grade 1: 197 patients, grade 2: 73 patients and grade 3: 38 patients); 339 patients of stage B (grade 0: 25 patients, grade 1: 107 patients, grade 2: 51 patients and grade 3: 156 patients); 44 patients of stage C (grade 0: 9 patients, grade 1: 19 patients, grade 2: 11 patients and grade 3: 5 patients) and 51 patients of stage D (grade 0: 7 patients, grade 1: 6 patients, grade 2: 11 patients and grade 3: 27 patients). The most frequent presentation

Table 2: The prevalence of wound severity in our groups of 776 patients by wound stages and grades (Wagner, 1979; Lavery *et al*., 1996)

Items	Grade 0	1	2	3
Stage A 342 pts (44.1%)	Pre or post-operative lesion completely epithelized 34 pts (4.4%)	Superficial wound, not involving tendon, capsule, or bone 197 pts (25.4%)	Wound penetratingto tendon or capsulex 3 pts (9.4%)	Wound penetratingto bone or joint 38 pts (4.9%)
Stage B 339 pts (43.7%)	Infection 25 pts (3.2%)	Infection 107 pts (13.8%)	Infection 51 pts (6.6%)	Infection 156 pts (20.1%)
Stage C 44 pts (5.6%)	Ischemia 9 pts (1.2%)	Ischemia 19 pts (2.4%)	Ischemia 11 pts (1.4%)	Ischemia 5 pts (0.6%)
Stage D 51 pts (6.6%)	Infection and Ischemia 7 pts (0.9%)	Infection and Ischemia 6 pts (0.8%)	Infection and Ischemia 11 pts (1.4%)	Infection and Ischemia 27 pts (3.5%)

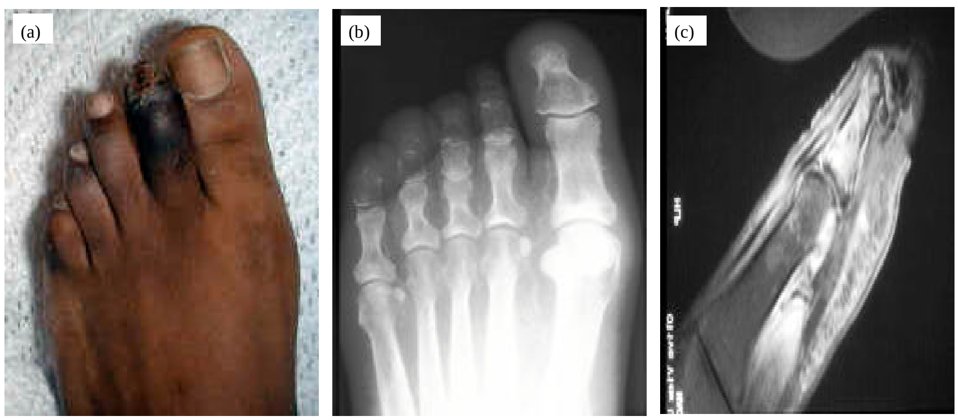

Fig. 1: Diabetic infection of second left toe: (a) clinically, (b) plain x-ray and by (c) MRI. (Sagittal T1 weighted image with fat saturation demonstrates absent signal of the distal soft tissues and bone of the 2nd toe secondary to dry gangrene)

was in stages A (grade 1: 197 patients (25.4%) with superficial wound, not involving tendon, capsule, or bone) and in stage B (grade 3: 156 patients (20.1%) with infected wound penetrating to bone or joint). While the least presentation was noticed in stage C (grade 3: 5 patients (0.6%) with ischemic wound penetrating to bone or joint) and stage D (grade 1: 6 patients (0.8%) with infected and ischemic superficial wound, not involving tendon, capsule, or bone). There was a significant overall trend toward an increased prevalence of amputations as wounds increased in both depth (from stage A to stage D) and grade (from grade 0 to grade 3); usually decision of amputations occurred in grade 3 where ischemia was prevalent. This was true for every subcategory as well, with the exception of all stage A (non-infected, non-ischemic) wounds. There was no lower- extremity amputations performed within this stage during the follow-up period.

Procedures used in Management of our Diabetic Patients

Of all patients (776 pts) presenting for care, 243 patients (31.1%); received some form of lower extremity amputation (Fig. 1b, 2a-c and 3a) of them 50 patients scanned by MRI (20.6%) (Fig. 1c, 3b), all revealed positive data. These amputations included digital or ray-level amputations in 193 patients (79.4% of total amputations), mid-foot-level amputations in 29 patients (11.9%) and trans-femoral (above knee) amputations in 15 patients (6.2%) and

Fig. 2: (a) Post forefoot amputation:P\A plain x-ray demonstrates pointed shards of bone projecting into the soft tissue stump. (b) P\A plain x-ray demonstrates progressive osteomyelitis of the second rays (radiograph was obtained after amputation of the first toe). (c) P\A Plain x-ray obtained 8 months and demonstrates progressive destructive osteomyelitis involving the 1st metatarsal stump and the sesamoids. There is also septic arthritis of the 2nd MTP joint with osteomyelitis of the 2nd metatarsal head and 2nd proximal phalange

Fig. 3: (a) P\A plain x-ray demonstrates wound (ulcer) of medial forefoot with adjacent, underlying osteomyelitis of the 1st metatarsal head. (b) MR image demonstrates fluid filled sinus tract draining from the phalange to the plantar skin area

trans-tibial (below knee) amputations in 6 patients (2.5%). Patients were more at risk to receive a mid-foot or higher level amputation if their wound probed to bone (grade 3: 38+156+5+27=226 patients vs. grade 2 stage C and D: 11+11=22 patients; p 0.001). Similarly, patients with infection and ischemia (stage D) were more likely to receive a mid-foot or higher amputation compared with patients in less advanced wound stages (27 patients in stage D vs. 7; 6 and 11 patients in stages A, B and C, respectively). There were no lower-extremity amputations of any level in stage A (non-infected-non-ischemic) and stage B wounds, regardless of depth. These data were collected in Table 3.

Table 3: Lower limb amputations

Items	Results
Total No. of Patients	243 pts (100%)
MRI scan	50 pts (20.6%)
Digital or ray level	193 pts (79.4%)
Big toe	127 pts (52.3%)
Other toes	66 pts (27.1%)
Mid-foot level	29 pts (11.9%)
Trans-femoral level (Above knee)	15 pts (6.2%)
Trans-tibial level (Below knee)	6 pts (2.5%)
High levels of amputations in stages	C and D
Higher rates of amputations	In grade 3 (wound probed to the bone)
No amputation of any levels	In stage A

Table 4: Showing ABIs in relation to palpable pulses in our different stages

Items	No. of Patients	ABIs	Palpable pedal pulses
Stage A	342	1.039±0.15	293 pts (85.7%)
Stage B	339	1.023±0.13	256 pts (75.5%)
Stage C	44	0.731±0.17	7 pts (15.9%)
Stage D	51	0.613±0.19	3 pts (5.5%)
Total	776	0.991±0.16	559 (72.0%)

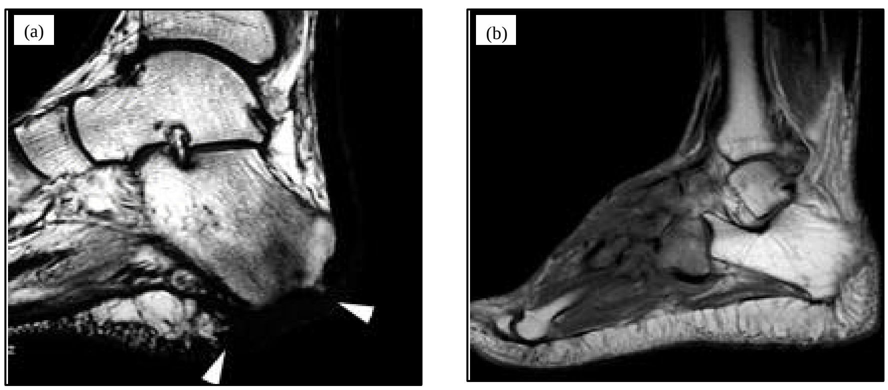

Fig. 4: (a) Chronic heel diabetic ulcer with osteomyelitis demonstrating induration and flattening of the subcutaneous tissues down to the calcaneus. (b) Foot cellulitis with soft tissue oedema and image demonstrating loss of the normal fatty marrow signal in the midfoot and loss of the normal signal from the subcutaneous tissues indicating oedema

The data outlined in Table 4 shows patients presented in stages C and D had significantly lower Ankle\Brachial Indices (ABIs) than those in non-ischemic stages A and B (0.731 ± 0.17 and 0.613 + 0.19 vs. 1.039 + 0.15 and 1.023 ± 0.13, p 0.001). Furthermore, significantly more of the patients in ischemic stages had non-palpable pulses; stage C and D (84.1 and 94.5%) vs. stage A and B (14.3 and 24.5%; p 0.001).

Tunneling and antibiotics soiling and drainage: in 428 patients (Stage A: grade 1 (197 pts), grade 2 (73 pts) and stage B: grade 1 (107 pts), grade 2 (51 pts)); of them 43 patients (10%) scanned with MRI, (Fig. 4a, b) which revealed 37 pts (86%) with positive data ranged from soft tissue, tendons and muscles inflammatory changes with spreading of infection, to deep abscesses formation.

A meticulous wound exploration is carried out, with removal of infected sloughy tissue and opening of all sinuses. It is rare to find a well-defined abscess. All heavily infected sloughy, gray tissue, removed down to healthy, bleeding tissues. All dead tendons and necrotic tissues, also removed. Wide excision is necessary with removal of fragmented infected and non-bleeding bones, as well as opening up all sinuses. In addition to this generous debridement and performing tunnels between foot layers washed with two ampoules of 80 mg gentamycin (Garamycin ®); we applied gauge soaked with solution of bovidine iodine (Betadine ®) 10% mixed with 20 volume hydrogen peroxide by average 1:3; to establish drainage from all these tunnels.

We had not sutured the wound but left to heal by secondary intention. It is important to inspect the wound every day after the operation and if signs of infection recur, then the patient may need further surgical intervention. After surgery, the edges of the wound are debrided every day and all callus, slough and nonviable tissue were removed and again the gauge soaked with solution of bovidine iodine (Betadine ®) 10% mixed with 20 volume hydrogen peroxide by average 1:3 applied with each dressing with decreasing its length according to degree of improvement. The wounds were kept open and drained to heal from the base. Infections extending into the deep spaces of the foot were required longitudinal incisions along the plantar surface to provide adequate drainage and debridement. Intact vascular structures and viable muscle were preserved, but tendons may be needed to be debrided in many cases, as they are more prone to undergo necrosis. In all cases, debridement was taken back to healthy bleeding tissue.

Wound care needed to continue on an outpatient basis in the diabetic foot clinic or surgical outpatients clinic with extreme patience (daily for first week, day by day for two weeks, then every three days for month and finally a weekly visit until complete wound healing); outcomes were, so surprisingly good.

However, large surgical defects treated with this procedure of therapy until they are granulating, when they can either have split skin grafts applied or otherwise be left to heal by secondary intention.

From our 428 patients grouped in this line of treatment (Tunneling and antibiotics soiling and irrigation), no patient need any type of amputation, 407 patients (95.1%) all healed with secondary attention in a period from 33 days to 257 days (with average of 73 days); 21 patients (4.9%) needed split skin grafts and doing well (Table 5).

Vascular Procedures

In 36 patients (4.6%): (Stage C: grade 1 (19 pts), grade 2 (11 pts) and stage D: grade 1 (6 pts)), all received MRI angiography scan (100%); all with positive data, Table 6.

Thirty Six patients (in our series were treated by operative surgical procedures (Bypass surgery (femoro-popliteal and femero-posterior tibial bypass) in 32 (88.9%) patients;

Table 5: Tunneling and antibiotics soiling and drainage

Items	Results
Total No. of patients:	428 pts (55.2%)
MRI scan	43 pts (10.0%); 37 pts (86%) with positive data (soft tissue, tendons and muscles inflammatory changes and deep abscesses formation).
Procedure	Generous surgical debridement with draining of all sinuses and abscesses with tunnels between foot layers and applying gauge soaked with Betadine ® and Hydrogen peroxide solution 1:3 and daily dressing
Results	407 pts (95.1%) healed with secondary intention • 21 pts (4.9%) needed split skin grafts. • No patient needed any type of amputation

Table 6: Vascular procedures

Items	Results
Total No. of patients	36 pts (4.6%)
MRI angiography	36 pts (100%)
Stage of wounds	Stage C: grade 1 (19 pts), grade 2 (11 pts) Stage D: grade 1 (6 pts)
Vascular procedures	Bypass surgery in 32 (88.9%) patients Endartrectomy in 5 (13.9%) patients) PTA in 4 (11.1%) patients
Results	Arterial patency in 18 patients (50%) Revascularization in 9 patients (25%) Amputations in 9 patients (25%)

Table 7: Isolated organisms and its percentages in the conservative management group (75 pts)

Organisms	No. of Patients	%
Staphylococcus aureus	11	14.70
E. coli	5	6.70
Proteus	2	2.70
Streptococcus viridans	4	5.30
Pseudomonas	7	9.30
Fungus	2	2.70
Mixed Infection	44	58.70
Total	75	100.00

Table 8: Conservative measures

Items	Results
Total No. of patients	75 pts Stage A: grade 0 (34 pts) Stage B: grade 0 (25 pts) Stage C: grade 0 (9 pts) Stage D: grade 0 (7 pts)
MRI scan	No one
Aim	Prevent systemic spread of infection
Procedure	Prolonged, culture-guided antibiotics Daily dressing Tight blood sugar control
Offloading	We advised our patients to use specially designed Foot-wears
Results	All patients cured without need for amputation

five patients of them were needed endartrectomy (13.9%) in the common femoral artery and Percutaneous Transluminal Angioplasty (PTA) in 4 (11.1%) patients (in common femoral and superficial femoral arteries)).

Stabilization of the arterial patency occurred in 18 patients (50%) and 9 patients (25%) had undergo revascularization procedures (supra-inguinal bypass) due to macro-embolism and re-occlusion; while the rest 9 patients (25%) had undergo amputations.

Conservative measures: The aim is to prevent systemic spread of infection. Conservative treatment, including prolonged, culture-guided parenteral and oral antibiotics, (Table 7, 8) daily dressing (using bovadine iodine 10% (Betadine ®) and film dressing, foam dressing, non-adherent dressings, hydrogels, hydrocolloids and alginates) and tight blood sugar control, were successful without amputation in this group of our patients admitted for diabetic foot infection: in 75 patients (Stage A: grade 0 (34 pts); stage B: grade 0 (25 pts); stage C: grade 0 (9 pts) and stage D: grade 0 (7 pts)), no one need MRI examination. In the absence of osteomyelitis, a 10 to 14 day period of antibiotics will usually be adequate.

Antibiotic therapy with a broad spectrum antibiotic was usually begun immediately after cultures have been obtained; the antibiotic adjusted based upon the sensitivities of the causative organisms. The initial antibiotic chosen should be effective against aerobes (gram-negative and gram-positive organisms) as well as anaerobes organisms. We usually used as initial antibiotics 1gm ceftriaxone (Rocephin ® or Cefotrix ®) twice daily i.v.; then antibiotic adjusted according to the culture and sensitivity results. The most common antibiotics used in our cases ranged from cephradine (Velosef ®), ampicillin\sulbactam (Unasyn ®), amoxicillin\clavulanic acid (Augmentin ®) to quinolones group e.g. Ciprofluxacine ® or Levofluxacine (Venaxan ®) vials. Clindamycin (Dalacin-C ® 600mg amps) twice daily usually added in presence of anaerobic infections or in mixed infections. Anti-fungal infusion (Diflucan ®) was used twice daily for five days in our two cases of fungal infection.

Offloading is a term used to describe the elimination of abnormal pressure points in order to prevent the development or recurrence of foot ulcers or to promote healing. Ideally, offloading will reduce the pressure at the wound site while maintaining mobility. We advised our patients to use specially designed footwear and crutches evacuated below the pressure sites in the sole, all assist in reducing pressure at danger points.

DISCUSSION

The Human foot is a mechanical marvel. It has 26 bones, 29 joints and 42 muscles. The bones include 7 tarsal, 5 metatarsals and 14 phalanges. The plantar pressure on a foot of a normal man of 60 kg who is standing on one foot is 61 kilopascals. In a normal walking speed, the plantar pressure at the 1st Meta-Tarso-Phalangeal (MTP) joint is about 299 kilopascals (Rosenbaum *et al*., 1994).

The normal walking cycle consists of two phases; the stance phase, which takes 60% of entire gait cycle and the swing phase, which takes 40% of the gait cycle. The stance phase is divided into heel strike, mid-stance and toe off. During toe off, the great toe bears about 70% of body weight.

There are many clinical approaches to the diabetic foot wound, but, to our knowledge, there is no evidence at this time for a single best management strategy; so we tried four different procedures in management of our patients depending on the stage and degree of wounds, infection and ischaemia; with different degrees of success.

Amputation of the great toe, leads to disturbance in the biomechanics of the foot; where the pressure is transferred to the next toe (Sullivan, 2005). A hammertoe deformity of the second toe frequently ensues and is subject to ulceration.

A significant number of amputations in diabetic individuals can be prevented by patient education and increased awareness on the part of diabetes care teams of effective strategies in diabetic wound management (Krans *et al*., 1992; Sanders, 1994). Not all diabetic foot wounds, however, are amenable to successful conservative outpatient treatment; a number of patients require hospitalization with a view to intravenous antibiotic therapy, debridement and/or amputation. We defined success not only as local healing, but also as nonlocal recurrence after prolonged follow-up without amputations.

Other reports emphasize the importance of previous amputation or foot lesions in diabetic patients as risk factor for amputation of the contralateral leg (Bild *et al*., 1989; Wagner, 1979; Kucan and Robson, 1976). The present study exclude those reported in their history of hospitalization for diabetic infection independently predicts failure of conservative treatment or previous amputations and with difficult ambulation.

Predictably, most patients with wounds stages A and B were cured with conservative treatment (no amputation), whereas, in those with infection and ischaemia (stage C and D), failed; so amputation was the option in many cases (243 patients (31.3%) + 9 patients in vascular procedures group (25%)). Osteomyelitis (Wounds stage C and D), was present in up to 12.5% of all cases (95 from 776 pts) and one third of diabetic foot infections (95 from 243 pts) in present study, as by Wheat *et al.* (1986) and they had classically been treated by aggressive surgical resection, up to amputation. This was a controversial to Tan *et al.* (1996) and also, Bamberger *et al.* (1987) who were the first to challenge this approach; as they described a series of 51 diabetic patients with foot osteomyelitis in whom 27 (53%) showed clinical resolution without amputation at the time of follow-up (mean, 19 months). Those patients responded to conservative treatment only (involving a course of at least 4 weeks of intravenous antibiotics or a combination of intravenous and oral administration for at least 10 weeks). Again, Peterson *et al.* (1989), described the successful outcome of 27 (56%) of 48 diabetic patients with pedal osteomyelitis for whom conservative treatment only was implemented (follow-up, 12 months). So, we were tried a type of conservative management (Tunneling and antibiotics soiling and drainage) in a large number of our patient 428 patients (55.2%), with 407 pts (95.1%) healed with secondary intention, 21 pts (4.9%) needed split skin grafts and no patient needed any type of amputation. In addition to performed totally conservative treatment in 75 pts (9.7%), also without need for amputation; see boxes (3) and (5).

Despite important technical advances (Edelman *et al.*, 1997; Williamson *et al.*, 1989; Newman *et al.*, 1991), the diagnosis of osteomyelitis in diabetic patients remains difficult (Edelman *et al.*, 1997; Caputo *et al.*, 1994). The probe-to-bone test is a reliable, inexpensive and easy-to-perform approach to diagnose pedal osteomyelitis in diabetic patients (Grayson *et al.*, 1995).

Investigations suggest that Magnetic Resonance Imaging (MRI) may not be of primary importance in the management of the diabetic foot ulcer (Edelman *et al.*, 1997; Weinstein *et al.*, 1993; Eckman *et al.*, 1995). While, others reported that MRI may be necessary in some patients to define underlying bony involvement (Soysal *et al.*, 2007). Ledermann *et al.* (2002), proved that MR imaging revealed abscesses, predominantly in the forefoot, in 18% of patients suspected of having pedal osteomyelitis. We totally agreed with both groups of investigators as we applied MRI scan for 50 patients (20.6%), in the first group (243 pts) treated with different forms of amputations; all revealed positive data; in 43 patients (10%) in the second group (428 pts) treated by tunneling and antibiotic soiling and drainage; which revealed 37 pts (86%) of them with positive data ranged from soft tissue, tendons and muscles inflammatory changes with spreading of infection, to deep abscesses formation and in 36 pts of the third group treated with vascular procedures, all received MRI angiography scan (100%); all reported with positive data and finally in our fourth group (75 pts) treated with conservative measures, there was no need for MRI scan.

As adequate tissue perfusion is necessary for the healing and delivery of antibiotics, the surgeon should determine the extent of ischemia and assess whether the risks of any proposed procedure will be justified by the functional benefit offered to the patient (Caputo, 2008). Also, Caputo (2008) stated that the extent of claudication is not necessarily a useful indicator in patients with diabetes as neuropathy may mask the symptoms and it may be more useful to confirm a diagnosis of ischemia with the ankle-brachial index (ABIs).

As we were expected, in our patients presented in stages C and D had significantly lower Ankle\Brachial Indices (ABIs) than those in non-ischemic stages A and B (0.731 ± 0.17 and 0.613 ± 0.19 vs. 1.039 ± 0.15 and 1.023 ± 0.13, p 0.001). Furthermore, significantly more of the patients in ischemic stages had non-palpable pulses; stage C and D (84.1 and 94.5%) vs. stage A and B (14.3 and 24.5%; p 0.001). This is in spite of its importance (Caputo, 2008); as a method of estimation of the lower extremities vascular tree; Bodikova and Flak (2007) reported that ABIs seems to be not adequate method for evaluation of astherosclerotic damage in those patients with mediocalcinosis, as it is known that occurrence of mediocalcinosis is higher in diabetic patients. Ischemic wounds are extremely slow to heal even after revascularization.

Conservative treatment was successful in all our patients managed by this procedure: 75 patients (Stage A: grade 0 (34 pts); stage B: grade 0 (25 pts); stage C: grade 0 (9 pts) and stage D: grade 0 (7 pts)); no one need MRI examination and no amputation was done. The probe-to-bone test is a reliable, inexpensive and easy-to-perform approach to diagnose osteomyelitis in our diabetic patients, beside plain x-ray films. Grayson *et al.* (1995) also depend on this test and reported success rate of conservative measures in 35 (70%) of 50 patients with deep lesion or suspected osteomyelitis examined by probe-to-bone test. We advised our patients to use specially designed footwear and crutches evacuated below the pressure sites in the sole.

We agreed with Caputo *et al.* (1994) that prolonged, culture-guided antibiotic therapy is the least expensive approach, with daily dressing and strict glycaemic control and nearly equal results were reported.

Importantly, we studied the four groups of patients and we hope that our observations would help physicians decide whether to choose a conservative approach in the treatment of such a condition and it would provide a comparison with results obtained with early amputation or novel therapeutic strategies.

CONCLUSIONS

Diabetes is reaching epidemic proportions and with it carries the risk of complications. Disease of the foot is among one of the most feared complications of diabetes. The ultimate endpoint of diabetic foot disease is amputation, which is associated with significant morbidity and mortality, besides having impact social, psychological and financial consequences. As the majority of amputations are preceded by foot trauma, wounds and ulcerations, it is crucial to identify those at an increased risk. Diabetic foot wounds and ulcers may develop as a result of neuropathy, ischaemia or both and when infection complicates a foot wound or ulcer, the combination can become limb and life threatening.

As the majority of amputations are preceded by foot ulceration, it is crucial to identify those at an increased risk. Once identified, specific interventions can be directed to reduce this risk. As these patients are also likely to harbor other associated complications of diabetes (peripheral neuropathy, ischemia and arthropathy), they are best managed by a multidisciplinary team.

Present study has confirmed the effectiveness of existing interventions in the management of diabetic foot complications. Each of these interventions, when used appropriately, may result in excellent outcome and may reduce the risk of foot ulceration and with it the risk of amputation.

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