PERSONAL EXPERIENCES IN TREATMENT OF DIABETIC FOOT SYNDROME

ADAM LEWANDOWSKI, WITOLD PASZTA, WŁODZIMIERZ NOWATORSKI

2nd Department of General and Oncology Surgery, District Hospital in Płock
Ordynator: dr n. med. W. Nowatorski

Changes like deformities, ulcerations, infection and destruction of deep tissues of foot caused by diabetes mellitus are called diabetic foot syndrome. About 2.5 million people (6% of population) suffer from diabetes mellitus in Poland. About 100 000 of them suffer from diabetic foot syndrome.

The aim of the study was to retrospectively analyze patients with diabetic foot syndrome and present results of the surgical treatment of these patients.

Material and methods. The study group comprised 112 patients of both sexes aged between 34 and 90 years treated in our Department of Surgery from January 2003 to December 2007. The mean age for men was 61 years and for women – 72 years. Most patients in the study group were diagnosed with type 2 diabetes mellitus (89.2% in men and 95.7% in women). Symptomatic atherosclerosis occurred in 25% of treated patients.

Results. 112 patients with diabetic foot syndrome needed 144 hospitalizations (65 male patients needed 86 hospitalizations and 47 female patients needed 58 hospitalizations). The average hospitalization duration for male patients was 24 days and for female patients was 22 days. 8 patients (7.1%) died – 3 men and 5 women. 82 (73%) patients were operated. Operative methods consisted of phlegmon incision, amputation of toes, metacarpal amputation and amputation of limb under and above the knee. 38 different bacterial species were cultured as the results of microbiological evaluations in 71 patients.

Conclusions. Patients with diabetic foot syndrome are hospitalized in department of surgery many times, they need multidisciplinary treatment and can be a source of nosocomial infections.

Key words: diabetic foot syndrome, type 2 diabetes mellitus, atherosclerosis, amputation of limb, nosocomial infections

Diabetics develop foot lesions involving deformities, ulcerations, necrosis and infections, collectively referred to as the diabetic foot syndrome. Approximately 6% of Polish population, i.e. 2.5 million people, suffer from diabetes, including approximately 100 thousand subjects with diabetic foot syndrome (1, 2, 3).

The foot has a complex anatomical structure. Loose and relatively fat-free subcutaneous tissue on the dorsum of the foot facilitates the spread of inflammatory processes along the tendons, vaginas and intrafascicular spaces. An infection spreads through the dorsal fascia of the foot and spreads to the fascia of the shin. On the plantar surface of the foot, the infection spreads along the plantar aponeurosis. Disturbances of perfusion and innervation in the diabetic foot syndrome lead to lesions of the skin (calluses), subcutaneous tissue (atrophy), muscles (atrophy, contractures), joints and bones (deformities, atrophy), infection (ulceration, phlegmon), necrosis and requirement of more or less extensive amputation.

There are 3 types of infected necrosis relevant for the surgical treatment: in the neuropathic foot syndrome, ischemic foot syndrome and the diabetic foot syndrome of mixed etiology related to diabetic neuropathy, microangiopathy and macroangiopathy (atherosclerosis). Markedly poorer prognosis of patients with diabetic foot syndrome and associated symptomatic atherosclerosis is related to the impaired tissue metabolism, decreased immune resistance and worse conditions for formation of collateral circulation (4). The treatment of diabetic foot syndrome begins in the
Emergency Department with a consultation by an internist. Proper cooperation of a surgeon and internist is important in the further therapy. The standard management of the diabetic foot syndrome is “a small step surgery”, supported in more complex amputations within the foot or the shin by orthopedic assistance.

The aim of this study was to retrospectively analyze patients with the diabetic foot syndrome and to present the results of surgical treatment of these patients.

**MATERIAL AND METHODS**

The study population included 112 patients diagnosed with diabetic foot syndrome, treated within the 5 year period in the II Department of General and Oncological Surgery, District Hospital in Płock, between 2003 and the end of 2007. The study population included 65 males (mean age 61 years) and 47 females (mean age 72 years).

The patient’s health status was rigorously examined at the admission. Often the patients were admitted to the hospital with sepsis, uncontrolled diabetes mellitus, coexisting heart failure. Locally, the infection involved deep spaces of the dorsal or plantar foot. After the patient was admitted to the Department, the disease advancement was assessed by: medical history (intermittent claudication, resting pain), warmth of both limbs, pulse and time for vein filling, preservation of various types of sensations was examined, shape and size of infection sites was evaluated, recesses were probed, X-ray of both feet was performed, Doppler US, possibly classic arteriography and CT/ MR angiography were performed. Basic blood tests were performed. The feet were relieved of the load by requirement of bed rest to improve perfusion and decrease the injury risk. Anticoagulation with low molecular weight heparin was started, insulin therapy and broad-spectrum antibiotic were given, potential antibiotic neurotoxicity was taken into consideration. Small vessel dilating medications were given at early stages of the diabetic foot, to improve its perfusion. Analgesic medications including narcotic analgesics, were given when needed. Surgical treatment was supported by interdisciplinary management (diabetologist, anesthesiologist, cardiologist, nephrologist, ophthalmologist, orthopedist).

In case of foot abscesses and phlegmon, extensive parallel incisions were made in all compartments in the deep abscesses of the foot and in the phlegmon of the dorsal foot. The pus was taken from the deep tissue for the culture of aerobic and anaerobic organisms and antiogram. Necrotic tissue was radically removed, the wound was drained with latex drains and flushed with antiseptic solution – 0.25% solution of silver nitrate. If needed, the toe where the gangrene had originated, was amputated. The wound underwent an “open” healing. Daily bathing in 2% aqueous iodine solution or potassium permanganate was performed. Incision of the phlegmon and necrosis removal were repeated multiple times, as needed.

The following rules of the surgical therapy were used: early diagnosis and life saving treatment, limitation of the disease process (preservation of the affected limb or lowering of an amputation level), pain alleviation, shortening of the treatment duration. Amputation, as sparing as possible, was restricted only to affected structures. When the limb ischemia was the dominating factor, perfusion restoration procedure was considered (procedures of reconstruction of large arteries). Before the procedure, a patient was informed that it was possible to change the amputation level during the operation. Some of the performed procedures were of diagnostic-therapeutic nature, e.g. in the incision of the phlegmon of the metatarsus with required simultaneous toe amputation. Femoral amputation was performed only when, with associated atherosclerosis and symptoms of chronic ischemia, the infection progressed from the foot to the shin through the fascia cruris. Femoral amputation was a life-saving procedure of choice in patients in a septic state.

Postoperative therapy: possible change of an antibiotic, according to the result of culture, analgesic medications, clonazepam against phantom pain, dressings twice daily, follow-up glycemic profile and consultation by a diabetologist after the healing was achieved, to establish insulin doses that the patient was to use at home, follow-up at the outpatient department of surgery and fixing of the prosthesis.

**RESULTS**

Between 2003-2007 the total number of patients hospitalized in II Department of Gene-
ral and Oncological Surgery, District Hospital in Płock, was 9964. Out of these patients, 112 (1.1%) patients had the diabetic foot syndrome (DFS).

An average duration of hospitalization in the department was 24 days for men and 22 days for women. 9 (8%) subjects had type 1 diabetes mellitus. 193 (92%) patients had type 2 diabetes mellitus: 58 (89.2%) men and 45 (95.7%) women. Symptomatic atherosclerosis of the lower limbs was diagnosed in 13 men and 15 women, corresponding to 25% of DFS patients.

8 patients (3 males and 5 females) died during therapy, corresponding to 7.1% of all patients treated for the diabetic foot syndrome. 82 (73%) patients underwent surgical treatment, while 30 (27%) underwent medical therapy. 112 patients required a total of 144 hospitalizations over the 5 year period: 65 men required 86 hospitalizations and 47 women – 58 hospitalizations. The number of surgical hospitalizations was 87 (60%), while the number of medical hospitalizations was 57 (40%).

A total of 38 different bacterial species or types, with predominance of aerobic organisms, were cultured from infected wounds in 71 (63%) of patients; furthermore Candida fungi were cultured from the samples taken from 3 patients (fig. 1). Among 71 patients with infected necrosis, as many as 50 (70.4%) were infected with more than 1 bacterial strain; on average 2.6 bacterial strains were cultured from one patient, 9 bacterial strains at most (fig. 2).

**DISCUSSION**

The diabetic foot syndrome is a complication of poorly controlled diabetes and results from changes in the peripheral nervous system and small and large blood vessels. The resulting ulceration that often persists for many years, is covered by fibrin and necrotic tissue that hamper proliferation of new cells and pro-

---

**Table 1. Type and number of surgical procedures performed in 112 patients with the diabetic foot syndrome**

<table>
<thead>
<tr>
<th>Procedure</th>
<th>Total number of performed procedures</th>
<th>Number of multiple procedures</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n</td>
<td>%</td>
</tr>
<tr>
<td>Phlegmon incision</td>
<td>16</td>
<td>14.8</td>
</tr>
<tr>
<td>Aoe amputation</td>
<td>40</td>
<td>37</td>
</tr>
<tr>
<td>Metacarpal amputation</td>
<td>6</td>
<td>5.6</td>
</tr>
<tr>
<td>Shin amputation</td>
<td>11</td>
<td>10.2</td>
</tr>
<tr>
<td>Femoral amputation</td>
<td>35</td>
<td>32.4</td>
</tr>
<tr>
<td>Total</td>
<td>108</td>
<td>100</td>
</tr>
</tbody>
</table>

**Table 2. The number of patients who underwent multiple surgical procedures**

<table>
<thead>
<tr>
<th>Number of patients</th>
<th>n = 2</th>
<th>n = 3</th>
<th>n = 4</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>% of patients with DFS undergoing surgical treatment (100% = 82 patients)</td>
<td>20.7</td>
<td>3.7</td>
<td>1.2</td>
<td>25.6</td>
</tr>
</tbody>
</table>

**Table 3. The number of patients who underwent multiple hospitalizations**

<table>
<thead>
<tr>
<th>Number of patients</th>
<th>n = 2</th>
<th>n = 3</th>
<th>n = 4</th>
<th>n = 5</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>% of treated patients with DFS (100% = 112 patients)</td>
<td>13.4</td>
<td>3.6</td>
<td>0.9</td>
<td>0.9</td>
<td>18.8</td>
</tr>
</tbody>
</table>
vide nutrients for bacteria. Thus, to reduce the risk of infection, it is necessary to quickly clean the wound and eliminate constituents of infections from its bottom (1, 2, 5, 6, 7, 10).

New dressing technologies, next generations of skin substitutes and extracellular matrix substitutes in combination with progress in science seem to decrease the pressure on laboratory animal experiments and increase the probability of success in clinical trials. New technologies are used in the diagnosis of the diabetic foot that allow for prediction of efficacy and feasibility of the proposed treatment. Khaodhiar et al. tested the possibility of using the spectral HT technology. This technology allows for quantitative assessment of oxy- and deoxyhemoglobin in the tissues. Abnormalities of the microcirculation and tissue oxygenation detected with this technology allow for determination of prognosis with regard to the ulceration healing and monitoring of the process of the ulceration healing in the diabetic foot (5). Lawson et al. attempted to assess the effect of electrostimulation and high temperature on the wound healing in the diabetic foot, during changes of the dressing. Wound healing rate and skin perfusion around chronic ulcerations were examined with a Doppler apparatus. A significant increase of the healing rate resulting from improved skin perfusion was observed in the group undergoing electrostimulation in the room with elevated temperature (32°C) (6). Kavros et al. presented their clinical experience from the period of 2004 – 2006 from the treatment of chronic foot and shin ulceration of ischemic origin, using non-contact low energy and frequency MIST ultrasound therapy. As the authors believe, combination of MIST with other methods of local treatment is beneficial and should be used in

---

**Fig. 1.** The cultured bacterial types or species and the number of patients infected with these bacteria

**Fig. 2.** The number of patients infected with multiple bacterial strains
patients with ulcerations of ischemic origin (7). Frank et al. decided to verify whether larval therapy that cleans the wounds at the diabetic foot from the fibrin deposits, leads to eradication of methicillin-resistant staphylococcus aureus (MRSA) from these wounds. The investigators achieved complete eradication after 2 – 8 larval therapies. However larval therapy has low efficacy in fighting Gram-negative bacteria, including Pseudomonas aeruginosa. There are suggestions to intensify therapy in the event of infection with Gram-negative bacteria, by using higher number of the larvae and prolonged treatment duration and by supporting systemic antibiotic therapy. When there is no overt infection, antibiotics are not used (8,9). However, according to some authors, high number of the bacteria in the chronic wound inhibits the process of healing and antibiotics are beneficial even when there are no clinical symptoms of infection: they limit the number of hospitalizations and decrease the risk of amputation. Experience in the wound healing demonstrated that the wounds can be cleaned relatively easily and using various methods. Furthermore, stimulation of the granulation process in the clean wound is not a big problem. The most difficult thing is to cover the skin defect with epidermis. The substitutes of the extracellular matrix or substitutes of the skin seem to be a good solution to improve the epidermization process. Minke et al. investigated the product OASIS® Wound Matrix, which was based on the porcine intestinal submucosal membrane (10). Wound cleaning is not synonymous with its complete healing. None of the wound cleaning methods will result in permanent benefit when tissue malnutrition and ischemia persist. The subsequent step after the wound cleaning should involve restoration of adequate perfusion of the limb, if it is possible (4).

We used 0.25% solution of silver nitrite – an antiseptic that stimulates granulation and epidermization, in the treatment of wounds of the diabetic foot in our patients. As the presented material indicates, the disease has highly chronic nature which is reflected by the number of hospitalizations – 112 patients required 144 hospitalizations. The “small step” surgery requires use of multiple procedures in the same patient. Results of the cultures require special consideration. What should be emphasized, among 71 patients with infected necrosis, as many as 50 (70.4%) were infected with more than one bacterial strain, 9 bacterial strains at most. The type of cultured bacteria: MRSA in 7 patients, Proteus in 17 patients, Pseudomonas aeruginosa in 6 patients, also indicates difficulties in the antibiotic therapy. Furthermore, the number of fungal infections is increasing. Patients with the diabetic foot can be the source of nosocomial infections due to their complex bacterial flora and long-term hospital therapy (11, 12, 13).

CONCLUSIONS

The authors conclude, basing on analysis of their own material related to patients with the diabetic foot syndrome, treated over the 5 year period:
1. The diabetic foot syndrome occurs more often in men.
2. Type 2 diabetes predominates in both genders.
3. Symptomatic atherosclerosis of the lower limb arteries accompanies 25% cases of diabetic foot syndrome.
4. Small procedures that are repeated many times, predominate in the therapy.
5. The patients undergo multiple hospitalizations.
6. The cultures demonstrate several bacterial species or types.
7. The diabetic foot syndrome patients can be the source of nosocomial infections.
8. The treatment efficacy largely depends on good cooperation with a diabetologist and orthopedist.

REFERENCES

5. Khooedhia L, Dinh T, Schomacker KT et al.: The use of medical hyperspectral technology to evalu-


