SURGICAL CLASSIFICATION OF COMPLICATED SYNDROME OF DIABETIC FOOT
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Abstract
The article generalizes the experience of surgery treatment of 1532 patients with the complicated diabetic foot syndrome (DFS). The authors offer an original surgical classification of complicated DFS, which is based on establishing the clinical form ("С" symbol), anatomic localization ("Z" symbol), etiologic factor ("E" symbol) of affection of lower limb tissues. The classification allows defining a surgical tactics depending on a concrete complication of DFS, and creates conditions for unification and common registration of the form and severity of complicated DFS, as well as the volume of providing surgical help.

Introduction
The complication of creating and introducing a common surgical classification of complicated DFS is conditioned, foremost, by a combination of a few pathogenetic mechanisms of pathology development. It is conventional that development of complicated DFS is conditioned by neuropathy, diabetic osteoarthropathy, disorder of microcirculation and main blood flow and bacillosis [4, 14, 17, 24].

In addition, polymorphism of DFS complications, distinctions in forming indications and choosing the extent of surgical operation also create difficulties at developing the classification [1, 8, 12, 15, 20].

Judging from the bases of conclusive medicine modern classifications of illnesses have to meet the following principles:
- to be clear and accessible;
- to precisely determine the extent of disease severity;
- to make the process of coming to a clinical decision simple and more objective;
- to teach doctors the best modern methods of providing medical care;
- to increase economic efficiency of medical care;
- to serve as a criterion for estimating professional activity;
- to be an instrument of external control;
- to create a possibility of common control of patient database [2, 5, 11, 13, 18, 26].

The basic requirements made by surgeons to a modern classification of complicated DFS are the following: a possibility to create precise and significant subgroups of patients for making a clinical diagnosis, for choosing a method of treatment and for determining the prognosis of its results [3, 6, 9, 19, 21].

To fulfill these requirements the classification must be complex, i.e. to take into account a number of criteria. It is preferable that an amount of these criteria should be minimum sufficient for meeting the indicated requirements.

The aim of the research
To offer an original clinical classification of complicated DFS by improving and adjusting the known modern classifications to conditions of the clinical practice.

Materials and methods
The authors have presented the results of examination and treatment of 1532 patients with complicated DFS, who underwent a course of treatment on the base of chair of surgery with the course of purulent & septic surgery of the Zaporizhzhya medical academy of postgraduate education from 2006 to 2010.
According to International classification of DFS 351 patients have a neuropathic form (22.9%), 168 - ischemic (11.0%), 1013 – neuron-ischemic (66.1%).

The character of purulent & necrotic complications of DFS made up: superficial ulcer - 43 (2.8%); uncomplicated panaritium - 51 (3.3%); corn abscess - 32 (2.1%); hypodermic abscess - 49 (3.2%); deep ulcer - 39 (2.6%); purulent tendovaginitis - 52 (3.4%); purulent tendosynovitis - 26 (1.7%); fasciitis - 64 (4.2%); epifascial phlegmon - 110 (7.2%); subaponeurotic phlegmon - 126 (8.2%); panphlegmona - 53 (3.5%); myonecrosis - 154 (10.1%); osteomyelitis - 113 (7.4%); diabetic osteoarthropathy - Charcot foot - 22 (1.4%); acral necrosis of finger/pandactylitis/gangrene of a few toes or distal part of foot - 394 (25.7%); gangrene of foot and shin - 204 (13.2%) patients.

Except gathering the anamnesis, general clinical and biochemical analyses the examination included additional methods (glycated hemoglobin; C-peptide). Immunological examination included the study of CD clusters of differential antigens (CD3; CD4; CD8; CD16; CD19; CD22; CD25; CD95), as well as the study of interleukines (TNF-α; IL10β; IL2; IL6; IL10), immunoproteins (IgA; IgM; IgG), circulating immune complexes. We examined the activity of CH50 complement, spontaneous nitroblue tetrazolium test, phagocytal activity of neutrophils, phagocytal index, cytochrome index. An instrumental examination included reovasography, Dopplergraphy, Doppler ultrasonic flowmeter of condition of vessels of lower limbs. We made blood inoculation on sterility, determination of specific composition and susceptibility of wound microflora to antibacterial medication.

1489 (97.2%) out of 1532 patients have been operated. Totally there have been 1563 operations, which made up 104.9% in relation to the amount of the operated patients. 241 (16.2%) out of 1489 operated patients had amputations at the level of the shin and thigh, among them 28 patients (1.9%) at the shin level, 213 (14.3%) at the thigh level. 7.5% cases (16 patients) had sepsis diagnosed.

In all 18 patients died, general postsurgery lethality made up 1.2%. As for patients with high amputation 12 persons died, postsurgery lethality made up 5.6%.

Results and discussion

DFS Wagner P.M. classification is the most known and widely used in practice [25]. It includes determining the depth (prevalence) of development of infectious inflammatory process and reflects degrees (from 0 to 5 degree) of tissue affection:

0 stage – the skin intact, possible hyperemia, pre-ulcerous skin changes, bone deformations;
1 stage – superficial ulcerous defect;
2 stage – deep ulcer (there is subcutaneous fat, tendons, joint capsule at the ulcer bottom);
3 stage – deep ulcer which gets to the bone structures, joint cavities, with the presence of infection;
4 stage – limited gangrene (fingers, heel or gangrene of transmetatarsal level);
5 stage – widespread gangrene.

However this classification does not take into account the etiologic features of DFS development. The classification is "conditional", as it does not distinguish all variety of tissue affection, as well as it complicates or makes it impossible to describe (grade) the ulcerous defect. In addition, this classification does not reflect clinical peculiarities and differences of DFS complications, and thus it cannot be a basis for developing standards of surgical treatment.

The modified classification of chronic arterial insufficiency of lower limbs according to Fontaine-Pokrovskokiy is based on the severity degree of tissue ischemia syndrome [7]:

I stage – pain in a limb appears after protracted walking (about 1 km);
II stage – the distance of painless walking (at an average pace at the speed about 3 kilometers per hour) more than 200 m;
II b stage – a patient walks less than 200 m;
III a stage – "pain at rest" appears in the horizontal position, which compels a patient to periodically pull down his leg (up to 3-4 times a night);
III b stage (critical ischemia) – an edema of shin and foot;
IV a stage (critical ischemia) – necrosises in the foot toes;
IV b stage – gangrene of the foot or shin.

However at the neuroischemic form of DFS a pain syndrome and syndrome of intermittent claudication disguise polyneuropathy, therefore there are certain difficulties at using this classification. According to its positions, ischemia of the first, second and third degrees is clinically
diagnosed according to the extent of the expressed pain syndrome, which patient of DFS with
neuroischemia can not have. According to the principles of Fontaine-Pokrovskokiy’s classification,
the reason of necrosis at the fourth degree of ischemia is an occlusion of the main blood stream,
which is not typical for the neuroischemic form of DFS. As latest researches show, at neuroischemia
necrosis can be the consequence of peripheral, but not the main occlusion. It is not always a result
of irreversible violations of hemodynamics, which also contradicts this classification.

Texas University’s classification [16] foresees 12 gradations as for stages and severity degrees of
DFS development, which distinctly enough distinguish etiological components (Table 1).

**Table 1. Texas University’s classification of DFS**

<table>
<thead>
<tr>
<th>Degrees</th>
<th>Stages</th>
<th>I</th>
<th>II</th>
<th>III</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Pre- or post-ulcerous changes of the skin after its epithelization</td>
<td>Surface ulcer, not affecting the sinew, joint capsule or bone</td>
<td>Ulcer, the bottom of which is the sinew or joint capsule</td>
<td>Ulcer, the bottom of which is the bone or joint</td>
</tr>
<tr>
<td>B</td>
<td>+ the presence of infection</td>
<td>+ the presence of infection</td>
<td>+ the presence of infection</td>
<td>+ the presence of infection</td>
</tr>
<tr>
<td>C</td>
<td>+ the presence of ischemia</td>
<td>+ the presence of ischemia</td>
<td>+ the presence of ischemia</td>
<td>+ the presence of ischemia</td>
</tr>
<tr>
<td>D</td>
<td>+ the presence of infection and ischemia</td>
<td>+ the presence of infection and ischemia</td>
<td>+ the presence of infection and ischemia</td>
<td>+ the presence of infection and ischemia</td>
</tr>
</tbody>
</table>

The classification allows describing an ulcerous defect in more detail. In our view, it is the most
successful classification which is simple enough in practice. However it does not reflect the level and
localization of purulent & necrotic affection, which hampers the differential approaches to surgical
treatment.

“PEDIS” classification [23] foresees the following categories:

- Perfusion;
- Extent/size;
- Depth/tissue loss;
- Infection;
- Sensation.

However this classification does not allow estimating the extent of tissue loss.

The international classification [10] classifies DFS according to neuropathic, neuronischemic and
ischemic forms, which make up 60-75%, 20-30% and 5-10%, accordingly. However this classification
does not reflect specific complications of DFS and does not allow defining surgical tactics.

At the International Symposium on the diabetic foot B. Briskin and cowriters (2008)
recommended a new classification of purulent & necrotic complications of DFS, which is based on D.
Ahrenholz’s offer (1991) to distinguish different similar affections of soft tissues [22]. According to
this classification six levels of affections are offered to be distinguished:

I. Skin affection itself (surface ulcer, cutaneous whitlow, subungual panaritium);
II. Affection of hypoderm (the ulcer is deep, usually infected; subcutaneous whitlow, corn
abscess, hypodermic abscesses);
III. Affection of surface fascia (purulent tendovaginitis of the back and sole, tendosynovitis,
abscess, cellulitis, necrotizing fasciitis, non-clostridial fasciitis, epifascial phlegmon);
IV. Affection of muscles and deep fascial structures:
    a) phlegmon of spaces: subaponeurotic one of the sole and back, lateral, medial and middle
spaces, panphlegmona;
    b) necrotizing phlegmon;
    c) myonecrosis nonclostridial and clostridial.
V. Affection of bones and joints:
    a) diabetic osteoarthropathy – Charcot joint;
    b) osteomyelitis – bone, joint, bone & joint.
VI. Gangrene (dry, moist, necrosis acral toe necrosis, pandactylitis, gangrene of foot and shin).
In authors’ opinion, the offered classification represents all the stages of the pathological process, which is important not only for choosing adequate surgical operations but also at making reasonable medical & economic standards which determine both the terms of treatment and payment of charges on medications and implementations of surgical operations. But this classification has not been ratified.

Some authors of their own classifications, in our opinion, a little bit exaggerate the role of instrumental methods of examination (ultrasonic Dopplergraphy, partial oxygen pressure in capillary blood of foot, regional systolic pressure) at gradation of neuropathic, neuroischemic and ischemic forms of DFS. Except this, not all hospital surgical departments have above-mentioned equipment, that is why much simpler and much clearer classification of complicated DFS is needed for everyday use.

At the XXII congress of surgeons of Ukraine (Vinnitsa, 2010) participants offered the classification of complicated DFS, which foresees the creation of standard treatment protocols from positions of conclusive medicine, and grounds real duration of patient’s stay in hospital.

The surgical classification of complicated DFS offered by us is defined as "CZE" system. It takes into account a clinical form ("С" symbol), anatomic localization ("Z" symbol), and etiologic factor ("E" symbol).

The clinical form foresees to identify certain DFS complication, and is indicated by symbols from С1 to С18 taking into account the increasing degree of severity of local tissue affection of a limb:
- С1 – surface ulcer;
- С2 – uncomplicated whitlow;
- С3 – corn abscess;
- С4 – hypodermic abscess;
- С5 – deep ulcer;
- С6 – purulent tendovaginitis;
- С7 – purulent tendosynovitis;
- С8 – fasciitis;
- С9 – epifascial phlegmon;
- С10 – subaponeurotic phlegmon;
- С11 – panphlegmona;
- С12 – myonecrosis;
- С13 – osteomyelitis;
- С14 – diabetic osteoarthropathy - Charcot foot;
- С15 – acral necrosis of finger;
- С16 – pandactylitis;
- С17 – gangrene of a few fingers or distal part of foot;
- С18 – gangrene of foot and shin.

The extent of local pathological process is estimated by anatomic criteria which are marked from Z1 to Z4, and also reflect an increasing character of severity of tissue affection:
- Z1 – skin, hypoderm, surface fascia;
- Z2 – muscles and deep fasciae;
- Z3 – bone and/or joint;
- Z4 – all tissues of foot and/or shin.

The following clinical variants correspond to the indicated anatomic criteria of tissue affection of a limb:
- for Z1 – С109 (from «surface ulcer» to «epifascial phlegmon»);
- for Z2 – С1012 (from «subaponeurotic phlegmon» to «myonecrosis»);
- for Z3 – С1314 («osteomyelitis» або «diabetic osteoarthropathy - Charcot foot»);
- for Z4 – С1518 (from «acral necrosis of finger» to «gangrene of foot and shin»).

The etiologic factor is taken into account as the presence of infection – Е1, presence of ischemia – Е2, presence of infection and ischemia – Е3.

Taking into account an etiologic factor the symbol indication of clinical diagnosis of complicated DFS according to "CZE" system can have the following four basic groups of variants:
- С109Z1Е13;
- С1012Z2Е13;
- С1314Z3Е13;
Results show that the offered gradation of clinical variants of DFS complications is correlated with the character and volume of surgical treatment, and allows making the quantitative account of the latter (Table 2).

Table 2. The character of purulent & necrotic complications of patients with DFS

<table>
<thead>
<tr>
<th>Complications</th>
<th>Recommended abbreviation</th>
<th>The number of patients</th>
<th>The number of operations</th>
<th>Amputations (emergency) of</th>
<th>shin</th>
<th>thigh</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>abs %</td>
<td>abs %</td>
<td>abs %</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Surface ulcer (C₁)</td>
<td>C₁Z_E₁_3</td>
<td>43 2,8</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Uncomplicated whitlow (C₂)</td>
<td></td>
<td>51 3,3</td>
<td>51 3,3</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Corn abscess (C₃)</td>
<td>C₃Z_E₃_3</td>
<td>32 2,1</td>
<td>32 2,1</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Hypodermic abscess (C₄)</td>
<td></td>
<td>49 3,2</td>
<td>49 3,2</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Deep ulcer (C₅)</td>
<td></td>
<td>39 2,6</td>
<td>22 1,4</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Purulent tendovaginitis (C₆)</td>
<td></td>
<td>52 3,4</td>
<td>57 3,7</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Purulent tendosynovitis (C₇)</td>
<td></td>
<td>26 1,7</td>
<td>28 1,8</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Fasciae (C₈)</td>
<td></td>
<td>64 4,2</td>
<td>71 4,6</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Epifascial phlegmon (C₉)</td>
<td></td>
<td>110 7,2</td>
<td>112 7,3</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Subaponeurotic phlegmon (C₁₀)</td>
<td>C₁₀Z₀E₁_3</td>
<td>126 8,2</td>
<td>134 8,7</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Panphlegmona (C₁₁)</td>
<td>C₁₁Z₀E₁_3</td>
<td>53 3,5</td>
<td>69 4,5</td>
<td>5</td>
<td>0,3</td>
<td>8 0,5</td>
</tr>
<tr>
<td>Myonecrosis (C₁₂)</td>
<td>C₁₂Z₀E₁_3</td>
<td>154 10,1</td>
<td>159 10,4</td>
<td>2</td>
<td>0,1</td>
<td>7 0,4</td>
</tr>
<tr>
<td>Osteomyelitis (C₁₃)</td>
<td>C₁₃Z₀E₁_3</td>
<td>113 7,4</td>
<td>121 7,9</td>
<td>3</td>
<td>0,2</td>
<td>-</td>
</tr>
<tr>
<td>Diabetic osteoarthropathy - Charcot foot (C₁₄)</td>
<td>C₁₄Z₀E₁_3</td>
<td>22 1,4</td>
<td>22 1,4</td>
<td>2</td>
<td>0,1</td>
<td>-</td>
</tr>
<tr>
<td>Acral necrosis of finger (C₁₅)</td>
<td>C₁₅Z₁E₁_3</td>
<td>394 25,7</td>
<td>427 27,9</td>
<td>4</td>
<td>0,3</td>
<td>6 0,4</td>
</tr>
<tr>
<td>Pandactylitis (C₁₆)</td>
<td>C₁₆Z₁E₁_3</td>
<td>204 13,2</td>
<td>209 13,6</td>
<td>12</td>
<td>0,8</td>
<td>192 12,5</td>
</tr>
<tr>
<td>Gangrene of a few fingers or distal part of foot (C₁₇)</td>
<td>C₁₇Z₁E₁_3</td>
<td>1532 100</td>
<td>1563 105,0</td>
<td>28</td>
<td>1,8</td>
<td>213 13,9</td>
</tr>
</tbody>
</table>

Let’s make examples of diagnosing according to "CZE" system: acral necrosis of a foot toe – $C₁₅Z₁E₁₃$; gangrene of distal foot regions – $C₁₇Z₁E₁₃$.

At first sight the bulky classification of complicated DFS is absolutely leveled in everyday practical work of surgeons – specialists who are engaged in the problem of diabetes mellitus. But this classification is adapted to the specific character of purulent & necrotic complications of DFS, and lets more fully take into account the basic variants of local displays of DFS forms which need surgical treatment.

The advantages of the offered clinical classification of complicated DFS are the following:
– a complex clinical estimation of the local state of the affected area at complicated DFS, which takes into account anatomic features (localization and depth of affection), clinical form, prevailing etiologic factor;
– a clear division of anatomic and clinical features which are at complicated DFS;
– a strict correlation of anatomic features of local affection with the clinical form of DFS;
– making a clinical diagnosis individual for every patient according to "CZE" system;
– developing the common medical tactics and prognosis of treatment results for each patient estimated according to "CZE" system.

Conclusions
The offered original classification of complicated DFS is based on establishing the clinical form ("C" symbol), anatomic localization ("Z" symbol), etiologic factor ("E" symbol) of affection of lower...
limb tissues. The classification is clinical, allows defining a surgical tactics depending on a concrete complication of DFS, and creates conditions for unification and common registration of the form and severity of complicated DFS, as well as the volume of providing surgical help.

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