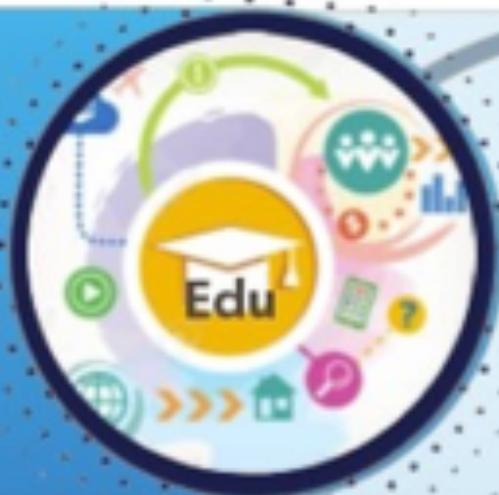




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# Purulent-Necrotic Forms of Diabetic Foot Syndrome in Patients with Chronic Renal Failure

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## ABSTRACT

*Purulent-necrotic lesions in diabetic foot syndrome remain one of the most difficult clinical problems in patients with a combined course of diabetes mellitus and chronic renal failure. In the conditions of uremia and impaired tissue metabolism, infectious and necrotic processes on the lower extremities are especially severe, often requiring urgent surgical interventions. The present study is aimed at a comparative analysis of two categories of patients: patients with end-stage chronic renal disease who are on programmatic hemodialysis, and patients with chronic renal failure who receive only conservative therapy (diuretics and metabolic correction). A total of 28 patients with purulent-necrotic forms of diabetic foot syndrome were included in the study, of whom 14 were on hemodialysis and 14 were without dialysis. Clinical and laboratory parameters, the dynamics of the purulent process, the applied antibacterial therapy regimens, the volume and timing of surgical interventions, as well as treatment outcomes were analyzed. It has been established that patients on hemodialysis are characterized by a more pronounced systemic inflammatory reaction, a high frequency of the need for amputations, and a long period of re-epithelialization. At the same time, in patients with chronic renal failure without dialysis, conservative approaches are more effective with a lower frequency of severe surgical interventions. The data obtained emphasize the need for a differentiated therapeutic approach, taking into account dialysis status, as a key factor in the prognosis and tactics in the treatment of purulent-necrotic forms of diabetic foot syndrome.*

**Keywords:** *diabetic foot syndrome; chronic renal failure; Hemodialysis; purulent-necrotic lesions; surgical tactics; antibiotic therapy; Diabetic complications*

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## INTRODUCTION

**D**iabetic foot syndrome is a severe complication of diabetes mellitus, characterized by damage to the tissues of the foot with the development of ulcerative-necrotic and purulent-destructive changes, often leading to disability and amputations. According to epidemiological studies, the incidence of diabetic foot syndrome in patients with diabetes mellitus reaches 10–15%, and in the presence of concomitant chronic renal failure, it increases significantly [1]. This combination of pathology not only aggravates the course of the local infectious process, but also determines the complexity of the choice of therapeutic tactics, especially in the conditions of the terminal stage of chronic renal failure and programmatic hemodialysis.

Chronic renal failure in patients with diabetes mellitus is accompanied by multi-organ metabolic disorders, including uremic intoxication, anemia, dysproteinemia and immune dysfunction, which predisposes to the development of severe infectious and inflammatory complications. At the same time, hemodialysis itself, despite its substitutive nature, does not completely eliminate these disorders, and in some cases increases the inflammatory background due to the activation of complement and transmembrane transport of endotoxins [2]. Together, these changes reduce the effectiveness of standard antibiotic therapy regimens, prolong the time of tissue regeneration and increase the risk of septic complications.

Features of purulent-necrotic forms of diabetic foot syndrome in patients with terminal chronic renal failure on dialysis therapy include a higher incidence of moderate and profound lesions according to the Wagner classification, a high degree of microbial contamination of wounds, pronounced tissue ischemia, and a reduced ability to regenerate [3]. At the same time, in patients with preserved residual renal function who are on conservative therapy, the course of diabetic foot syndrome may be less aggressive, allowing to be limited to antibiotic therapy and local surgical debridement.

Currently, there is no single standard for the management of patients with diabetic foot syndrome in the setting of chronic renal failure, taking into account dialysis status. Most clinical guidelines are focused either on patients with normal renal function or on the general principles of managing diabetic foot syndrome without taking into account renal pathology [4, 5]. In this regard, it seems relevant to conduct a comparative analysis of the clinical course, surgical tactics and drug treatment of purulent-necrotic forms of diabetic foot syndrome in pa-

tients with chronic renal failure with and without hemodialysis, which is the purpose of this study.

## MATERIAL AND METHODS

**T**his study covers clinical observation of 28 patients with an established diagnosis of purulent-necrotic form of diabetic foot syndrome combined with chronic renal failure of varying degrees. All patients were treated in a specialized surgical department during 2024. The main objective was to conduct a comparative analysis of therapeutic tactics in patients with end-stage chronic renal failure receiving renal replacement therapy in the form of programmatic hemodialysis, and patients on conservative treatment who do not need dialysis.

The formation of two study groups was carried out taking into account the dialysis status of patients. The first group included 14 patients (the main group) with end-stage chronic renal failure, who were on regular hemodialysis for at least three months (the average dialysis experience was  $2.1 \pm 0.6$  years). The second group (comparative, also  $n = 14$ ) included patients with stage IIIb–IV chronic renal failure, who had stable residual renal function, were on diuretic therapy (mainly furosemide at doses of 40–80 mg per day and torsemide up to 20 mg/day), as well as receiving metabolic support and correction of anemia.

The inclusion criteria for the study assumed the presence of type 2 diabetes mellitus lasting at least five years, the presence of signs of purulent-necrotic foot lesions, confirmed clinically and instrumentally, as well as laboratory-verified chronic renal failure of at least stage IIIb according to the KDIGO classification. All patients provided voluntary written consent to participate in the study. Patients with signs of sepsis outside the focus of diabetic foot syndrome, with active oncological, autoimmune or hematological diseases, as well as patients under 40 or over 75 years of age were excluded from the number of admissions.

The diagnostic program included a complete blood test, an extended biochemical profile with the determination of glucose, creatinine, urea, glycosylated hemoglobin (HbA1c), C-reactive protein and procalcitonin. The functional state of the kidneys was additionally assessed using the Cockcroft-Gault formula to calculate creatinine clearance. The severity of foot ischemia was determined by ultrasound duplex scanning of the arteries of the lower extremities, and the nature of bone destruction was assessed by X-ray data. All patients underwent

bacteriological examination of wound discharge followed by antibacterial susceptibility testing.

Drug therapy in both groups included correction of carbohydrate metabolism with the use of short-acting and extended-acting insulin, maintenance of water-electrolyte balance, correction of anemia with iron and/or erythropoietin, as well as antibacterial therapy taking into account the microbiological culture data. In patients on hemodialysis, regimens with the use of carbapenems, vancomycin or linezolid were more often used, due to the high risk of contamination of wounds with resistant forms of hospital flora. While in the second group, third-generation cephalosporins were predominantly used in combination with fluoroquinolones or metronidazole.

Local therapy included daily dressings using modern antiseptics (octenisept, dioxidine, polyoxidonium), enzyme ointments (iruxol) and vacuum dressings if indicated. Surgical tactics were formed individually depending on the clinical picture and the extent of the process, including drainage incisions, necrectomy, amputations of phalanges, foot rays or lower leg.

Statistical processing of the data obtained was carried out using the Statistica v.12.5 and SPSS v.22 software packages. Arithmetic mean (M), standard deviation (SD), median (Me) and interquartile range (IQR) were used to describe the quantitative data. To compare quantitative features between groups, the Student's t-test or the Mann-Whitney U-test was used, depending on the distribution of data. For qualitative features, Pearson's  $\chi^2$  test was used. The differences were considered statistically significant at a significance level of  $p < 0.05$ .

## RESULTS

**A** comparative analysis of the two groups under study demonstrated significant differences both in the clinical course of purulent-necrotic forms of diabetic foot syndrome and in the treatment tactics used. In patients with chronic renal failure undergoing programmatic hemodialysis, the course of diabetic foot syndrome was characterized by a greater severity of systemic inflammatory response, a more severe angiopathic background, and the need for aggressive surgical intervention in the early stages of hospitalization.

The mean leukocyte count on admission in Group I patients (hemodialysis) was  $13.4 \pm 1.8 \times 10^9/L$ , which was statistically significantly higher than in Group II patients ( $10.1 \pm 1.2 \times 10^9/L$ ;  $p < 0.01$ ). Serum C-reactive protein concentrations were also higher in dialysis patients ( $72.6 \pm 11.4$  mg/L versus  $51.3 \pm 8.9$  mg/L;  $p < 0.01$ ), reflect-

ing a more intense systemic inflammatory response. The level of procalcitonin exceeded 0.5 ng/ml in 10 out of 14 patients on dialysis, while in the control group this indicator did not exceed the threshold of sepsis in 85.7% of cases ( $p = 0.02$ ).

The stage of foot lesions according to the Wagner classification in the first group averaged  $3.8 \pm 0.6$  points, which indicated the predominance of phlegmonous-necrotic and osteonecrotic forms with deep tissue involvement. In the second group, the mean value was  $2.7 \pm 0.5$  points ( $p < 0.01$ ), corresponding to ulcerative or superficial purulent forms without bone destruction. Microbiological examination of wound discharge in patients on dialysis more often revealed multi-resistant flora (in 71.4% of cases), represented by strains of *Pseudomonas aeruginosa*, *Acinetobacter baumannii* and MRSA, while in patients without dialysis, mixed gram-positive microflora with moderate sensitivity to standard drugs prevailed.

The antibiotic therapy used differed significantly between the groups. In patients of the first group, 11 out of 14 cases required the prescription of combination therapy with the participation of carbapenems, vancomycin or linezolid, often with subsequent correction of the regimen based on the results of the antibiotic gram. In contrast, in the second group, empirical therapy with ceftriaxone, ciprofloxacin, or amoxicillin/clavulanate was most effective. The mean duration of antibiotic therapy was  $14.8 \pm 2.1$  days in the study group and  $10.1 \pm 1.7$  days in the comparative group ( $p < 0.05$ ).

Differences were also noted in the structure of surgical interventions. In patients on hemodialysis, in 9 cases, necrectomy was required with subsequent wound revisions under anesthesia, in 5 cases — amputations (including 2 foot amputations and 3 amputations of fingers or rays). In the control group, necrectomy was performed in 4 cases, amputations in 2 cases (both cases were limited to finger resection). Thus, the frequency of radical surgical interventions (amputations) was 35.7% in the study group versus 14.3% in the second group.

The duration of the wound process and the period to clinical epithelialization also differed. In patients receiving hemodialysis, the mean duration of open wound management was  $28 \pm 4$  days, while in the control group it was  $19 \pm 3$  days ( $p < 0.01$ ). The duration of hospitalization correlated with clinical dynamics and amounted to  $25.4 \pm 3.6$  days in the study group versus  $17.1 \pm 2.8$  days in the second group ( $p < 0.01$ ).

Thus, the results of the study showed that the presence of renal replacement therapy in the form of he-

modialysis in patients with diabetic foot syndrome is associated with a more severe clinical course, the need for the use of broad-spectrum antibiotics and an increased frequency of radical surgical interventions. The control group of patients, despite the presence of chronic renal failure, demonstrated more favorable treatment dynamics with fewer interventions and less aggressive antibacterial support.

## DISCUSSION

**D**iabetic nephropathy is one of the most common and severe microvascular complications of diabetes mellitus, leading to the development of chronic renal failure and the need for renal replacement therapy. The pathogenesis of diabetic nephropathy includes glomerular hyperfiltration, activation of the renin-angiotensin-aldosterone system, oxidative stress, and chronic inflammation, which leads to progressive glomerular sclerosis and loss of filtration capacity [1]. In the late stages of renal failure, the level of uremic toxins increases sharply, the immune response decreases and tissue metabolism is disrupted, which together creates favorable conditions for the chronicity and generalization of the infectious process in the presence of trophic defects.

Patients with end-stage chronic renal failure undergoing programmatic hemodialysis have persistent immune disorders due to both uremia itself and exposure to dialysis membranes. Pro-inflammatory cytokines are activated, the function of neutrophils and macrophages is impaired, complementary activity and cellular immunity are reduced [2]. This makes such patients vulnerable to nosocomial infections and worsens reparative processes in the areas of chronic wounds. Along with this, anemia, hypoalbuminemia and acidosis intensify ischemic processes in peripheral tissues, forming an unfavorable metabolic background for the healing of ulcerative-necrotic lesions.

In contrast, patients with diabetic nephropathy who are at a preclinical or intermediate stage, chronic renal failure and do not require dialysis, retain partial renal functional activity, which allows for more effective control of water-salt and acid-base balance, avoids pronounced uremic intoxication and minimizes the need for massive drug load. With competent correction of hypertension, glycemia, and metabolic disorders, it is possible to achieve stabilization of renal parameters and provide a more favorable immunoinflammatory background in infected diabetic wounds [3].

Diabetic foot syndrome is a multifactorial clinical syndrome that develops against the background of a combination of peripheral neuropathy, ischemia and immune deficiency. The most severe variant is the purulent-necrotic form, in which the infection penetrates deep tissues and bone, causing osteomyelitis and phlegmons that require surgery. According to large multicenter studies, the risk of amputation in such patients can reach 20–30%, especially in the presence of concomitant cardiovascular or renal diseases [4]. Ischemia and angiopathy slow the migration of leukocytes, impair the delivery of antibiotics and reduce the effectiveness of regeneration.

In patients on hemodialysis, the course of diabetic foot syndrome is accompanied by a higher frequency of deep tissue lesions, since pronounced capillaropathy and vasoconstriction cause impaired perfusion at the level of the microcirculatory bed. In addition, such patients often have an increased tendency to swelling of the soft tissues of the foot due to disorders of water metabolism, which additionally increases the risk of necrotization and delimitation of purulent foci. Interestingly, even with adequate antibiotic therapy, the wound process in these patients proceeds slowly, with frequent relapses and a tendency to chronicity [5].

In the group of patients without dialysis, despite the presence of diabetic angiopathy and immunodeficiency, recovery after surgical debridement of wounds was more active. This is evidenced by the lower need for amputations, shorter epithelialization times, and a higher response to standard antibiotic therapy. Therefore, the combination of diabetic angiopathy and uremia without hemodialysis leaves room for less aggressive treatment, including conservative treatment, provided that therapy is started early and metabolic parameters are strictly monitored.

The relationship between diabetic nephropathy and diabetic foot syndrome is especially manifested in conditions of decompensation of renal functions. A sharp decrease in immunological reactivity, impaired microvascular permeability, imbalance of potassium, calcium and magnesium, as well as activation of pro-inflammatory cascades make the course of diabetic foot syndrome in patients with chronic renal failure severe and unpredictable. Dialysis status, in turn, exacerbates this process, increasing the risk of multiple organ complications, sepsis, and adverse surgical outcomes. In the presented study, it was noted that in patients on hemodialysis, purulent-necrotic forms of diabetic foot syndrome had a more pronounced inflammatory and tissue component, required early surgical intervention and the use of com-

combined antibiotic therapy, often with the participation of reserve drugs.

The results obtained emphasize the importance of stratification of patients with diabetic foot syndrome not only by the degree of ischemia and the depth of the lesion, but also by renal status. The presence of hemodialysis should be considered as an independent aggravating factor that requires strict antibacterial and surgical tactics. At the same time, in the presence of residual renal function in patients with chronic renal failure, it is possible to use more sparing approaches, including the rejection of amputations in favor of step-by-step sanitation and local control of infection. Such differences should be taken into account when forming clinical protocols and predicting treatment outcomes in this category of patients.

### CONCLUSION

The results of the study confirmed that the presence of chronic renal failure in patients with diabetic foot syndrome has a pronounced impact on the nature of the course of purulent-necrotic forms of the disease. In patients undergoing programmatic hemodialysis, the infectious process proceeded with more pronounced signs of a systemic inflammatory reaction, a high incidence of osteonecrosis and microbial contamination of tissues with multiresistant flora. These features determined the need for early and extended surgery, the use of broad-spectrum antibiotics and an extended therapy regimen.

Patients with chronic renal failure who did not receive hemodialysis, despite the presence of angiopathy and immune disorders, demonstrated a more stable course of the purulent process, a better response to standard antibiotic therapy, and less need for radical surgery. Comparative analysis showed that it is dialysis status that serves as a key stratification factor in the formation of treatment tactics, determining both the medical and surgical scope of interventions.

Thus, individualization of approaches to the treatment of purulent-necrotic forms of diabetic foot syndrome in patients with chronic renal failure should be based on the

assessment of dialysis dependence. In patients on hemodialysis, the strategy of early surgical intervention, parenteral antibacterial therapy with reserve drugs and prolonged control of the wound process is justified. At the same time, in patients with preserved residual renal function, it is advisable to use staged sanitation and less aggressive methods of treatment, which reduces the risk of amputations and shortens the duration of inpatient treatment.

**Conflict of Interest** - The author declares that there is no conflict of interest.

**Funding** - The study was carried out without external funding.

**Ethical Approval** - The clinical trial was conducted in accordance with the Declaration of Helsinki (2013) and approved by the Local Ethics Committee of Tashkent State Medical University. All patients signed voluntary informed consent to participate in the study.

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**SURUNKALI BUYRAK YETISHMOVCHILIGI  
FONIDA GEMODIALIZ QILINAYOTGAN VA  
QILINMAYOTGAN BEMORLARDA DIABETIK  
OYOQ SINDROMNING YIRINGLI-NEKROTIK  
SHAKLLARI**

**SAITOV D.N.**

**TOSHKENT DAVLAT TIBBIYOT UNIVERSITETI**

**ANNOTATSIYA**

Diabetik oyoq sindromining (DOS) yiringli-nekrotik shakllari, ayniqsa surunkali buyrak yetishmovchiligi (SBY) bilan ogʻrigan bemorlarda, zamonaviy xirurgiyaning dolzarb muammolaridan biri hisoblanadi. Bu kasallikning kechishi, ayniqsa, gemodializ oluvchi bemorlarda jiddiyroq boʻlib, infeksiyon jarayon tez chuqurlashadi va murakkab xirurgik yondashuvni talab qiladi. Ushbu tadqiqotda 28 nafar SBY bilan ogʻrigan va diabetik oyoq sindromining yiringli shakllariga ega bemorlar oʻrganildi. Ularning 14 nafari muntazam gemodializ olgan, qolgan 14 nafari esa diuretiklar asosida konservativ davolangan. Tadqiqot davomida klinik va laborator koʻrsatkichlar, antibiotik terapiyasi turlari, operatsiyalar hajmi hamda davolanish samaradorligi solishtirildi. Gemodializ guruhidagi bemorlar yuqori yalligʻlanish belgilariga, sekin epitelizatsiyaga va koʻproq amputatsiya ehtiyojiga ega boʻlgan. Konservativ davolanayotgan bemorlarda esa yiringli jarayon ancha yengil kechgan, operatsiyalarga ehtiyoj kam boʻlgan va davo natijalari ijobiy boʻlgan. Tadqiqot natijalari gemodializ holatini individual davolash strategiyasini belgilashda muhim omil sifatida hisobga olish zarurligini koʻrsatdi.

**Kalit soʻzlar:** diabetik oyoq sindromi; surunkali buyrak yetishmovchiligi; gemodializ; yiringli-nekrotik oʻzgarishlar; xirurgik davolash; antibiotik terapiyasi; diabet asoratlari

**ГНОЙНО-НЕКРОТИЧЕСКИЕ ФОРМЫ  
СИНДРОМА ДИАБЕТИЧЕСКОЙ СТОПЫ ПРИ  
ХРОНИЧЕСКОЙ ПОЧЕЧНОЙ  
НЕДОСТАТОЧНОСТИ**

**САИТОВ Д.Н.**

**ТАШКЕНТСКИЙ ГОСУДАРСТВЕННЫЙ  
МЕДИЦИНСКИЙ УНИВЕРСИТЕТ**

**АННОТАЦИЯ**

Гнойно-некротические формы синдрома диабетической стопы (СДС) у больных с хронической почечной недостаточностью (ХПН) представляют собой одну из актуальных проблем современной хирургии. Особенно тяжёлое течение отмечается у пациентов, получающих программный гемодиализ, у которых инфекционный процесс склонен к быстрому прогрессированию и требует расширенного хирургического подхода. В настоящем исследовании были обследованы 28 пациентов с ХПН и гнойно-некротическими формами СДС: 14 получали гемодиализ, остальные 14 находились на консервативной терапии с применением диуретиков. Проведен сравнительный анализ клинико-лабораторных показателей, применяемых схем антибактериальной терапии, объёма хирургических вмешательств и результатов лечения. Установлено, что у пациентов на гемодиализе воспалительный процесс имел более тяжёлое течение, сопровождался отсроченной эпителизацией и чаще требовал ампутаций. У больных, находящихся на консервативном лечении, гнойный процесс протекал менее агрессивно, а результаты терапии были более благоприятными. Полученные данные подчёркивают значимость диализного статуса как одного из ключевых факторов индивидуализации лечебной стратегии.

**Ключевые слова:** синдром диабетической стопы; хроническая почечная недостаточность; гемодиализ; гнойно-некротические изменения; хирургическое лечение; антибактериальная терапия; осложнения сахарного диабета