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The Importance Of Surgical Treatment In Purulent-Necrotic Soft Tissue Infections Associated With Diabetes Mellitus

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Abstract

At present, there is no optimal treatment method for infectious complications of diabetic foot syndrome, especially in cases of sepsis, developing against the background of diabetes mellitus. Despite advances in modern medicine in recent years, the timely diagnosis and proper treatment of infectious complications associated with diabetes mellitus remain highly relevant. The main risk factors for the development of systemic inflammatory response syndrome and various forms of sepsis in purulent-necrotic diseases of soft tissues and postoperative wound infections have been identified. In addition, rational principles of surgical and conservative treatment of local and generalized forms of soft tissue infection are described. This review article presents modern approaches to the treatment of infectious complications developing in patients with diabetes mellitus, and discusses classifications as well as перспективные направления развития методов хирургического лечения.

Keywords. Diabetes mellitus, Systemic Inflammatory Response Syndrome (SIRS), Sepsis, Soft tissue infection.

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1. Introduction

In recent decades, there has been an increase in the number of patients with generalized forms of purulent-necrotic soft tissue infections, in which clinical manifestations of various forms of sepsis are observed in 62.5–77.6% of cases, with severe sepsis accounting for 2% to 18%. The mortality rate for this pathology remains high, ranging from 19% to 70%, and, according to current data, sepsis ranks 11th among the causes of overall mortality in the Russian Federation [1, 2, 3, 5, 6].

In 1991, at the International Consensus Conference in Chicago, the pathophysiological basis of sepsis was revised, and a classification of septic conditions was adopted, which included: bacteremia, systemic inflammatory response syndrome, sepsis, severe sepsis, and septic shock [7]. This largely determined the directions of scientific research.

Despite the numerous proposed approaches to treatment, the issue of the timing and extent of surgical intervention in generalized forms of infection remains controversial. Some authors consider it necessary to control endotoxemia before performing surgery [4]. Others believe that in generalized infection the septic focus is not localized, and its early surgical debridement makes it possible to break the so-called “vicious cycle” of the pathological process [1, 3, 5, 7]

The aim of this study was to determine the optimal timing and specific features of surgical interventions, as well as postoperative wound management, in local and generalized

soft tissue infections

Materials and Method

A prospective study and analysis of treatment outcomes was conducted in 250 patients with purulent-necrotic soft tissue infections treated at Twins Medical Center from 2024 to 2026. During the study, all patients were divided into three groups. The first group included 44.9% of patients (n=112) with a local form of infection who had no systemic response of the organism. The second group comprised 13.3% of patients (n=33) with compensated systemic inflammatory response syndrome, which persisted for less than 72 hours after sanitation of the infectious focus. The third group included 41.8% of patients (n=105) with various forms of sepsis, in whom systemic response syndrome persisted for more than 72 hours after sanitation of the infectious focus, and signs of multiple organ failure or hemodynamic instability were present.

The basis of complex treatment for this category of patients included surgical treatment, rational antibacterial therapy, and detoxification therapy. Local treatment included the use of antiseptics, ultrasound wound cavitation, enzyme preparations, and open wound management under abacterial conditions. The use of abacterial environment conditions was carried out in accordance with the ethical standards set out in the Declaration of Helsinki; all patients in this group were informed about the specifics of open wound management and gave their voluntary informed consent.

For analysis of the obtained results, nonparametric statistical methods were used: the Kruskal–Wallis test and the chi-square test with Yates' correction. The critical level of significance was set at 0.05.

Results and Discussion

Considering the high probability of the influence of prolonged persistence of the primary infectious focus and the characteristics of the local inflammatory tissue response on the development of different forms and clinical variants of infection, we analyzed these parameters in patients with various forms of soft tissue infections.

The average duration of outpatient treatment in local infection was 5.2 ± 0.091 days, in compensated systemic inflammatory response syndrome (CSIRS) 6.8 ± 0.22 days, and in various forms of sepsis 10.4 ± 0.123 days ($p1–3 < 0.05$). From this it follows that if the infectious focus persists for more than 5–6 days, it acquires septic properties, which leads to the development of a generalized form of infection.

Regarding the nature of the inflammatory response, 70% of patients with local infection demonstrated a well-demarcated inflammatory process, while soft tissue phlegmon was observed in 58% of patients with CSIRS and 71% of patients with various forms of sepsis ($p < 0.05$). At the same time, a purulent inflammatory character was noted in 91% of patients with local infection and 89% of patients with CSIRS ($p > 0.05$), whereas necrotic tissue changes were identified in 31% of patients with sepsis ($p < 0.05$).

Comorbid diabetes mellitus and pathology of the arteries and veins of the lower extremities also influenced the nature of the inflammatory tissue response and wound healing. Angiopathy was more frequently diagnosed in generalized infection: 6.4% (CSIRS) and 7.3% (sepsis), while in local infection it was present in 1.2% of patients ($p < 0.05$). Diabetes mellitus accompanied soft tissue infection in 3.9% of cases in local infection ($p < 0.05$), and in generalized infection in 10.7% (CSIRS) and 11.8% (sepsis) of cases.

Analysis of surgical treatment outcomes showed that in various forms of sepsis, the severity of the patients' condition and the need for primary detoxification and correction of organ dysfunction allowed primary debridement of the infectious focus to be performed 7.4 ± 0.07 hours after admission for purulent infection, and 5.3 ± 0.08 days after hospitalization in cases of putrid-necrotic infection ($p < 0.05$). In contrast, in local infection and CSIRS, primary debridement was performed in purulent cases after 2.6 ± 0.03 and 4.7 ± 0.08 hours, respectively, and in necrotic cases after 2.8 ± 0.04 and 3.5 ± 0.05 days of hospitalization ($p < 0.05$). In some patients, repeated planned and emergency surgeries were used for adequate debridement of the infectious focus.

In purulent inflammation, repeated surgeries were generally emergency in nature and were performed in 1.3% of patients with local infection, 1.1% of patients with CSIRS, and 28% of patients with various forms of sepsis ($p1–2 > 0.05$; $p1–3$, $2–3 < 0.05$).

The high rate of repeated surgeries in various forms of sepsis was due not only to insufficient adequacy of primary surgical debridement but also to the independent and often uncontrolled course of the systemic inflammatory response. In such cases, repeated operations served as a method of differential diagnosis between a persistent focus of bacterial invasion and different variants of generalized infection. In addition, the wound process in sepsis was characterized by a slow course and prolonged inflammatory response of tissues, requiring staged surgical interventions. In local infection and CSIRS, debridement of the infectious focus

acted as a trigger for the resolution of both local and systemic inflammatory signs, which explained the lower rate of repeated operations.

In putrid-necrotic infection, the course of the wound process is characterized by the presence of non-viable tissues within the inflammatory zone, which cannot always be removed during primary debridement. In some cases, necrotic tissue changes were directly associated with the characteristics of the pathogen (Pseudomonas aeruginosa, anaerobic infection, etc.) or developed secondarily against a background of circulatory disorders (arterial or venous insufficiency, etc.).

Treatment of putrid-necrotic infections was generally multi-stage, which determined a high rate of repeated planned operations: in 12%[1] of patients with local infection, in 30%[2] of patients with compensated systemic inflammatory response syndrome, and in 72%[3] of patients with clinical sepsis ($p1–2–3 < 0.05$).

Results of cytological studies in sepsis indicate late appearance of inflammatory (12 ± 0.23 days) and regenerative (20 ± 0.31 days) cytogram types, reflecting dysfunction of the local immune response (phagocytic activity (PA) = 53%, phagocytic index (PI) = 2.9 microorganisms per cell) against a background of systemic proinflammatory cytokinemia. This slowed wound cleansing from necrotic tissues and required multiple staged necrectomies. In patients with local infection (PA = 86%; PI = 3.6 microorganisms per cell) and compensated systemic inflammatory response syndrome (PA = 88%; PI = 3.7 microorganisms per cell), the local immune response corresponded adequately to the level of bacterial invasion, and high activity of the neutrophil–macrophage immune link shortened wound cleansing time, transition from the inflammatory phase ($5.7 \pm 0.12–5.9 \pm 0.3$ days) to the regenerative phase ($11 \pm 0.19–12 \pm 0.5$ days), and reduced the rate of repeated operations.

These features of local and systemic inflammatory responses determine the need for early adequate surgical debridement of the infectious focus. Surgical intervention in the presence of systemic inflammatory response syndrome without signs of organ dysfunction should be performed as early as possible after hospitalization (within the first 2–4 hours for purulent infections and no later than 3–4 days for necrotic infections), which increases the likelihood of resolution of the systemic response within the first 72 hours and reduces the risk of sepsis development.

If, at the time of hospitalization, the patient presents with signs of organ dysfunction or failure and the duration of the infectious focus exceeds 10 days, surgical intervention should be preceded by a short course of intensive antibacterial, anti-inflammatory, and detoxification therapy; otherwise, "surgical stress" may aggravate systemic changes in the body.

Surgical interventions in various forms of sepsis should be as short and minimally traumatic as possible, while achieving maximal possible debridement of infectious foci. If there is no clinical effect after primary or subsequent debridement and no clear signs of progression of local inflammatory changes, the dynamics of laboratory inflammatory markers should first be evaluated, secondary infectious foci should be excluded, and detoxification and anti-inflammatory therapy should be intensified. Only if there is no sustained positive response within 12–24 hours should repeat surgical intervention be considered.

This approach is based on the fact that in sepsis, systemic responses lose correlation with the local inflammatory process, and any additional tissue trauma in the septic focus area usually expands its boundaries and triggers further release of proinflammatory factors into the bloodstream, maintaining the chain of systemic pathophysiological reactions.

In cases of soft tissue infection combined with angiopathy due to atherosclerosis or diabetes mellitus, adequate debridement of the primary focus required limb amputation in 76% of patients (n=112) with sepsis, 64% of patients (n=14) with compensated systemic inflammatory response syndrome, and 15% of patients (n=148) with local infection ($p < 0.05$). It should be noted that high-level amputations at the level of the leg or thigh were performed in only 45% of septic patients (n=50), while in the remaining cases, limb-sparing procedures (toe amputations, typical and atypical foot resections) were sufficient.

In the process of searching for effective methods of postoperative wound management in patients with primary and secondary (postoperative wound infection) purulent-necrotic phlegmons of soft tissues, two comparable subgroups were randomly selected according to infection type. The first subgroup, "AMC," included 184 patients in whom, from day 2–3 of treatment, open wound management in an abacterial environment with staged use of single-layer dressings was applied. The remaining 955 patients formed the comparison subgroup and were treated using a closed method with antiseptic-soaked dressings.

Initially, a local form of infection was diagnosed in 33% of

patients in the "AMC" subgroup and 30% in the comparison subgroup, while signs of generalized infection were observed in 67% and 70% of patients, respectively ($p > 0.05$). General treatment in both subgroups included antibacterial, anti-inflammatory, and detoxification therapy.

In the course of comprehensive clinical and laboratory studies, in patients treated in an abacterial environment, normalization of complete blood count parameters was observed in purulent phlegmons 1.7–3 days earlier, and in necrotic processes 3.4–8.5 days earlier compared with the comparison subgroup ($p < 0.05$).

In bacteriological examination of wound exudate in the "AMC" subgroup, elimination of pathogenic flora was observed within 4 ± 0.13 to 16 ± 0.3 days, whereas in the comparison subgroup it occurred within 11 ± 0.09 to 40 ± 0.16 days ($p < 0.001$). According to cytological analysis of the wound surface, the transition from the inflammatory phase to the regenerative phase during treatment in an abacterial environment occurred within 7.6–12.4 days, while in the comparison subgroup it occurred within 13.7–22.7 days ($p < 0.001$).

Treatment in an abacterial environment and open wound management had a positive effect on the course of the systemic inflammatory response. Thus, from day 2 to day 10 of hospitalization in the "AMC" subgroup, 85% of patients showed a clinical picture of local infection, 14% had compensated systemic inflammatory response syndrome, and only 1% had clinical signs of sepsis.

In contrast, with closed treatment, a local form of infection persisted in 20% of patients, compensated systemic inflammatory response syndrome was observed in 31%, and in the remaining 49% of cases various forms of sepsis were recorded (33% sepsis, 16% severe sepsis) ($p < 0.05$).

In addition, the method of open wound management in an abacterial environment reduced the average length of hospital stay in generalized infection from 34.3 ± 0.15 to 27.5 ± 0.6 days, and in patients with local infection from 11.6 ± 0.1 to 9.2 ± 0.08 days ($p = 1.9 \times 10^{-5}$; $p < 0.001$).

Conclusions

1. In order to determine rational treatment tactics for purulent-necrotic soft tissue infections, it is necessary to differentiate between local and generalized forms of infection and to distinguish compensated systemic inflammatory response syndrome and various forms of sepsis as independent clinical variants.

2. The development of a generalized form of infection is promoted by prolonged persistence of the septic focus, the presence of necrotic tissue, and a phlegmonous type of inflammatory tissue response.

3. The main stage of treatment for local infection is adequate early debridement of the inflammatory focus and active management of the wound process in the postoperative period. In cases of compensated systemic inflammatory response syndrome and sepsis, adequate debridement of the primary focus should be performed as early as possible and must be combined with preoperative antibacterial, anti-inflammatory, and detoxification therapy. In severe sepsis, treatment should begin with intensive care and correction of organ dysfunction, and surgical intervention should combine adequacy with minimal invasiveness.

4. The optimal timing for surgical intervention in patients with local and generalized infection in cases of purulent inflammation is within 2–4 hours; in putrid-necrotic processes, no later than 4 days of hospitalization and intensive therapy.

5. Early debridement of purulent-necrotic foci, as well as postoperative open wound management in an abacterial environment, accelerates eradication of wound pathogens, promotes the transition from the inflammatory to the regenerative phase, allows systemic inflammatory response to be controlled within the first 72 hours, reduces the risk of sepsis development, increases the effectiveness of minimally invasive limb-sparing foot surgery in patients with angiopathy and diabetic foot syndrome, and shortens hospitalization time by 1.2–1.3 times.

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