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The effectiveness of the application of nanomaterial polymer technologies in a comprehensive approach to surgical treatment of soft tissue wounds

O. Y. Popadyuk, O. M. Plehutsa

Ivano-Frankivsk National Medical University

Oleg Popadyuk, PhD, Associate Professor General Surgery
Ivano-Frankivsk National Medical University
popadyukoleg@ukr.net, <https://orcid.org/0000-0001-6287-1280>

Oleksandr Plehutsa, Associate Professor, Patient Care and Higher Nursing Education
HSEE of Ukraine «Bukovinian State Medical University»
popadyukoleg@ukr.net, <https://orcid.org/0000-0002-8639-1262>

Abstract

Treatment of purulent wounds remains one of the most important problems of surgery, both theoretically and practically. The aim was to study the effect of biodegradable polymer film "biodep-nano" and hydrated fullerene C₆₀ on the healing of soft tissue wounds and prevention of their infection. We observed 124 patients with purulent-inflammatory soft tissue complications. Scientific group 53 (42.7%) patients who, in addition to complex treatment, performed the proposed therapy. The control group consisted of 71 (57.2%) patients who were treated according to conventional methods. The results showed that the temperature of the study area in the main group returned to normal on the 3rd day (2.8 ± 0.2 days), and in the group where traditionally used wipes on the 5-7th ($5.9 \pm 0, 4$) the day where ($p < 0.05$). Note that the average time of postoperative wound cleansing in patients of the control group was

14.1 ± 0.8 days, the appearance of granulation tissue - 15.6 ± 0.9 days, and the beginning of the marginal epithelialization - 18.4 ± 1.0 days The length of stay of patients in this group on an inpatient bed was 34.3 ± 2.8 days. Thus, from a surgical point of view, a new promising alternative is a combination of surgical treatment of wounds and the use of nano-containing biodegradable polymeric material, which not only destroys pathogenic wound flora, but also can prevent re-infection and purulent-inflammatory recurrence.

Key words: surgical treatment; purulent wound; polymer film.

Introduction. Treatment of purulent wounds, despite the long history of the study, remains one of the most important problems of surgery, both theoretically and practically [1].

Taking into account the biological laws of wound healing of any genesis, common, general principles of wound healing are defined: - control of infection; - early removal of necrotic tissues; - suppression of inflammatory processes; - acceleration of reparative processes; - reduction of terms of wound healing and formation of high-quality invisible scar of dermal type [2].

Today, the treatment of purulent wounds is used in antimicrobial therapy, detoxification, immunostimulatory therapy, local and surgical treatment of wounds. Antimicrobial agents are used in the complex treatment of such wounds, but the use of one such agent with a certain sensitivity of microorganisms in the wound is not always effective [3].

Therefore, antimicrobial therapy in the treatment of wounds must be proven. In 2018, the World Association for Urgent Surgery (WSES) and the European Association for Surgical Infection (SIS-E) adopted Recommendations for the treatment of skin and soft tissue infections, which indicated that patients with common purulent wounds have increased resistance to pathogens, so treatment is purulent. -inflammatory diseases require local application of antimicrobial materials based on antiseptics of multicomponent action in combination with antibiotics [4].

Only such local medical treatment which is carried out in strict accordance with the pathogenesis of the wound process, ie taking into account its phase, can be considered justified. Improper approach to the use of antiseptics can have a negative impact on the timing of wound healing. For effective treatment, wound healing agents must correspond to the pathogenesis of a specific phase of the wound process, provide multidirectional action, have no side effects and be cost-effective [5].

To ensure a comprehensive and effective treatment of wounds of various genesis and prevention of secondary infection of wounds, we have developed and introduced into production a means of hygienic and prophylactic biodegradable polymer film "biodep-nano" [6].

Objective: to clinically evaluate the effect of biodegradable polymer film "biodep-nano" and hydrated fullerene C60 on the healing of soft tissue wounds and prevention of their infection.

Materials and methods: We observed 124 patients with purulent-inflammatory complications of soft tissues of the Department of Bone and Purulent Infection of Ivano-Frankivsk Regional Clinical Hospital (2018-2019). Patients are divided into two groups. The scientific group consisted of 53 (42.7%) patients who, along with comprehensive treatment, performed the proposed therapy. The control group consisted of 71 (57.2%) patients who were treated according to conventional methods. The largest number of patients 102 patients (82.2%) were aged 51-80 years, 22 patients (17.7%) - 20-49 years.

During the first week after the onset of purulent-inflammatory complications, 65 patients sought medical help, which was 52.4% of the total number of patients studied. Two weeks after the onset of purulent-inflammatory complications in 39 patients, which is 31.4%. Five (4.03%) patients were admitted three weeks after the onset of soft tissue inflammatory complications. The analysis of the reasons for late admission to the clinic made it possible to establish that the vast majority of patients, in the event of the initial manifestations of purulent-inflammatory complications, engaged in self-medication.

Diabetic gangrene of the distal parts of the foot was observed in 17 (13.7%) patients. Gangrene of the first toe was observed in seven (5.6%) patients. Isolated gangrene of II, III, IV or V fingers was observed in 21 (16.9%) patients. Phlegmon of the foot occurred in 25 (20.16%) people with diabetes, phlegmon II, III fingers in three patients (2.4%), phlegmon of the shin in 5 patients (4.03%). Purulent wounds of limited areas of the foot occurred in 15 (12.1%) patients, toes in eight (6.5%) patients, shins in seven (5.6%) patients. In 10 (8.06%) patients long-term ulcers of the leg and foot were observed.

In the process of treatment, patients underwent surgery: in 33 (26.6%) patients underwent primary surgical treatment of the wound; exarticulation of the fingers of the lower extremities in 37 (29.8%) patients, with the first finger in 11 (8.9%) patients, the second in 10 (8.1%), the third the 5th in (4.0%), the 4th in the 4th (3.2%), the 5th in the 7th (5.6%); opening and drainage of abscesses in 30 (24.2%) patients.

Amputations of the lower extremities at the level of the lower third of the thigh were performed in 15 (12.1%) patients with purulent-inflammatory soft tissue wounds; one (0.8%) patient performed reamputation of the lower limb at the level of the lower third of the thigh; amputation of the foot by the Chopar method was performed on one (0.8%) person.

Traditional conservative treatment of patients included the following drugs: infusion therapy (5% glucose solution, Ringer-Locke solution, 0.9% sodium chloride solution, reosorbilact), vasoactive drugs (trental, vasoprostane), nicotinic acid, anticoagulants and antiplatelets (heparin, fraxiparin, aspirin, antispasmodics (no-spa, spasmalgon, platyphylline), vitamins A, C, E, group B, biological stimulants, anabolic steroids (retabolil, nerobol), antagonists and agonists, cinnarizine, corinfar), cocarboxylase, ATP, desensitizing drugs (diphenhydramine solution, suprastin, loratadine), diuretics (lasix, furosimide), anti-inflammatory (nimesil, diclofenac, naclofen), cardiac drugs - drugs for the correction of acid antibacterial drugs were prescribed taking into account the sensitivity of microorganisms to them. in the syndrome - ketones, spasmalgon, if necessary, narcotic analgesics (omnupon, promedol). Correction of carbohydrate metabolism (tablets, sugar-lowering drugs and insulin drugs according to the scheme, under the control of blood glucose levels).

We added our own developments to the treatment of patients of the main group: after opening, necrectomy, sanitation and drainage of pus the patient was applied a biodegradable polymer film saturated with nanosized particles of zinc oxide for 48 hours with an interval of two days, which accelerated wound healing, the absence of adverse reactions of body tissues, elasticity, adsorption and moisture permeability of the polymer film and its ability to deliver drugs to the affected area. Per complex therapy was prescribed per os hydrated fullerene C60 (0.0002 mg of compound in 100 ml of water), which patients took in the form of an aqueous solution of 50 ml 3 times a day for 20 minutes before meals for 3 weeks (Permission of the Ministry of Health of Ukraine № 05.03.02-04 / 95179 dated December 2, 2010).

This study was guided by generally accepted world and domestic standards for research in biology and medicine (Vancouver Convention on Biomedical Research) and the provisions of the Helsinki Declaration of Human Rights, the Constitution of Ukraine and other legislation in force in Ukraine. Patients or authorized persons agreed to perform surgical interventions in each specific case.

Results of the study and their discussion. The obtained results showed that the temperature of the study area in the main group returned to normal on the 3rd day (2.8 ± 0.2 days), and in the group where traditionally used napkins on the 5-7th ($5.9 \pm 0, 4$) day, where ($p < 0.05$). Also, it should be noted that in the main group there was a decrease in tissue edema

by an average of 3.8 ± 1.2 days, and in the control group by an average of 6.1 ± 1.7 days, where ($p < 0.05$). Regarding hyperemia, it gradually decreased, and in the main group it was up to 3.9 ± 2.1 days on average, and in the control group by 6.0 ± 1.9 days ($p < 0.05$).

In the main group, the appearance of purulent discharge was noted in the 1st patient, who after sowing was found St. Aureus - $2.4 * 10^6$ CFU / ml, and in the control group signs of infection with severe inflammation and the appearance of purulent discharge were observed in 6 patients, where it was detected in 4 cases of St. Aureus, and in 2 E.Coli. The performed statistical calculations showed a significant statistical difference in the reduction of the inflammatory process in both groups. In the main group there was a decrease in the inflammatory process and a smaller number of secondary infections compared with the control group.

It should be noted that in the main group removal of sutures was performed for 8.7 ± 1.3 days, and in the control group for 10.4 ± 0.9 days, which was caused by prolonged healing of infected wounds in the control group and indicates effective protection of the applied film . The additional use of polymer films in the process of dressings provided reliable protection of the vascular access area in patients on hemodialysis and reduced the risk of secondary external infection due to such properties of the film as: high elasticity, vapor and moisture permeability, tight contact with skin, antimicrobial action , no toxic and sensitizing effects on the body. An important factor is that the absence of secondary infection and reliable prevention reduce both the patient's stay in the hospital and the cost of treatment, which is extremely important in the modern medical system as a whole.

In purulent-inflammatory processes of soft tissues, the pathophysiological process mentioned in general is inextricably linked with progressive intoxication. Accordingly, a prolonged intoxication background creates the effect of endotoxicosis in the body. As a result, the prognosis for purulent-necrotic soft tissue lesions worsens significantly. In recent years, the use of methods of regional supply of drugs to the lesion and activation of the reparative process by physical factors has become widespread in the treatment of this pathology. Their use in the complex treatment of patients with purulent-necrotic soft tissue processes significantly improves the functional results of the complex treatment of patients with this pathology. We found in the clinical material that with internal use of hydrated fullerene C60 and local nano-containing films there is a more intensive activation of reparative processes in the lesions than when performing standard complex antibacterial and antiplatelet therapy on the background of ongoing therapy.

Of particular interest is the analysis of the immediate results of comprehensive treatment of patients with purulent-necrotic soft tissue processes.

The study of the effectiveness of the proposed option was conducted in 53 patients, who were included in the main experimental group.

In patients of the main group in 46 (86.8%) cases received a satisfactory result, ie after surgery the course of the wound process was not complicated by the formation of necrotic tissue, the spread of purulent-necrotic process, the development of osteomyelitis and the like. The edema after surgery was significantly reduced by the third day. Hyperemia of the skin of the foot gradually decreased and disappeared for 3-4 days after surgery. The pain in the postoperative wound was moderate in intensity. In 39 (73.6%) patients on the second day after surgery there was no need to prescribe narcotic analgesics. The formation of granulation tissue was observed from 7 days after surgery.

Increased pain in patients of the main group was observed during exercise in the wound area, which limited the motor activity of patients. Secondary necrotic changes in the area of the postoperative wound, if they occurred, were insignificant in volume and captured a thin strip of skin around the wound. The discharge from the wound was intricate in nature, granulation tissue was formed relatively quickly and marginal epithelialization began.

Complications of the postoperative wound are associated with the prevalence of purulent-necrotic process and the occurrence of septic conditions, was observed in 4 patients (3.8%).

In the main group of subjects, the average time of postoperative wound cleansing on the foot was 7.1 ± 0.4 days, the appearance of granulation tissue - 8.0 ± 0.5 days, and the beginning of marginal epithelialization - 10.7 ± 0.8 days. The average length of stay of patients in this group on an inpatient bed was 19.3 ± 1.2 days and was 1.8 times shorter compared to the same indicator in the control group of patients.

Note that the average time of postoperative wound cleansing in patients of the control group was 14.1 ± 0.8 days, the appearance of granulation tissue - 15.6 ± 0.9 days, and the beginning of the marginal epithelialization - 18.4 ± 1.0 days. The length of stay of patients in this group on an inpatient bed was 34.3 ± 2.8 days.

Summarizing the results of treatment of patients in the control group, we can note that in the study groups, the distribution of patients by volume of surgery and the definition of pathological changes in tissues was characterized by an increase in purulent-inflammatory complications of postoperative wounds and repeated surgical interventions in comparison with the study group.

Based on the results of the study, we first proposed the concept of limiting and preventing the progression of secondary alteration changes in wounds complicated by purulent infection on the basis of new wound healing drugs that have a complex effect on various pathogenesis of the wound process and molecular biochemical healing mechanisms. wounds and prevention of their complications.

Conclusion

1. From the surgical point of view, a new promising alternative is a combination of surgical wound treatment and the use of nano-containing biodegradable polymeric material, which not only destroys pathogenic wound flora, but also can prevent re-infection and purulent-inflammatory recurrence, reduce existing contamination of inflammatory and destructive processes. own plastic resources of the skin, accelerate the formation of granulation and collagen, which promotes rapid and high-quality wound healing.

2. Nanoparticles, as an alternative to antibiotics, in affected soft tissues include mechanisms of induction of oxidative stress, release of metal ions and non-oxidative mechanisms, resulting in several simultaneous mechanisms of action against microbes create several simultaneous gene mutations in a single bacterial cell resistant to antibacterial; which makes it impossible for bacterial cells to become resistant to nanoparticles.

3. Treatment of soft tissue wounds, including those complicated by purulent infection remains a complex, unresolved problem of modern surgery, requires comprehensive discussion, research and a comprehensive approach to solving using the latest modern technologies.

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