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Effect of direct current electric field on the rate of wound epithelization in patients with diabetic foot syndrome

The aim of the work: to study the development of wound process in dynamics by means of examination of impression smear from the wounds of patients with diabetic foot syndrome by means of Pokrovska-Makarova method, planimetric examination by means of L. M. Popova method in case of treatment by traditional methods combined with galvanization of an afflicted lower limb and application of interstitial Berlithion electrophoresis.

Materials and Methods. 113 patients with complicated forms of diabetic foot syndrome were examined and treated. Group 1 of patients underwent a traditional course of treatment, whereas a complex of treatment measures was complemented with galvanization of the affected lower extremity for the patients of group 2 at an early stage of the postoperative period. The patients of group 3 were additionally treated with local interstitial electrophoresis of Berlithion during an early stage of the postoperative period. A control over the dynamics of the wound process was carried out by means of estimating wound impression smears.

Results and Discussion. A comparison of the rate of the transition of the cytological picture of impression smears from the inflammatory type to the regenerative, regenerative-inflammatory and finally to the regenerative types demonstrated that these processes among patients of 1st group occurred, on an average, during 20 days, among patients of the group 2 during 16 days and group 3 – during 14 days. Reducing the area of injury in patients of group 1 is ≈ 1 % per day, patients in group 2 – 2 %, followed by – 2.1–2.2 % per day and patients in group 3 speed up wound area reduction on an average 3 %. Therefore, under effect of direct current of electric field an inflammatory type of cytogram was found mainly from the 3–4 to 7–8th days compared with the control group, where these phenomena were found from the 3-4 to the 11–12th days. Approximately similar dynamics was found in case of ISEP action with Berlithion. When the wound process is passed into the second phase which is evidenced by the appearance of inflammatory impression smear, the rate of regeneration appeared to be the highest in the group of patients who received interstitial electrophoresis with Berlithion.

Key words: diabetes mellitus; diabetic foot syndrome; purulent-necrotic process; wound; galvanization.

Introduction. Purulent-necrotic injuries of the lower limbs are one of the most frequent surgical complications of diabetes mellitus (DM). Unfortunately, the results of their treatment cannot be considered satisfactory [1]. Occurrence of diabetes mellitus among population in different countries is from 1 to 6 % [2].

The aim of the work: to study the development of wound process in dynamics by means of examination of impression smear from the wounds of patients with diabetic foot syndrome by means of Pokrovska-Makarova method, planimetric examination by means of L. M. Popova method in case of treatment by traditional methods combined with galvanization of an afflicted lower limb and application of interstitial Berlithion electrophoresis.

Materials and Methods. 113 patients with complicated forms of diabetic foot syndrome (DFS) were examined including 64 (56.64 %) men and 49 (43.36 %) women, aged from 17 to 84.

In the majority of patients – 53 (46.9 %) DM lasts from 11 to 20 years. 10 (8.9 %) patients were from 20 to 37 years of age. 50 (44,.2 %) patients suffered from diabetes mellitus less than 10 years. Insulin dependent DM was found in 96 (85 %) patients. Moderate degree of DM was found in 93 (82.3 %) patients, and severe DM – in 20 (17.70 %) individuals. Compensated DM was found in 14 (12.39 %) patients, subcompensated – in 78 (69.03 %) and decompensated – in 21 (18.58 %) individuals. 33 (29.20 %) patients suffered from ischemic-gangrenous form of DFS, neuropathic-infected – 20 (17.70 %) and mixed – 60 (53.10 %). According to F. Wagner (1979) patients were divided in the following way: IIb degree was diagnosed in 7 (6.19 %) patients, III degree – in 50 (44.25 %), and IV degree – in 56 (49.56 %).

Conservative treatment included vasoactive drugs, antiaggregants, spasmolytics, biological stimulators, nicotinic acid drugs, anabolic steroids, calcium ions antagonists, vitamins A, C, E, and group B, means for correction of lipid metabolism and those improving the nervous system function, antibacterial broad-spectrum agents considering sensitivity of microorganisms to them. Intra-arterial introduction of medical agents was applied.

Surgical treatment included necrectomy, amputation and exarticulation of toes, transmetatarsal amputations with surgical treatment of phlegmons on the soles, and surgical treatment of phlegmons on the feet.

To assess the characteristics of wound process the method of impression smears taken from wounds elaborated by M. P. Pokrovska and M. S. Makarov (1942) was used. To study the objective criterion of

a wound process development – rate of wound healing – a simple and demonstrative tests suggested by L. N. Popova (1942) was used.

During postoperative period all the patients were divided into three groups. Group 1 included 45 individuals receiving traditional treatment. Group 2 included 51 patients who were subjected to galvanization of the afflicted lower limbs by means of the apparatus "Potok-1" during the early postoperative period (since the first day). Group 3 included 17 patients who in addition to traditional treatment during the early postoperative period received interstitial Berlithion electrophoresis locally on the afflicted lower limb. The circulatory-longitudinal variant of electrode location was used applying anode on the foot and cathode – on the femur. Current density was 0.025–0.05 mA/cm^2. Duration of the procedure was 60 minutes. Interstitial electrophoresis was combined with intravenous drop-by-drop introduction of Berlithion and direct current electric field effect. The course of treatment in both cases lasted no less than 10 sessions.

Results and Discussion. During postoperative period many pathogenic factors influence on the body of patients with complicated forms of DFS. Meanwhile endocrine metabolic disorders associated with the major pathology, effect of purulent-necrotic factor and operation trauma and narcosis should be isolated first of all among them. Hemorheology system is one of the weakest link in which compensation can be lost under the action of the above pathogenic factors. Taking into account the above mentioned it was considered that application of direct current electric field (DCEF) and interstitial electrophoresis (ISEP) with Berlithion recognizing anti-inflammatory action of the indicated methods, activation of blood and lymph circulation, a positive effect on fibrinolytic activity and creation of conditions for much higher concentration of drugs in the purulent focus, can be effective for the correction of hemorheology chain that can be appropriately reflected in the development of wound process.

On admission to hospital cytological picture of impression smears was studied in all the patients. The specimens were indicated to contain practically solid detritus, remains of destructed neutrophils with extracellular location of massive microflora corresponding to a necrotic type of cytogram.

In patients who were admitted at the stage of DM decompensation and signs of multiple organ dysfunction requiring partial surgical treatment to be performed, great amount of neutrophils in the state of degeneration and destruction in the shape of karyopyknosis and cytolysis were found in the impression smear. The signs of phagocytic activity of certain neutrophils were determined. Intracellular location of microorganisms was stated, though phagocytosis character was not completed and sometimes even distorted. Therefore, degenerative-inflammatory cytogram type was determined.

After radical surgical treatment the amount of preserved neutrophils was 80–90 %, and 5–15 % of them constituted a part of lymphocytes and monocytes. Microflora was determined in a moderate amount mainly at the state of completed phagocytosis. Further favourable course of the wound process promoted inflammatory-regenerator, regenerator-inflammatory and regenerator types of cytograms, when the amount of neutrophils was reduced to 40–50 %. Non-differentiated fibroblasts, polyblasts and lymphocytes appear, followed by appearance of young cells of the granulation tissue. With regenerator type epithelium appears in the specimens in the form of characteristic aggregations of light cells with a wide cytoplasm. Microflora disappears gradually in such impression smears.

M. I. Kuzin and B. M. Kostiuchenok (1990) stated that in case of uncomplicated course of the wound process development the surface of the wound 4 % decreased daily. Examination of such subjective criterion of the wound process development as the rate of wound healing we obtained the results evidencing that a general rate of wound regeneration after surgical treatment in patients with DFS is lower than that of the analogical index mentioned above. It is about ≈ 1 % per day among the patients from the group 1, among the patients from the group 2 who were subjected to DCEF effect it was 2 % during the first 6 days followed by 2.1–2.2 % per day. Among the patients from the group 3 who received ISEP with Berlithion the rate of wound surface decrease was on an average 3 % (Table).

Table. Dynamics of the rate of the wound surface decrease in patients with complicated forms of diabetic foot syndrome

	6th day	12th day	18th day
Group 1 (n=14)	6 %	11 %	17 %
Group 2 (n=15)	12 %	25 %	38 %
Group 3 (n=9)	18 %	32 %	48 %

The obtained results present preliminary suggestions concerning a positive action of physical methods of effect. It can be associated with a positive effect of DCEF and ISEP with Berlithion on an increased intensity of enzymatic fibrinolysis, certain growth of fibrinogen concentration, a low level of which inhibits wound healing considerably (Knighton D. Et al., 1982). Moreover, decreased intensity of intravascular fibrinogenesis promotes inhibition of proteolytic destruction of high molecular proteins and normalization of lysis of low molecular proteins and collagen.

Conclusions. Therefore, under effect of DCEF an inflammatory type of cytogram was found mainly from the 3–4 to 7–8th days compared with the control group, where these phenomena were found from the 3–4 to the 11–12th days. Approximately, similar dynamics was found in case of ISEP action with Berlithion. When the wound process is passed into the second phase which is evidenced by the appearance of inflammatory-regenerator impression smear, the rate of regeneration appeared to be the highest in the group of patients who received ISEP with Berlithion. This fact can be associated with achieving of higher concentration of α-lipoic acid in the wound that promotes membrane stabilization and stimulation of regeneration processes.

Our observations enable to suggest a positive effect of such physical factors as direct current electric field effect on the rates of wound regeneration both during the first phase of the wound process (inflammation) and the second one (regeneration).

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ВПЛИВ ЕЛЕКТРИЧНОГО ПОЛЯ ПОСТІЙНОГО СТРУМУ НА ШВИДКІСТЬ ЕПІТЕЛІЗАЦІЇ РАН У ХВОРИХ НА СИНДРОМ ДІАБЕТИЧНОЇ СТОПИ

Мета роботи: вивчити динамічний розвиток ранового процесу за допомогою дослідження відбитка-мазка з ран хворих на діабетичний синдром стопи методом Покровської–Макарова, планіметричного обстеження методом Л. М. Попової у разі лікування традиційними методами у поєднанні з гальванізацією ураженої нижньої кінцівки та застосування інтерстиціального берлітіонового електрофорезу.

Матеріали і методи. Обстежено і проліковано 113 хворих на синдром діабетичної стопи. 1-ша група хворих отримувала традиційне лікування, у 2-й групі пацієнтів комплекс лікувальних заходів у ранньому післяопераційному періоді доповнювали гальванізацією ураженої нижньої кінцівки і хворим 3-ї групи в ранньому післяопераційному періоді приєднували локально внутрішньотканинний електрофорез із берлітіоном. Контроль за динамікою ранового процесу здійснювали шляхом оцінки мазків-відбитків із ран та планіметричним дослідженням.

Результати досліджень та їх обговорення. Порівняння темпу переходу цитологічної картини мазка-відбитка від запального до запальнорегенераторного, регенераторно-запального і, нарешті, регенераторного типу продемонструвало, що ці процеси у хворих 1-ї групи відбувались, у середньому, протягом 20 днів, у 2-й групі протягом 16 днів і у 3-й групі протягом 14 днів. Зменшення площі рани у хворих 1-ї групи складає ≈ 1 % на добу, у хворих 2-ї групи – 2 %, у подальшому – 2,1–2,2 % на добу. У пацієнтів 3-ї групи темп зменшення площі рани в середньому склав 3 %. Тому під дією прямого постійного струму цитограма була представлена запальним типом переважно з 3–4 по 7–8 день порівняно з контрольною групою, де ці явища були виявлені з 3–4 по 11–12 день. Приблизно схожа динаміка була виявлена у випадку дії інтерстеційного електрофорезу з берлітіоном. Коли рановий процес переходить у другу фазу, про що свідчить поява запальнорегенераторного мазка, швидкість регенерації виявилася найбільшою у групі пацієнтів, які отримували інтерстеційний електрофорез із берлітіоном.

Ключові слова: цукровий діабет; синдром діабетичної стопи; гнійно-некротичний процес; рана; гальванізація.

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ВЛИЯНИЕ ЭЛЕКТРИЧЕСКОГО ПОЛЯ ПОСТОЯННОГО ТОКА НА СКОРОСТЬ ЭПИТЕЛИЗАЦИИ РАН У БОЛЬНЫХ С СИНДРОМОМ ДИАБЕТИЧЕСКОЙ СТОПЫ

Цель работы: изучить динамичное развитие раневого процесса с помощью исследования отпечатка-мазка из ран больных с синдромом диабетической стопы методом Покровской–Макарова, планиметрического обследования методом Л. М. Поповой при лечении традиционными методами в сочетании с гальванизацией пораженной нижней конечности и применения интерстициального берлитионового электрофореза.

Материалы и методы. Обследовано и пролечено 113 больных с синдромом диабетической стопы. 1-я группа больных получала традиционное лечение, 2-й группе пациентов комплекс лечебных мероприятий в раннем послеоперационном лечении дополняли гальванизацией поражённой нижней конечности и больным 3-й группы в раннем послеоперационном периоде присоединяли локально внутритканевый электрофорез с берлитионом. Контроль за динамикой раневого процесса осуществляли путём оценки мазков-отпечатков с ран и планиметрическим исследованием. Сравнение темпа перехода цитологической картины мазка-отпечатка от воспалительного до воспалительнорегенераторного, регенераторно-воспалительного и, наконец, регенераторного типа продемонстрировало, что эти процессы у больных 1-й группы происходили, в среднем, на протяжении 20 дней, у больных 2-й группы на протяжении 16 дней и у 3-й – на протяжении 14 дней. Уменьшение площади раны у больных 1-й группы составляет ≈ 1 % в сутки, у больных 2-й группы – 2 %, в последующем – 2,1–2,2 % в сутки и у пациентов 3-й группы скорость уменьшения площади раны в среднем составил 3 %. Поэтому под действием прямого постоянного тока цитограмма была представлена воспалительным типом преимущественно с 3–4 по 7–8 день по сравнению с контрольной группой, где эти явления были обнаружены с 3–4 по 11–12 день. Примерно похожая динамика была обнаружена в случае действия интерстециального электрофореза с берлитионом. Когда раневой процесс переходит во вторую фазу, о чем свидетельствует появление воспалительно-регенераторного мазка, скорость регенерации оказалась большей в группе пациентов, получавших интерстециальный электрофорез с берлитионом.

Ключевые слова: сахарный диабет; синдром диабетической стопы; гнойно-некротический процесс; рана; гальванизация.