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Analysis of clinical effectiveness of complex treatment of limited border burns

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Abstract

Aim – to evaluate the effectiveness of the developed method for local treatment of limited border burns.

Material and methods. The results of treatment of 39 patients with limited first- and second-degree burns were studied. In patients of the main group (19 people), during the changing of the gel with silver ions, the wound was irradiated with ultraviolet light, followed by exposure to a low-frequency pulsating magnetic field. Patients in the comparison group (20 patients) received conservative treatment using the gel with silver ions only, without physiotherapy. Monitoring of the healing of burn wounds was carried out using the "Complex automated system for assessing the area of burn wounds" (certificate of state registration of the computer program No. 2015660700 dated 10/06/2015). The effectiveness of the proposed method was assessed by clinical results, as well as by the time patients spent in the hospital. The obtained data were analyzed using clinical statistics methods.

Results. The developed method for treating local I-II degree burn wounds, which consists of covering the wound with gel with silver plus ultraviolet irradiation of the wound and magnetic therapy, turned out to be more effective compared to the method of wound coating with gel with silver, which was previously introduced into the clinic, without physiotherapeutic treatment.

Conclusions. The use of the proposed method in the treatment of burn wounds statistically significantly reduces the likelihood of the development of suppuration and accelerates the cleansing of wounds, and leads to a faster recovery.

Keywords: conservative treatment of burn wounds; wound coverings; documentation of wounds.

Conflict of interest: nothing to disclose.

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Анализ клинической эффективности комплексного лечения ограниченных пограничных ожогов

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Аннотация

Цель – оценка эффективности разработанного способа местного лечения ограниченных пограничных ожогов.

Материал и методы. Изучены результаты лечения 39 больных с ограниченными ожогами I и II степеней. Пациентам основной группы (19 человек) при смене геля с ионами серебра рана облучалась ультрафиолетовым светом с последующим воздействием низкочастотным пульсирующим магнитным полем. Пациенты группы сравнения (20 пациентов) получали консервативное лечение с использованием геля с ионами серебра без физиотерапевтического воздействия. Контроль заживления ожоговой раны выполнялся с использованием «Комплексной автоматизированной системы оценки площади ожоговых ран» (свидетельство о государственной регистрации программы для ЭВМ № 2015660700 от 06.10.2015 г.). Эффективность предложенного способа оценивали по клиническим результатам, а также по времени нахождения пациентов в стационаре. Полученные данные анализировались с помощью методов клинической статистики.

Результаты. Разработанный способ лечения локальных ожоговых ран I и II степеней, заключающийся в покрытии гелем с серебром в комбинации с ультрафиолетовым облучением раны и магнитотерапией, оказался более эффективным по сравнению с ранее внедренным в клинику покрытием с гелем и серебром, но без физиотерапевтического воздействия. Предложенный способ при лечении ожоговых ран статистически достоверно уменьшает вероятность развития нагноений и ускоряет очищение ран, а также приводит к более быстрому выздоровлению.

Ключевые слова: консервативное лечение ожоговых ран; раневые покрытия; документация ран.

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INTRODUCTION

In Russia, more than 315 thousand cases of burn injury are registered annually, or 220.6±6.5 burns per 100 thousand people of the country's population [1, 2]. Burn injury usually leads to long-term or permanent disability. Since about 75% of burn victims are of working age (16-59 years old), the development of modern methods of burn treatment is especially urgent [3]. Given that a skin burn area of less than 10% of the body surface area is reported in 52.2% of adult trauma patients and 65.2% of children, respectively, it is important to personalize the treatment method for the most common limited borderline burns [3–5]. With the right choice of treatment method and its timely implementation, healing of the burn wound occurs without the development of complications and without the need for surgical treatment [6–8].

The basis of first aid and subsequent treatment, especially in patients with limited burns of I and II degrees are modern wound coatings of “Activtex” and “APPOLO” series, as well as aerosol preparations, such as “Hitopran”, “Amprovisol”, “Olazol”, “Panthenol” [8–10].

Despite the effectiveness of wound coatings that activate the regeneration of superficial skin layers, preparations are required that have the ability to resist the development of infectious complications in the wound and simultaneously improve tissue repair.

According to many authors and scientists who have studied the processes of regeneration of wounds of various etiologies in experimental conditions, the advantages of using drugs with antimicrobial action have been proved. In particular, the inclusion of silver nanoparticles in the composition leads to a less pronounced inflammatory process in the site, which promotes faster development of granulation and subsequent epithelialization of the damaged area of the skin surface. Silver has a wide range of antimicrobial activity against aerobic and anaerobic microflora, including antibiotic-resistant, exhibits virucidal and fungicidal activity, and has anti-inflammatory effect [11–14]. We developed a complex of therapy measures to treat burn injuries using gels with silver nanoparticles and physiotherapeutic effect on the damaged area[1].

AIM

To evaluate the effectiveness of the developed method for local treatment of limited border burns.

MATERIAL AND METHODS

Evaluation of the effectiveness of the developed method of local treatment of limited border burns with the use of gel with silver ions and physiotherapeutic effect was performed on the results of treatment of 39 patients with limited burns of I and II degrees. The patients were divided into two groups. The primary (main) group included patients aged 19 to 67 years (mean age 44), with 17 men and 2 women. The comparison group comprised 20 patients aged 21 to 69 years (mean age 45), including 16 men and 4 women. The study participants were comparable in age, body mass index, and comorbidities. All patients had thermal burns. The primary etiological factors of burns were hot water, steam, and contact burns. The groups were matched in terms of burn severity, location, and affected surface area.

In the main group, during silver-ion gel dressing changes, the wound was irradiated with ultraviolet (UV) light at a dose of 50 μW·min/cm^2 for 30 seconds. The exposure duration was increased daily by 30 seconds. This was followed by low-frequency pulsed magnetic field therapy (50 Hz, 30 mT) for 5 minutes, with daily 1-minute increments in duration. A total of 7-10 sessions were performed.

The comparison group received conventional treatment using silver-ion gel without physiotherapy.

The monitoring of the burn wound healing was performed using the “Complex automated system for assessing the area of burn wounds” (certificate of state registration of the computer program No. 2015660700 dated 10/06/2015). The technology involves computer-assisted processing of wound area photographs. A wound surface image is uploaded to a computer system, where specialized software determines the wound boundaries and calculates its area. Additionally,

[1] Tolstov A.V., Novikov I.V. Method of treatment of localized burn wounds of II-III A degree. Patent: RU 2648869 C1. Available online: https://patentimages.storage.googleapis.com/70/63/f3/77f5ff89052568/RU2648869C1.pdf

Figure 1. *Photograph of the wound of patient I. (main group), loaded into the computer program.*
Рисунок 1. *Фотография раны больного И. (основная группа), введенная в программу ЭВМ.*

the software analyzes healing progression through dynamic assessment of color gradient changes across the wound surface.

The efficacy of the proposed method was evaluated based on the following: wound epithelization time, suppurate development and wound cleansing time, length of hospital stay. Data were analyzed using descriptive statistics and Student's t-test. Statistical processing was performed with Microsoft Office Excel 2010, with additional clinical statistical methods applied to the dataset.

RESULTS

The treatment method for localized borderline burns, involving silver gel dressing combined with ultraviolet wound irradiation and magnetotherapy, was evaluated based on wound epithelialization time, wound cleansing duration, and length of hospital stay.

The assessment of topical treatment efficacy proved highly informative and evidence-based when performed using our custom-developed computer program (**Figure 1**).

After uploading the patient's wound photograph to the computer program, the boundaries of relevant wound process parameters were marked with color-coded markers, and the program displayed the initial results (**Figure 2**).

The monitoring of the progress of the wound process was performed in the computer program on days three, five, and six (**Figures 3, 4**).

The obtained parameters were assessed using descriptive statistics and Student's t-test (**Table 1**). Analysis of the main group's parameters over the 5-day observation period, acquired through the developed computer program, revealed the following findings: the burn wound area decreased by 2.3-fold; the granulation area decreased by 2.6-fold; and the wound epithelialization area increased by 1.8-fold.

Similarly, wound surfaces were examined in the control group receiving silver-ion gel alone without physiotherapy. Evaluation of computer-program-analyzed data in the control group over the 13-day observation period demonstrated: the burn wound area decreased by 1.4-fold; the granulation area decreased by 1.6-fold; and the wound epithelialization area increased by 1.5-fold.

The mean wound cleansing time was 5.65 ± 0.86 days in the main group versus 8.87 ± 1.23 days in the control group. The average hospital stay duration was 13.24 ± 0.83 days for the main group compared to 16.87 ± 1.25 days for the control group ($p=0.02$).

To confirm the clinical significance of the obtained results from the proposed topical treatment method for localized borderline burns using silver nanoparticle gel combined with physiotherapy, we performed a treatment outcomes assessment through calculation of clinical statistical measures.

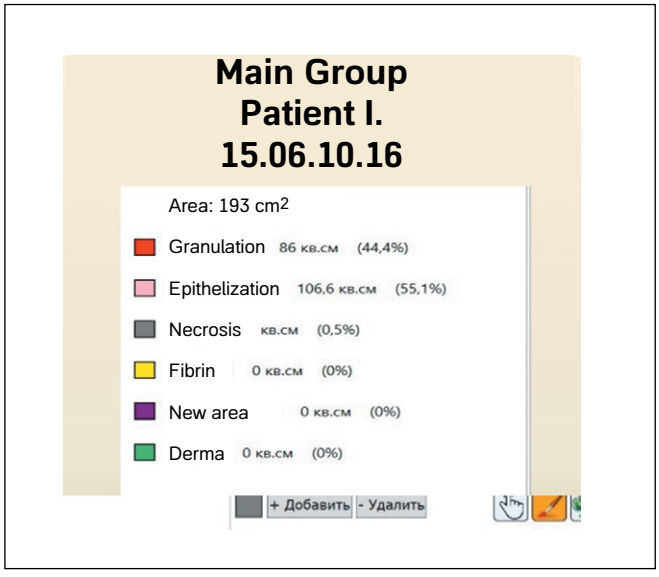

Figure 2. *Parameters of the wound of patient I. on the 1st day.*
Рисунок 2. *Параметры раны больного И. на первые сутки.*

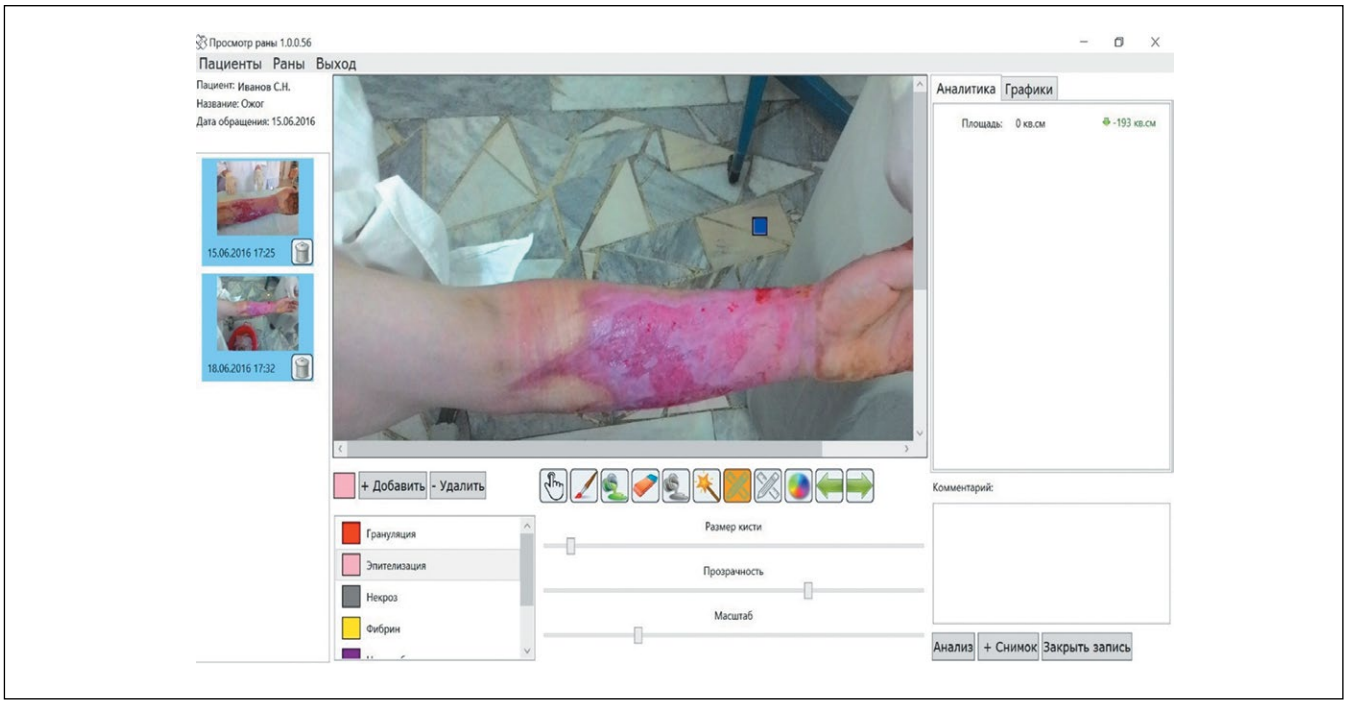

Figure 3. *Indicators of the wound of patient I. (main group) on the 3rd day.*
Рисунок 3. *Показатели раны больного И. (основная группа) на третьи сутки.*

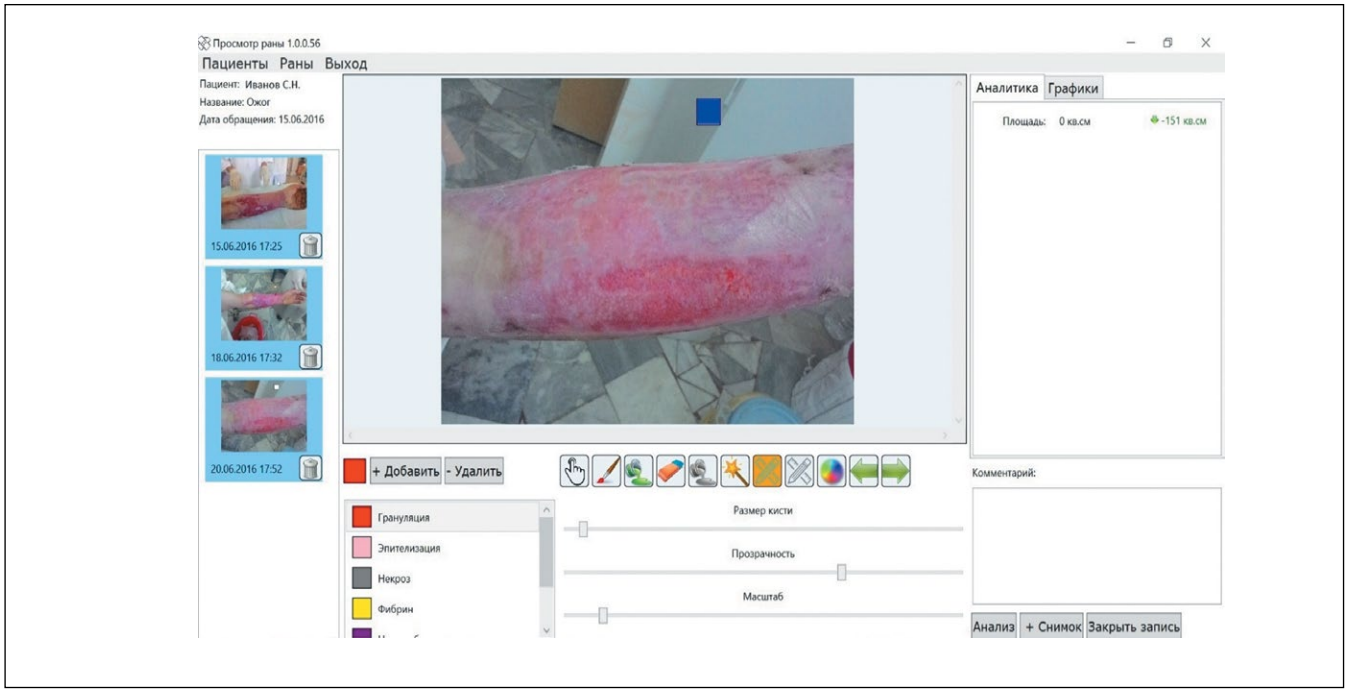

Figure 4. *Wound parameters of patient I. (main group) on the 5th day.*
Рисунок 4. *Параметры раны больного И. (основная группа) на пятые сутки.*

	Main group (n=19) M±m	Comparison group (n=20) M±m	t-test	<p
Wound cleansing time (days)	5.65 ± 0.86	8.87 ± 1.23	0.447 t<1.990	p<0.05
Hospital stay time (days)	13.24 ± 0.83	16.87 ± 1.25	0.447 t<1.990	p<0.05

Table 1. *Efficiency of using of wound dressings combined with physiotherapeutic interventions*
Таблица 1. *Эффективность применения раневого покрытия в комбинации с физиотерапевтическим воздействием*

The treatment success rate in the main group is represented as TSM = A / (A + B), where A is the onset of an adverse outcome (incidence rate of wound suppuration) in the study group, B is the absence of adverse outcomes. TSM = 3 / 19 = 0.158.

The treatment success rate in the control group is represented as TSC = C / (C + D), where C is the onset of an adverse outcome (incidence rate of wound suppuration), D is the absence thereof. TSC = 5 / 20 = 0.25.

RRD (relative risk decrease) = (TSM – TSC) / TSC. RRD = -0.38 = 38%, which meets a clinically significant effect.

ARD (absolute risk decrease) = (TSM – TSC). ARD = -0.094.

NPT, or the number of patients to be treated with this method over a specified period to prevent adverse outcomes per one patient is calculated as -1 / ARD. NPT = 10.76.

The odds ratio (OR) is calculated as (A / B) / (C / D). OR = 0.437.

DISCUSSION

The search for effective burn wound infection treatments has been ongoing for decades. Certain milestones in addressing this challenge were marked by remarkable achievements, when many issues of purulent surgery appeared resolved as surgeons gained access to promising antibacterial agents (antibiotics) and physical treatment modalities, e.g. laser therapy, ultrasound, and hyperbaric oxygenation [3,4,7]. However, subsequent experience revealed that all these methods, despite demonstrating positive outcomes, exhibited biological, technical, and economic limitations. None provided universal efficacy across all wound healing stages, thus the clinical challenges of burn wound management and wound infection treatment remain unresolved, necessitating further therapeutic development.

The application of various pharmaceutical agents and conservative burn treatment methods ultimately aims to establish conditions that suppress local wound infection and promote accelerated healing of burn injuries. Collectively, these interventions constitute a system of topical pharmacological burn therapy. Grounded in evidence-based evaluation of different conservative treatment modalities, this system is now becoming the standard of care [7].

Numerous modern methods exist for treating thermal burns of varying degrees, primarily involving dressings with different wound coverings. A key limitation of these approaches is that the applied coverings target only one phase of the wound healing process, resulting in persistent microbial contamination, prolonged debridement of necrotic tissue, delayed regeneration, insufficient stimulation of reparative processes in affected tissues, requirement for daily dressing changes (2-3 times per day), and high consumption of medical supplies and wound care materials.

Most publications on the use of wound dressings report the efficacy of only specific types of bandages, many of which are essentially similar. Furthermore, reviews discussing the applications of these dressings are largely promotional in nature.

It should be noted that contemporary wound treatment must be strictly tailored to the specific phase and characteristics of the wound healing process. The cornerstone of local burn wound therapy lies in comprehensive, appropriate treatment combining pharmacological intervention, antimicrobial-impregnated wound dressings, and physiotherapy [8]. However, the scope and methods of therapeutic intervention must create optimal conditions for the wound healing process, while accounting for individual wound biology considering existing comorbidities, treatment setting (inpatient, outpatient, treatment by general practitioner), and cost effectiveness. These principles guided the development of our burn wound treatment method.

Analysis of outcomes from the developed topical treatment protocol for localized borderline burns (using silver-ion gel combined with physiotherapy) revealed insufficient efficacy in preventing infectious complications in 3 patients (15.78%) of 19 in the main group, and 5 patients (25.0%) of 20 in the comparison group. However, the topical treatment protocol for localized borderline burns combining silver-ion gel with physiotherapy demonstrated significantly greater efficacy compared to silver-ion gel treatment without physiotherapy. Statistical analysis confirmed that this combined approach reduces complication rates and enhances rehabilitation effectiveness in patients with this condition.

The antimicrobial effect of ultraviolet irradiation during early stages of skin defect regeneration prevents suppurative complications. Gradual increase in both UV exposure dosage and duration of magnetic field application promotes proper differentiation of newly formed cellular structures and facilitates development of specialized connective tissue in the wound area. The combined use of physiotherapy and silver-ion gel significantly accelerates wound epithelialization compared to dressings without ultraviolet irradiation and magnetotherapy. The efficacy of our proposed dressings combined with physiotherapy enables complete wound epithelialization within 13–14 days, whereas conventional dressings (Chitopran, Amprovizol, Olazol, Panthenol) require 18–20 days for epithelialization of borderline dermal burns, with additional dressing changes needed for further burn wound management [8–10].

CONCLUSION

Thus, the clinical trial of this topical treatment protocol for localized borderline burns, combining silver-ion gel with physiotherapy, demonstrates statistically significant reductions in suppuration risk and accelerated wound cleansing and epithelialization.

The addition of physiotherapy to burn wound management ensures proper progression through all phases of wound healing, with timely transition between regenerative stages and prevention of suppurative complications in patients admitted to hospital within 24 hours after the injury. Therefore, the combined use of ultraviolet irradiation and magnetotherapy can be recommended for widespread clinical implementation in burn treatment protocols.

ADDITIONAL INFORMATION	ДОПОЛНИТЕЛЬНАЯ ИНФОРМАЦИЯ
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Conflict of interest. The authors declare that there are no obvious or potential conflicts of interest associated with the content of this article.	***Конфликт интересов.*** Авторы декларируют отсутствие явных и потенциальных конфликтов интересов, связанных с содержанием настоящей статьи.
Compliance with Ethical Standards. The authors confirm that the rights of the people who participated in the study were respected, including obtaining informed consent.	***Соответствие нормам этики.*** Авторы подтверждают, что соблюдены права людей, принимавших участие в исследовании, включая получение информированного согласия.
Contribution of individual authors. Tolstov A.V.: development of the concept and design of the study, analysis of the obtained data, editing of the text. Kolsanov A.V.: analysis of the obtained data, statistical processing of the data. Novikov I.V.: collection of material, statistical processing of the data, analysis of the obtained data. Milyudin E.S.: study design, analysis of the obtained data, preparation of the text. All authors gave their final approval of the manuscript for submission, and agreed to be accountable for all aspects of the work, implying proper study and resolution of issues related to the accuracy or integrity of any part of the work.	***Участие авторов.*** Толстов А.В. – разработка концепции и дизайна исследования, анализ полученных данных, редактирование текста. Колсанов А.В. – анализ полученных данных, статистическая обработка данных. Новиков И.В. – сбор материала, статистическая обработка данных, анализ полученных данных. Милюдин Е.С. – дизайн исследования, анализ полученных данных, подготовка текста. Все авторы одобрили финальную версию статьи перед публикацией, выразили согласие нести ответственность за все аспекты работы, подразумевающую надлежащее изучение и решение вопросов, связанных с точностью или добросовестностью любой части работы.

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