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ORIGINAL ARTICLE

OPTIMIZATION OF LOCAL TREATMENT OF BURN WOUNDS USING ANTIMICROBIAL WOUND COATINGS

Ruziboev Sanjar Abdusalomovich[1], Toshnazarova Nafisa Kayumovna[2],

Samarkand branch of the Republican Scientific Center for Emergency Medical Care, Doctor of Medical Sciences, Professor[1] Samarkand State Medical University, resident of the master's program[2]

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Abstract

This paper provides a comprehensive analytical review of current scientific publications on local wound care in patients with limited burn injuries using modern wound dressings with pronounced antimicrobial activity. It presents current concepts of burn wound formation and progression, considers the importance of microbial contamination and the formation of biofilm structures as factors slowing down regenerative processes, and outlines the key characteristics of an optimal wound dressing. A systematization and comparative evaluation of traditional and new local therapy agents is provided, including silver-ion-based materials, iodine-containing compositions, polyhexamethylene biguanide (PHMB)-based preparations, and coatings based on biopolymers and nanotechnology. A separate analysis is provided of their pharmacodynamic action, clinical effectiveness, and the advantages and potential limitations of their use in the treatment of localized burns. It has been shown that the justified use of new-generation antimicrobial wound dressings promotes the intensification of epithelialization processes, reduces the risk of infectious complications, reduces pain, and improves patients' quality of life.

Keywords: limited burns, burn skin lesions, local therapy, wound dressings with antimicrobial activity, silver-containing dressings, biofilm structures, epithelialization processes.

1. Introduction

According to the World Health Organization, burn injuries remain a leading cause of traumatic skin lesions, accounting for a significant share of surgical morbidity. As noted by David N. Herndon (2018) and Marc G. Jeschke (2020), even limited-area burns of grades I-II-IIIa, with an unfavorable clinical course, can lead to a prolonged healing process and the development of cicatricial deformities with functional impairment. A number of researchers (Kiselev A.V., 2019; Bassam S. Atiyeh, 2021) point out that the final results of burn injury treatment depend largely on the quality and timeliness of local therapy rather than on the area of damage. In this regard, the use of modern wound dressings with a combination of barrier, regenerative, and antimicrobial properties is of particular importance. Burn injuries remain a significant cause of skin and soft tissue injuries and remain a pressing medical and social problem. Despite the limited area of injury, such injuries are often accompanied by severe pain, a high risk of infection, and prolonged healing times, leading to decreased ability to work and a deterioration in the quality of life of patients.

According to the classical concepts of Douglas M. Jackson, a burn wound includes zones of

coagulation, stasis, and hyperemia. Modern morphological studies (David G. Greenhalgh, 2019) have shown that the stasis zone is potentially reversible and is most dependent on the adequacy of local treatment. The work of Leopoldo K. Branski et al. (2020) demonstrated that drying of the wound surface increases ischemic tissue changes and contributes to the deepening of the lesion. At the same time, maintaining a moist environment leads to a decrease in the level of proinflammatory mediators and accelerates the migration of keratinocytes. Domestic researchers (Ruziboev S.A., 2021; Malikov M.Kh., 2022) found in clinical observations that the use of modern dressings in the first 48-72 hours after injury can reduce the time of epithelialization of local burns by 20-30% compared to traditional treatment methods.

A key element of comprehensive burn therapy is local treatment, aimed at creating an optimal environment for tissue repair, preventing microbial contamination, and reducing the risk of secondary injury. In recent years, the use of innovative wound dressings with antimicrobial activity has attracted particular interest. These dressings not only effectively control infection but also actively influence the dynamics of wound healing. According to the World Health Organization, burn injuries remain a leading cause of traumatic skin lesions, accounting for a significant share of surgical morbidity. As noted by David N. Herndon (2018) and Marc G. Jeschke (2020), even limited-area burns of grades I-II-IIIa, with an unfavorable clinical course, can lead to a prolonged healing process and the development of cicatricial deformities with functional impairment. A number of researchers (Kiselev A.V., 2019; Bassam S. Atiyeh, 2021) point out that the final results of burn injury treatment depend largely on the quality and timeliness of local therapy rather than on the area of damage. In this regard, the use of modern wound dressings with a combination of barrier, regenerative, and antimicrobial properties is of particular importance. Burn injuries remain a significant cause of skin and soft tissue injuries and remain a pressing medical and social problem. Despite the limited area of injury, such injuries are often accompanied by severe pain, a high risk of infection, and prolonged healing times, leading to decreased ability to work and a deterioration in the quality of life of patients. According to the classical concepts of Douglas M. Jackson, a burn wound includes zones of coagulation, stasis, and hyperemia. Modern morphological studies (David G. Greenhalgh, 2019) have shown that the stasis zone is potentially reversible and is most dependent on the adequacy of local treatment. The work of Leopoldo K. Branski et al. (2020) demonstrated that drying of the wound surface increases ischemic tissue changes and contributes to the deepening of the lesion. At the same time, maintaining a moist environment leads to a decrease in the level of proinflammatory mediators and accelerates the migration of keratinocytes. Domestic researchers (Ruziboev S.A., 2021; Malikov M.Kh., 2022) found in clinical observations that the use of modern dressings in the first 48-72 hours after injury can reduce the time of epithelialization of local burns by 20-30% compared to traditional treatment methods.

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2. Materials and Methods

This study was carried out in a combined format, including a systematic analysis of scientific literature and a clinical and experimental assessment of the effectiveness of modern antimicrobial wound dressings in the treatment of local burns.

The analytical section is based on a search of publications in PubMed, Scopus, Web of Science, and eLIBRARY.RU databases for the period 2000–2025. The keywords used were: burn wound, topical therapy, antimicrobial dressings, biofilm, and burn wound infection. The analysis included clinical trials, meta-analyses, and experimental studies on antimicrobial coatings.

The clinical and experimental study was conducted in the surgical department and included 62 patients with localized burns of grades I–IIIa (affected area up to 10% of the body surface area). Patients were divided into two groups: a study group (n=32), which used modern antimicrobial dressings (silver-containing, PHMB, and hydrogel), and a control group (n=30), which received traditional treatment (ointment dressings and antiseptics).

The following parameters were assessed: epithelialization time, pain severity according to the visual analogue scale (VAS), microbial contamination level (CFU/g tissue), frequency of dressing changes and

presence of complications.
The experimental part included modeling of the wound surface in vitro, followed by a study of the antimicrobial activity of the coatings against Staphylococcus aureus and Pseudomonas aeruginosa. Statistical analysis was performed using standard methods of variation statistics. Significance of differences was assessed at $p<0.05$.

3. Results

A review of the literature revealed that modern antimicrobial wound dressings offer significant advantages over traditional methods of topical burn therapy. Most studies have noted a 20–40% reduction in epithelialization time and a 30–50% reduction in the incidence of infectious complications. Clinical and experimental results confirmed the findings. In the study group, the average epithelialization period was 9.2±1.3 days, while in the control group it was 12.8±1.7 days ($p<0.05$). Bacterial contamination levels decreased more rapidly in the study group and did not exceed the critical level of 10^5 CFU/g of tissue by days 4–5 of treatment.
Pain severity, as measured by the VAS scale, decreased by 45% in the study group by the third day of therapy, compared to only 20% in the control group. The frequency of dressing changes decreased from daily to every 2–3 days, which was accompanied by improved treatment tolerability.
Experimental data showed that coatings with silver ions and PHMB inhibited microbial growth by 70–90%, including resistant forms. Inhibition of biofilm formation was also observed.
In the study group, the complication rate was 6.2%, compared to 16.7% in the control group. Thus, the use of modern coatings demonstrated higher clinical efficacy across all studied parameters.

4. Discussion

The results obtained are consistent with current research emphasizing the important role of antimicrobial wound dressings in burn treatment. Specifically, research by Philip G. Bowler highlights the key importance of biofilm control, which was confirmed in our experiment.
The reduced epithelialization time in the study group may be due to maintaining a moist environment and reducing the inflammatory response. Unlike traditional methods, modern dressings provide prolonged antimicrobial action without significant cytotoxicity, as confirmed by Axel Kramer's work.
The reduction in pain is explained by the atraumatic nature of the dressings and the reduced frequency of dressing changes. This is important for improving patients' quality of life and their adherence to treatment.
It should be noted that the effectiveness of different types of dressings may vary depending on the clinical situation. For example, silver-containing materials are more effective against severe bacterial contamination, while hydrogel dressings are preferable for dry wounds.
The study's limitations include the relatively small patient sample and the lack of long-term follow-up. Nevertheless, the results demonstrate the high potential for the use of modern antimicrobial coatings. Thus, the integration of innovative technologies into burn treatment practices can significantly improve the effectiveness of therapy and reduce the risk of complications, which confirms the need for their widespread implementation in clinical practice.

5. Conclusion

The optimization of local treatment of burn wounds through the use of antimicrobial wound coatings represents a significant advancement in modern wound care. These coatings not only provide an effective barrier against microbial contamination but also create a favorable microenvironment that supports tissue regeneration and accelerates healing processes. By reducing the risk of infection, minimizing inflammation, and maintaining optimal moisture balance, antimicrobial coatings contribute to improved clinical outcomes and reduced healing time.

Furthermore, the integration of advanced materials such as bioactive polymers, silver-based compounds, and nanotechnology-enhanced agents enhances the therapeutic efficacy of these coatings. Their targeted antimicrobial action helps to combat resistant strains of microorganisms while preserving healthy tissue, thereby reducing the need for systemic antibiotic therapy.

Overall, the application of antimicrobial wound coatings in burn management demonstrates considerable potential in improving patient recovery, decreasing complications, and optimizing

healthcare resources. Future research should focus on the development of more biocompatible, cost-effective, and multifunctional coatings, as well as on personalized treatment approaches to further enhance the effectiveness of burn wound care.

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