BIOMEDICAL APPLICATION AND RESEARCHES OF SILVER NANOPARTICLES

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Annotation. Based on the totality of information presented in the paper, the tasks of reparative regeneration during healing of skin wounds are considered.

The review examines the research and prospects for the use of silver nanoparticles in the treatment of burn injuries as a carrier of medicines. The fields of application of silver nanoparticles to impart or enhance antibacterial, anti-ulcer, antimicrobial, anti-inflammatory effects of dressings and other medicinal substances are also analyzed.

Keywords: gel, wound treatment, wound healing, silver nanoparticles, nanotechnology, green synthesis, antibacterial effect, anti-inflammatory property.

Biomedical application of silver nanoparticles

Nanobiotechnology – (synonym bionanotechnology) is a section in nanotechnology dealing with the study and impact of nanometer–sized objects on biological objects and their use for the development of nanomedicine, engaged in the creation of nanodrugs, diagnostic systems based on nanoparticles, the development of medical nanorobots and the creation of medical nanomaterials. [1]

It is known from the literature data that all over the world silver itself and silver-containing preparations have been used for medicinal purposes since ancient times, as well as for disinfection, neutralization of water and food. To date, it has been scientifically proven that silver directly affects bacteria by suppressing their growth [2].

Silver nanoparticles are silver nanoparticles ranging in size from 1 nm to 100 nm. Although they are often referred to as "silver", some of them consist of a large percentage of silver oxide due to their large surface-to-bulk ratio of silver atoms. Depending on the specific application, nanoparticles of various shapes can be created. Commonly used silver nanoparticles have a spherical shape, but diamond, octagonal and thin sheets are also common.Their extremely large surface area makes it possible to coordinate a huge number of ligands. The properties of silver nanoparticles applicable to human treatment are being studied in laboratory conditions and on animals in order to assess potential efficacy, toxicity and cost.

Therefore, the use of silver-containing preparations as preservatives, antiseptics, disinfectants is absolutely justified [3, 4].

Silver was used for medicinal purposes until antibiotics came into widespread use. But in recent years, with the development of nanotechnology, interest in silver as an antibiotic and bactericidal agent has increased significantly.

The development and improvement of wound healing agents used in the treatment of skin defects in burn victims is one of the promising tasks in the field of surgery and combustiology [5].

Nanotechnology has made it possible to reduce the cost of silver-based drugs and make them more accessible in the treatment of many infectious diseases. Modern developments of new methods of treatment of infected wounds and inflammatory skin diseases are devoted to the use of silver nanoparticles, which have a number of advantages: multilevel antimicrobial effect (antibacterial, antifungal, antiviral), slow development of resistance, low level of toxicity. Recent literature data indicate that the wound-healing effect of drugs with silver nanoparticles is due not only to antibacterial, but also to anti-inflammatory, wound-healing, anti-tuberculosis, antitumor and reparative properties.

Researcher Buliga L.A. in her scientific article "Investigation of the effect of gels with silver nanoparticles on the wound healing process" confirms that the gel with silver nanoparticles (0.1%) and glucosamine has the most pronounced wound healing properties and is not inferior in activity to the comparison drug, since the differences in their reparative effects were only 7.8%. Changes in the immunobiochmic markers of inflammation in the blood of rats with purulent wounds during treatment with this gel suggest a synergism of anti-inflammatory and reparative mechanisms of action of the drug components in the treatment of wounds, along with an antimicrobial effect, which will be the subject of further research [6].

According to sources, it is known that in their research A.V. Zakharov, A.L. Khokhlov, A.E. Ergeshov in the article "Silver nanoparticles in solving the problem of drug resistance of the causative agent of tuberculosis" confirm that their research provides a scientific experimental justification for the effectiveness of the use of silver nanoparticles in the complex treatment of drug-resistant tuberculosis. The most effective dosage of silver nanoparticles in the composite in the treatment of experimental tuberculosis is 25 micrograms/kg [7].

As a result of research in the article "Silver nanoparticles in medicine", S.E. RZHEUSSKY found that in the treatment of trophic ulcers of the lower extremities, the preparation of nanocrystalline silver had a faster and more complete effect. The effectiveness of preparations or dressings based on silver nanoparticles has been proven in the treatment of bedsores, ulcers, traumatic and surgical wounds in patients [8], in the treatment of residual burn wounds [9, 10], in wound healing after circumcision [11], etc. In a study involving 92 women with cesarean section [12] and in a study with 34 patients with apical peridontitis, the presence of an analgesic effect was proved [13]. In a 2017 study, a gel with silver nanoparticles showed the same effectiveness in the treatment of vulgar acne as a gel with clindamycin [14]. As can be seen from the data presented, silver has good prospects as an antimicrobial, wound healing and anti-inflammatory agent. However, this is far from a panacea and the approach to its use in medicine should be balanced and thoughtful.

It is known from the literature data that L. A. Bulyga, V. P. Chernykh, B. A. Movchan, S. Y. Shtrygol, Ya. A. Butko, E. A. Ruban, T. V. Gorbach in the scientific article "Study of the wound-healing effect of gels with silver nanoparticles in animals with purulent wounds", conducted a study of the wound-healing properties of gels that contain nanoparticles silver obtained by electron beam vacuum evaporation followed by condensation on the carrier material (polyvinylpyrrolidone), in the treatment of purulent wounds in rats, which contributed to wound healing in animals [15].

According to literary sources, S.M. Smotrin, R.I. Dovnar, A.Y. Vasilkov, N.I. Prokopchik, N.N. Ioskevich in the scientific article "The effect of a dressing material containing gold or

silver nanoparticles on the healing of an experimental wound" received a series of dressing materials containing gold or silver nanoparticles based on a bandage medical gauze by metal-steam synthesis. It was also found that the use of a dressing material containing silver or gold nanoparticles makes it possible to accelerate the healing process of an experimental aseptic and contaminated wound. [16].

According to the literature data, in the article “Prospects for the use of metal nanoparticles for regenerative medicine”, I. A.Shurygina, M. G.Shurygin studied the possibility of using a hydrophilic gel of silver nanoparticles stabilized with arabinogalactan or its sulfated derivative for the treatment of wounds and burns. Using a burn wound model, it was found that the use of gels containing 1% silver nanocomposite on arabinogalactan or 1% silver nanocomposite on sulfated arabinogalactan accelerates the process of epithelization of the burn wound as compared with the control group [17].

In the literature it is established that S. E. Rzheussky, V. V. Kugach in the article “Development of vaginal suppositories with silver nanoparticles” found that, compared with other metals, silver has the strongest bactericidal, antiviral and fungicidal effect. It has a wider spectrum of antimicrobial action than many modern sulfonamide drugs and antibiotics, such as penicillin, biomycin [18]. And also determined that the addition of suppositories with silver nanoparticles as a stabilizer lanthanum nitrate allows you to maintain their antimicrobial activity for 24 months. It was found that the developed suppositories have a wide spectrum of antimicrobial action against Staphylococcus aureus, Pseudomonas aeruginosa, Escherichia coli, Proteus mirabilis, Bacillus subtilis, Klebsiella pneumoniae, Streptococcus mutans, Enterococcus faecalis, Candida albicans. It was determined that suppositories with silver nanoparticles are superior to the existing analog containing dexpanthenol in terms of wound healing efficiency [19].

According to the literature sources Yu. A. Bukin, E. A. Sergeeva in the scientific article “Antibacterial properties and mechanism of bactericidal action of nanoparticles and silver ions” established that the mechanism of action of silver on the microbial cell is that silver ions are sorbed by the cell membrane, which performs a protective function. The cell remains viable, but some of its functions are disrupted, for example, division (bacteriostatic effect). As soon as silver is sorbed on the surface of a microbial cell, it penetrates into the cell and inhibits the enzymes of the respiratory chain, as well as disconnects the processes of oxidation and oxidative phosphorylation in microbial cells, as a result of which the cell dies [20].

It is known from literary sources that D. T. Rejepov, A. A. Vodiashkin, A.V. Sergorodtseva, Ya. M. Stanishevsky in the article “Biomedical application of silver nanoparticles” showed that AgNP can be used in antitumor therapy for drug delivery, as well as the possibility of their use as cytostatic drugs. In addition, this paper reports on studies that prove the effective use of silver nanoparticles in the treatment of tumor diseases. Silver nanoparticles have pronounced antibacterial properties and, based on this, can be used to enhance or impart antibacterial properties to various materials. The high significance of research on the use of silver nanoparticles for medical purposes proves the prospect of using new nanoobjects in medical practice [21].

It is established in the literature sources that Muratalieva A.J., Dzhumanazarova A.Z., Gutsalyuk N.V., Shpota E.L. in the scientific article “Investigation of bacteriostatic properties of silver nanoparticles in extracts of Glycyrrhiza Uralensis Fisch. obtained after ultrasonic

treatment" established that silver nanoparticles were the most effective because they have good antimicrobial activity. Many methods, including physical and chemical ones, have been developed for the synthesis of silver nanoparticles [22, 23]. Also, green synthesis of nanoparticles turned out to be the best method due to slower kinetics, better control and control over crystal growth and their stabilization. Plant extracts, as regenerating and stabilizing agents, have received special attention, in particular due to the maintenance of an aseptic environment during the process [24, 25]. In this study, Ural licorice was studied, extracts of which may be of interest for the "green" synthesis of silver nanoparticles. It is known that this medicinal plant has antiviral, antioxidant, anti-inflammatory, anti-ulcer, anti-cancer and anti-HIV properties due to the presence of glycyrrhizin and flavonoids as the main ingredients [26].

Conclusion. Silver nanoparticles have pronounced antibacterial properties and, based on this, can be used to impart or enhance antibacterial properties to various dosage forms.

On the basis of this article and the literature data conducted by the authors, the prospects for the application of nanotechnology achievements in medicine are shown. It has been shown that silver nanoparticles can be used as a component in a medicinal form – gel, for the treatment of microbial and viral diseases, burn injuries. Currently, it is known that the dosage form "gel" has a number of advantages, which is one of the main advantages of the fact that silver nanoparticles can be part of this dosage form, showing their therapeutic effect.
The high significance of research on the use of silver nanoparticles for biomedical purposes proves the prospect of using new nanoobjects in medical practice.

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