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THE WAY TO IMPROVE THE FUNCTIONAL PROPERTIES OF MESH IMPLANTS FOR HERNIA REPAIR

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BACKGROUND

As you know, the use of meshes is a standard procedure in hernia repair surgery. About 20 million hernioplasty operations are performed annually in the world, ⅔ of which are performed using various hernial nets [1]. Implant-associated infections resulting from biofilm formation have become a common problem as the injected foreign material is an ideal medium for bacterial colonization [2, 3]. Unfortunately, systemic antibiotics have not been shown to provide effective treatment for implant infections. The functionalization of the antibacterial surface is the most effective way to reduce infections associated with the implant [4].

The main goal of the study is to use nanotechnological approaches for the prevention and treatment of infections associated with mesh on polypropylene hernial mesh.

MATERIALS AND METHODS

In this project, we aimed to develop new multilayer nanomaterials such as vanadium-doped TiO2 nanofilms for covering hernial mesh with antibacterial properties based on the Atomic Layer Deposition (ALD) method. ALD is a nanocoating method that allows you to create an absolutely uniform film on the surface of the material, with the formation of nanoroughness, which prevents the adhesion of microorganisms. Particular attention was paid to the TiO_2 nanocoating doped with vanadium (V) [5–8]. Doping with vanadium is a promising strategy for increasing the antibacterial activity of TiO_2 in visible light [9, 10]. The mesh samples were placed in the ALD reactor chamber. Thin Al_2O_3 films were deposited on polypropylene hernial mesh substrates using $Al(CH_3)_3$ and H_2O, then TiO_2 and V_2O_5 were grown on an Al_2O_3 layer using $TiCl_4$, $VOCl_3$, and H_2O as ALD precursors, and N_2 served as a purge gas. Thin TiO_2 films doped with vanadium were grown at a temperature of 85–95° C. A total of 250 cycles were performed (100 cycles for Al_2O_3 and 150 supercycles for TiO_2 / V_2O_5 films), corresponding to a 38 nm film (Al_2O_3 + TiO_2 / V_2O_5). All samples were sonicated in 70% ethanol followed by UV irradiation (30 minutes) for animal biological experiments.

EXPERIMENT

To determine the properties of the new Al_2O_3 + TiO_2 / V_2O_5 coating, the meshes were tested on animals. In the present study, 5 rabbits (4 months old, weighing 2.5–3.0 kg) and 10 rats were used. After 7, 14, 30 and 60 days, the hernial meshes with the surrounding soft tissues were removed and fixed for histological studies. We compared the inflammatory responses in serum and tissue as well as collagen deposition caused by uncoated polypropylene meshes with added vanadium coated with TiO_2.

RESULTS

As shown by the results of the study of the meshes removed from the organisms, the samples with the applied coatings did not cause inflammatory reactions from the tissues, in contrast to the control samples. Rejection reactions of the material were also not observed.

DISCUSSIONS

The study made it possible to determine the most optimal composition of the coating. To date, it is necessary to develop a universal thickness of the applied coating so that it can perform its functions to the maximum without harm to the body.

Conclusions. As a result of the study, was developed a universal nanocoating Al_2O_3 + TiO_2 / V_2O_5, which has the most pronounced antibacterial and biocompatible properties.

Keywords: hernia, surgical mesh, coating, antibacterial.