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MORPHOLOGICAL SUBSTANTIATION OF THE EFFECT OF AN INFRARED DIODE LASER ON THE REGENERATION OF THE ESOPHAGEAL MUCOSA

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Abstract

The article contains experimental studies and their results aimed at identifying and treating various pathologies of the esophageal mucosa due to gastroesophageal reflux disease (GERD). The experiments were carried out at the training center of the Department of experimental surgery of the State Institution "RSSPMCS named after Academician V. Vakhidov", and morphological studies in the pathoanatomic, morphological and scientific research department of this center. Our experiments were carried out on various animals (rodents and mammals) in order to treat changes in the mucous membrane of the esophagus, subsequently GERD. In the experiments, we used laser radiation, which is part of modern complex methods of treatment, while providing complete information about the stages of treatment and doses of laser radiation of pathological changes in the mucous membrane of the esophagus as a result of IR-diode laser irradiation.

Keywords: diode laser, experiment, erosion, irradiation.

Introduction

Today, lasers have literally penetrated almost all areas of medicine. It would not be a mistake to say that this direction, whether therapeutic or surgical, is a direct reason for the correction of pathologies in this area, each with its own beneficial effects [1, 6, 9, 12, 18, 21].

Low-intensity lasers mainly have a therapeutic effect, whereas high-energy lasers have a destructive effect. Based on this, low-intensity laser radiation is mainly used to stimulate reparative-regenerative processes in various pathological foci, wounds, and high-energy laser radiation is mainly used for dissection and cauterization of tissues. However, their effectiveness has not been fully and adequately studied to date, and many questions are waiting for an answer [5, 14, 15, 17, 23].

One of the most complex surgical nosologies performed in surgical gastroenterology are operations performed for various pathologies of the esophagus The esophagus is anatomically unique, it comes into contact with the mediastinal area and the abdominal area at the same time [3, 8, 11, 20]. Anatomically and physiologically, the esophagus is an important organ involved in the movement of food masses during digestion. For this reason, this organ is constantly exposed to various chemical, thermal and mechanical influences. As a result, they have various erosive pathologies [4, 7, 13, 19, 25].

Currently, laser radiation is used in various fields of surgery, it quickly normalizes the process in these pathological zones and normalizes their morphophysiological balance. Currently, laser beams of various wavelengths and power are known, and depending on their wavelength and power, various pathological processes can be reduced [3, 7, 15, 18, 24].

With erosive pathologies of the esophagus, the main task of the surgeon must necessarily include measures aimed at restoring the morphophysiological integrity of the organ and restoring the morphofunctional state in the affected areas [2, 10, 16, 22].

The purpose of the study:

To substantiate and evaluate the morphological changes occurring under the influence of various laser powers and energies on esophageal erosions created in the experimental model proposed by us.

Materials and methods of morphological research

Based on the goal, we studied a comparative morphological comparison of the effects of laser beams with an energy of 137 J, supplied at a voltage of 5 W and 7 W for experimental rats and 7 W and 9 W for experimental pigs at a distance of 0.5 cm for 2 seconds on the "erosion" of the mucous membrane formed in the lower third of the esophagus in experimental animals.

Experimental studies were conducted on mongrel white male rats with an average body weight of 210-260 g and mongrel male pigs weighing 30-32 kg at the age of 5 months. Biomaterials obtained from experimental animals were examined on the 1st, 3rd, 7th and 14th days after surgery. The obtained biomaterials were fixed in a 10% formalin solution on a phosphate buffer solution. Paraffin sections were stained with hematoxylin and eosin. Light-optical micrographs were obtained on a “DN-300M” microscope coupled with a digital camera and a computer.

All micrographs were processed and stored on a computer using Microsoft application programs - «BTindoBтs10 pro».

Research Results

On the 1st day of inflammation, almost identical morphological changes were observed in both groups. Necrosis of the esophageal epithelium along the course of the "eroded" zone of the mucous membrane, vasodilation, fullness in the submucosal region, dystrophic changes in the muscle layer, edema in all layers, diffuse neutrophil-lymphocytic infiltration were observed (Fig. 1). However, such changes differed in that in the group of experimental rats exposed to a 5 W laser voltage, compared with the 7 W group, tissue edema appeared less frequently, and neutrophil-lymphocytic infiltration accumulated to a lesser extent in the foci of erosions (Fig. 2). A unique aspect of this condition was shown in experimental pigs in the experimental group under the influence of a laser voltage with a power of 7 watts (Fig. 3).

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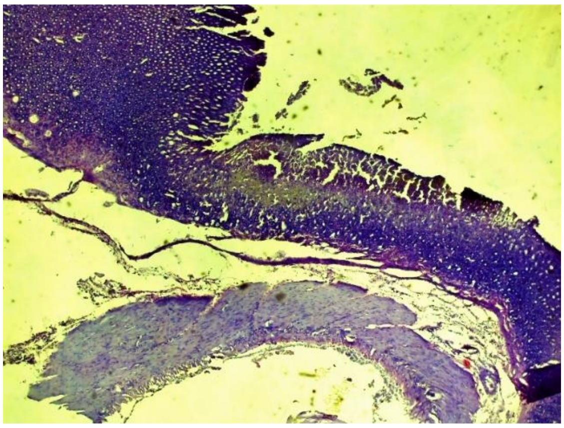

Figure 1. Esophageal cardioesophageal transition zone of an experimental rat. A layer of "erosive mucus". Necrosis of the esophageal epithelium, vasodilation in the submucosal region, fullness, dystrophic changes in the muscle layer, edema in all layers, diffuse neutrophil-lymphocytic infiltration. The effect of a laser with a voltage of 7 watts. 1 day of the experiment. G-E 10x4.

Figure 2. Esophageal cardioesophageal transition zone of an experimental rat. A layer of "erosive mucus". In the histological layers, there is less tissue edema, less neutrophil-lymphocytic infiltration in the areas of erosion. The effect of the laser voltage of 5W. 1 day of the experiment. G-E 10x2.

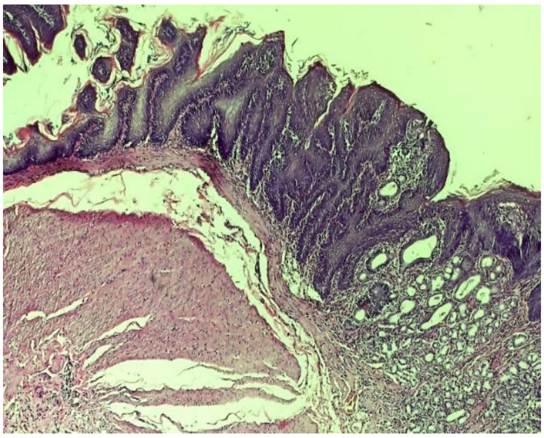

Figure 3. Esophageal-cardioesophageal transition zone of the experimental pig. A layer of "erosive mucus". Here, in the histological layers, there is significantly less tissue edema, less diffuse neutrophil-lymphocytic infiltration. The effect of a laser with a voltage of 7 watts. 1 day of the experiment. G-E 10x4.

On day 3, in the experimental group with a laser voltage of 7 W, signs of a proliferative inflammatory process prevailed in various poorly preserved alterative and erosive areas. At the same time, signs of restoration of violations of the histoarchitectonic order began in all layers, necrotic changes at the level of different histological layers were replaced by exudative-proliferative changes, focal infiltrates with foci in the submucosal layer or the spread of diffuse lymphocytic-leukocytic foci. Throughout decreased in size, there are chaotic (disorderly) changes in the connective tissue layer, there is a thickening of the vessel wall, various extensions (dilation), fullness (stasis), diapedesis of erythrocytes around the vessel, and a decrease in puffiness throughout the layer. Focal infiltration by neutrophils and lymphocytes is observed in the external serous (accessory) layer of the esophagus (Fig.4).

The proliferative process of inflammation prevailed in the experimental rats in the experimental group under the influence of a 5 W laser. Fibroblasts were clearly formed on the damaged ("eroded" part of the mucous membrane). In these areas, the formation of new vessels (neovascularization) increased mainly due to the differentiation of fibroblasts. Infiltration by histiocytes and macrophages is also observed in different layers. This, in turn, was considered the basis for the formation of new epithelial cells in the damaged (dystrophic and necrotic) epithelial layer. As mentioned above, in experimental pigs, this situation was clearly manifested in the control group with a laser voltage of 7 watts compared to the group receiving 9 watts (Fig. 5-6). These signs are observed mainly on the 3rd day and more clearly on the 7th day (Figures 7-9).

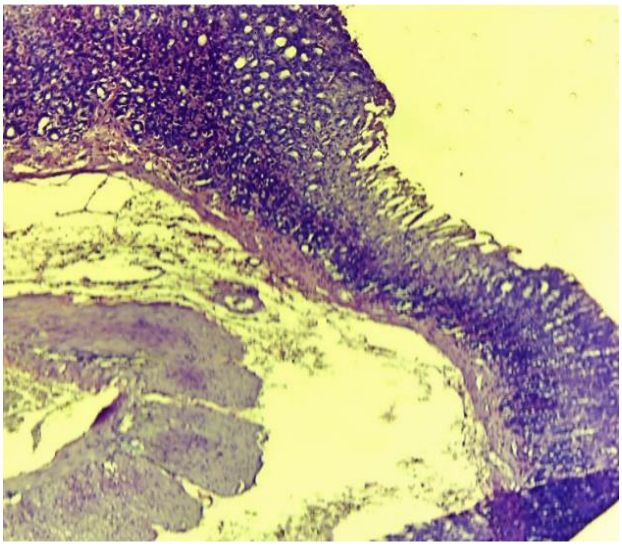

Figure 4. The stomach region of the cardioesophageal junction of the esophagus of an experimental rat. Necrotic changes at the level of different histological layers alternate with exudative-proliferative changes, diffuse lymphocytic-leukocytic foci of infiltration with a decrease in volume spread to the entire layer in the submucosal layer, chaotic (disorderly) arrangement of changes in the connective tissue layer, thickening of the vascular wall, dilation and stasis. Laser effect with a voltage of 7 watts. 3 days of experience. G-E 10x4.

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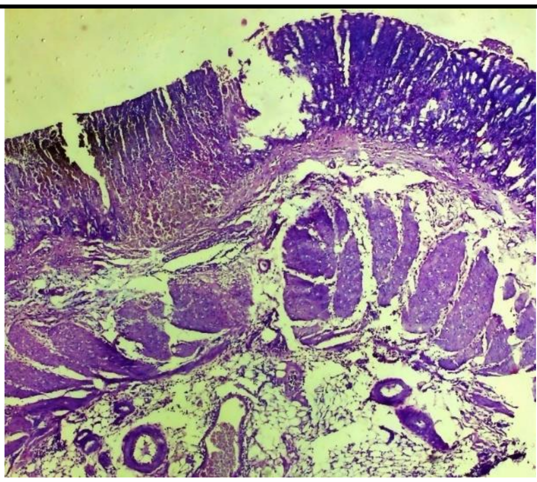

Figure 5. The stomach region of the cardioesophageal junction of the esophagus of an experimental rat. Fibroblasts have clearly formed in the damaged layers. Signs of neovascularization. Infiltration of histocytes and macrophages in different histomorphological layers. The effect of laser voltage 5W. 3 days of experience. G-E 10x4.

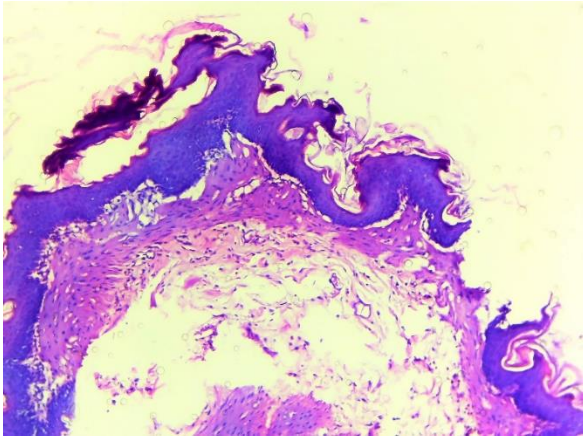

Figure 6. Histoarchitectonic layers of the esophageal wound area of an experimental pig. Fibroblasts were formed. The blood vessels are full. Laser effect with a voltage of 7 watts. 3 days of experience. Mr. 10x2.

At this time, in groups of rats with a laser power of 7 W and pigs with a laser power of 9 W, the exudative-proliferative process of inflammation prevailed, whereas in groups of pigs with a laser power of 7 W and groups of rats with a laser power of 5 W, proliferative processes prevailed. At the same time, swelling of submucosal areas, infiltration by lymphocytic foci were observed very rarely. In the erosive-wound zone of the esophagus, thin fibroblasts are clearly formed in the deep layers, reparative regeneration prevails. Also, the formation of new vessels (neorevascularization) began to appear in fibroblastic areas according to regenerative laws. This is one of the important signs of a complete transformation of the industry layers. Infiltration of histiocytes and macrophages is observed in different layers (Fig. 3.7-9). This, in turn, was considered the basis for the formation of new epithelial cells in the damaged (dystrophic and necrotic) epithelial layer. These signs are observed mainly on the 7th day (Fig. 3.7-9) and more clearly on the 10th day (Fig. 3.10-13).

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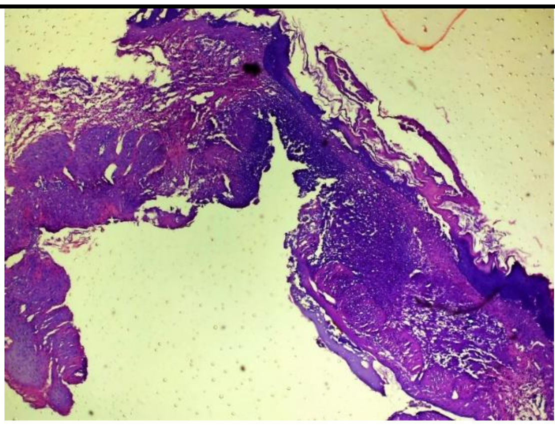

Figure 7. Esophageal lesion zone of the esophageal-cardio esophageal junction of an experimental rat. Swelling of submucosal areas, infiltration with a small number of diffuse lymphocytic foci. Signs of non-revascularization. Infiltration of histocytes and macrophages in different histomorphological layers. Laser effect with a voltage of 7 watts. 7 days of experience. G-E 10x4.

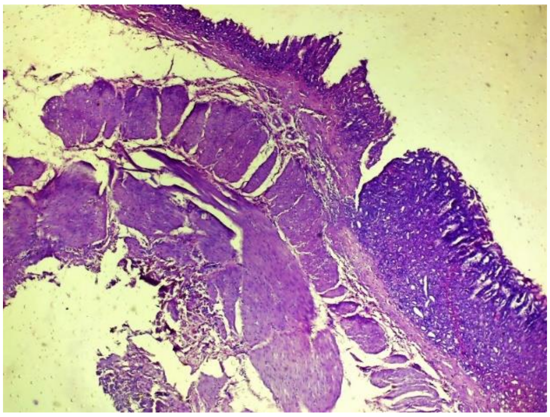

Figure 8. Experimental rat with damage to the esophagus of the cardiac zone. Swelling of submucosal areas, infiltration with a small number of lymphocytic foci. Small fibroblasts are detected in the deep layers of erosive lesions of the esophagus. New vessels are formed (neovascularization). Infiltration of histiocytes and macrophages is observed in different layers. The effect of laser voltage of 5 watts. 7 days of experience. G-E 10x4.

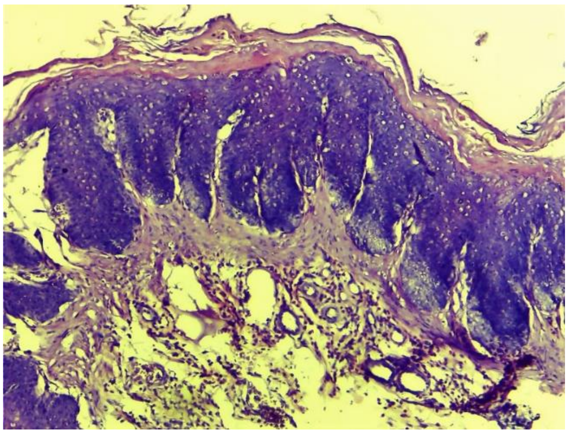

Figure 9. Experimental layers of the wound area of the esophagus of pigs. Small fibroblasts form on the damaged areas and layers. Diffuse infiltration by histiocytes and macrophages. Signs of neovascularization. Laser effect with a voltage of 7 watts. 7 days of experience. Mr. 10x2.

On the 14th day of the experiment, in rats exposed to a 5-watt laser and in pigs exposed to a 7-watt laser, the layers of the esophagus in the affected areas began to regenerate completely. In the area of the deep layers of the formed "eroded" mucous membrane, there is an overgrowth of soft fibrous connective tissue. Regeneration of the epithelial layer occurred due to the acceleration of differentiation and transformation of cells and was manifested by histiocytic tumors around different layers. The formation of new vessels is accelerated (neovascularization), the vessels are filled. In a word, it was found that all layers recovered to their morpho-physiological state (Fig. 11 and 13).

By the 10th day of the experiment, the first proliferative processes began to prevail in the group of pigs exposed to a 9-watt laser and in rats exposed to 7 watts, but exudative changes in the process remained dominant. In the area of deep cytoarchitectonic layers, formal regeneration of coarse connective tissue in the area of injury, lymphocytic-macrophage inflammatory infiltration was observed. The formation of fibroblasts is shown in the damaged layers. But here, unlike the experimental group with a laser power of 5 W and 7 W, fibroblasts were slightly disturbed, rough in deep areas, accompanied by swelling in some areas. The mucous and submucosal layers are in the final stage of recovery (Fig. 10-13).

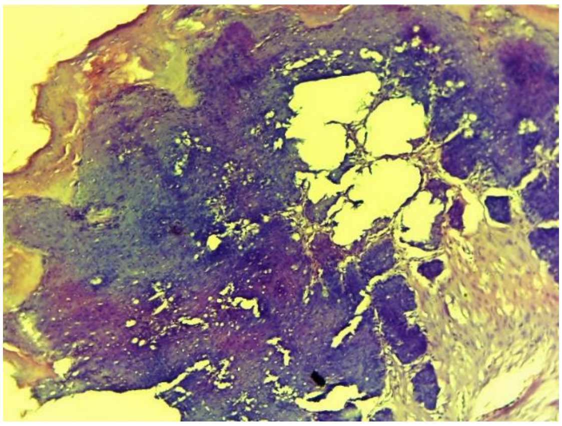

Figure 10. An experimental rat with damage to the esophagus of the cardiac zone. Formation of regeneration of coarse connective tissue in the area of injury, deep cytoarchitectonic layers, lymphocytic-macrophage inflammatory infiltration between sites. The formation of fibroblasts is shown in the damaged layers. Fibroblasts are chaotic and coarse. Diffuse puffiness in different layers of some areas. The mucous and submucosal layers are in the final stage of recovery. Laser effect with a voltage of 7 watts. 10 days of experience. G-E 10x4.

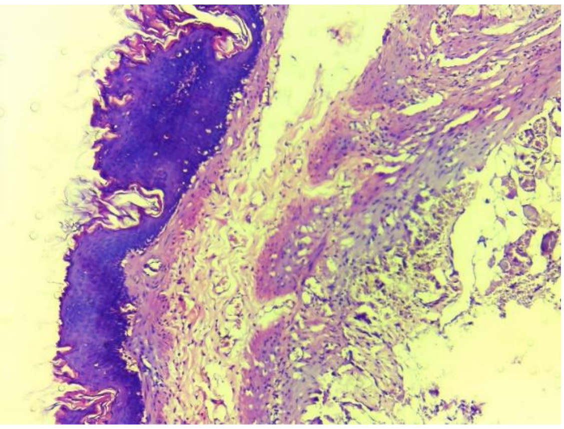

Figure 11. An experimental rat. Complete reconstruction of histomorphological layers in the affected area by esophageal erosion. There was a regeneration of the epithelial layer and some

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histiocytic tumors around different layers. The formation of new vessels is accelerated, the vessels are filled. The effect of laser voltage 5W. 10 days of experience. G-E 10x4.

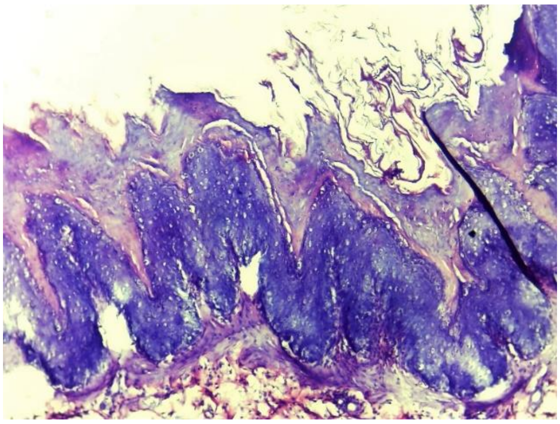

Figure 12. Experimental layers of the esophagus of pigs. Signs of the predominance of the exudative-proliferative process. Normalization of histoarchitectonics of the mucosa and submucosa. Vasodilation. The effect of laser voltage of 9 watts. 10 days of experience. G-E 10x4.

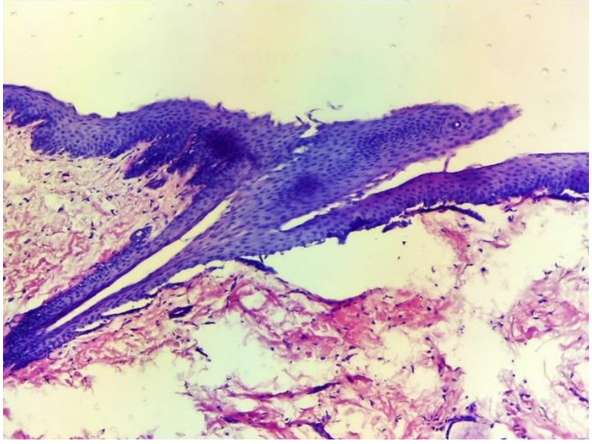

Figure 13. Sections of a completely reconstructed esophagus of an experimental pig. In the area of damage, there is a very small number of soft-fiber connective tissue elements. Predominance of signs of neovascularization. Laser effect with a voltage of 7 watts. 10 days of experience. G-E 10x2.

Conclusion

In medicine, lasers with different energies are widely used in both diagnostic and operative surgery. As we said above, their phototherapeutic value depends on several of their parameters. Of these, the wavelength mainly determines the degree of its penetration or passage through tissues, and its power is the cause of its biochemical and biophysiological effects.

The wavelength of the laser used in our work was 970 nm. It is known from many fundamental scientific studies that this spectrum corresponds to IR rays that penetrate deeply into tissues (up to 7-15 cm), improve microcirculation, improve reproductive processes, stimulating proliferative processes.

An analysis of the literature has shown that there are currently no clear recommendations for the use of laser power in the tissues of various organs. According to our observations, exposure to energy of 5 W 137 J had a positive effect on experimental rats, while exposure to energy of 7 W

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137 J showed its biophotoefficiency in experimental pigs. Basically, this effect begins on the 3rd day of the experiment (Fig. 4-6), and is clearly manifested on the 7th day of the experiment (Fig. 7-9).

Our research mainly consisted in determining the effect of lasers on the esophageal wall of experimental animals (rats and pigs).

Experimental animals, i.e. rats, have an average esophageal wall thickness of 0.5—1.0 mm, and adult experimental pigs have an average of 3-5 mm. In our opinion, such mutual changes of the same energy, but of different strength, as we have said, are directly proportional to the thickness of the morphological layers of the tissue. That is, as the thickness of the organ tissue increases, it is necessary to increase its power in order to achieve a biophotoeffective effect of lasers with the same energy.

In our opinion, the laser power should be chosen based on the morphophysiological structure of the tissue. These indicators should be calculated individually for each member. In our opinion, the use of lasers of different power in surgery gives a number of advantages.

This is what we talked about above, once again confirmed by experience.

Another important aspect is that laser radiation has a complex effect on almost all stages of inflammation, stimulating all stages of the process. In turn, the use of high-energy laser radiation in various erosive processes of the esophagus reduces inflammatory processes and reduces scarring. Moreover, infrared rays directly and indirectly stimulate microcirculation. From the theory of reparative regeneration, it is known that the basis of any pathological inflammation is a violation of microcirculation, If this is restored, self-regeneration accelerates and the wound heals.

In our results, based on the morphophysiological structure of the organs of experimental animals, tension of the erosive wound, signs of wound healing, reduction of infiltrative processes and acceleration of regenerative-reparative processes prevailed (Fig. 2, 3 , 5, 6, 8, 9, 11, 13).

As a result, in our opinion, on the basis of the above, the conclusions obtained as a result of the experimental morphological studies carried out by us in this work were confirmed in the above-mentioned signs and changes.

Finally, in short, the positive bio-effective effect of diode laser irradiation in erosive lesions of the esophagus can be achieved by selecting the power taking into account the thickness of the morphophysiological layers of the organ.

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