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The use of low level laser therapy in the treatment of surgical pathology

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An overview of the mechanisms of the effect of low level laser therapy at various structural levels and the main directions of its application for the treatment and prevention of surgical pathology is given.

Keywords: low level laser therapy, surgical pathology.

The progress of medical science and technology, clinical medicine is now largely determined by advances in the field of quantum electronics. The growing interest of physicians in optical generators (lasers) is primarily due to the inexhaustible possibilities of laser radiation. The unique properties of the laser beam have opened up wide possibilities for its application in various fields: surgery, therapy and diagnostics [1,2,8,14,15]. Clinical observations have shown the effectiveness of a laser of ultraviolet, visible and infrared spectra for local use on a pathological focus and for affecting the entire body.

Depending on the nature of the interaction of laser light with biological tissues, three types of photobiological effects are distinguished [2]:

1. Photodestructive effects - thermal, hydrodynamic, photochemical effects of light cause tissue destruction. This type of laser interaction is used in laser surgery.

2. Photophysical and photochemical effects, in which light absorbed by biological tissues excites atoms and molecules in them, causes photochemical and photophysical reactions. The use of laser radiation as a therapeutic one is based on this type of interaction.

3. Non-disturbing effect, when the biosubstance does not change its properties in the process of interaction with light. These are effects such as scattering, reflection and penetration. This type is used for diagnostics (for example, laser spectroscopy).

The article discusses examples of the application of photobiological effects depending on the parameters of low level laser therapy. The role of the use of low level laser therapy in the treatment of surgical pathology is indicated. Some examples are given and the corresponding conclusions are drawn.

Photobiological effects depend on the parameters of laser radiation: wavelength, intensity of the light energy flux, time of exposure to biological tissues, as well as the initial state of the organism and the irradiated tissues [7]. In laser therapy, light fluxes of low intensity are used, no more than 100 mW/cm^2. Therefore, this type of laser treatment is called Low Level Laser Therapy (LLLT). LLLT is used in medicine in two main directions: in photodynamic therapy (PDT) of tumors, where its damaging effect is used, and also for the treatment of a wide range of various inflammatory diseases, bearing in mind the stimulating effect of LLLT.

Laser therapy has the following features [1]:

1) the LLLT power required for indication by its body falls into the non-thermal effect area (wavelength range 0.3-1.55 microns);

2) the normalizing physiological effect persists after the termination of this effect; the duration of the preservation of the effect increases from procedure to procedure, overlapping at a certain moment the time between procedures;

3) the therapeutic effect is observed in the focus of pathology, although the effect can be made in a zone remote from the focus.

Light in the ultraviolet, visible and infrared regions of the spectrum has photobiological activity. Photobiological processes are based on photophysical and photochemical reactions that occur in the body when exposed to light [2]. Photophysical reactions are mainly caused by the heating of the object to varying degrees (in the range of 0.1-0.3 C) and the spread of heat in biological tissues. The temperature difference is more pronounced on biological membranes, which leads to the outflow of Na^+ and K^+ ions, the opening of protein channels and an increase in the transport of molecules and ions. Photochemical reactions are caused by the excitation of electrons in the atoms of a substance that absorbs light. At the molecular level, this is expressed in the form of photoionization of a substance, its reduction or photooxidation, photodissociation of molecules, in their rearrangement - photoisomerization.

Low level laser therapy both interacts with photosensitive cells and complexes [7,10] (copper-containing redox enzymes, catalase, cytochrome complex, peroxide radicals, singlet oxygen, some pigments, etc.) and disrupts weak interactions in biological systems. The strong interactions that determine the chain structure of biopolymers are not violated. The transformation of the excitation energy of a photosensitive cell is carried out by intramolecular conversion, nonradiative transfer of excitation energy to another molecule, and the use of excitation energy in photochemical reactions [14]. It is assumed that the action of laser radiation on human tissue leads to a reversible (non-damaging) change in the spatial configuration of cell membranes and enzyme molecules, which causes a change in their regulatory functions and, as a consequence, the functional activity of cells [1,12].

Low level laser therapy stimulates the metabolic activity of the cell. Stimulation of biosynthetic processes can be one of the important points that determine the effect of low level laser therapy on the most important functions of cells and tissues, vital processes and regeneration [4].

LLLT leads to an increase in the content of DNA and RNA in the nuclei of human cells, which indicates the intensification of transcription (division) processes. This is the first step in the protein biosynthesis process. This raises the question of triggering mutations. However, it has been proven that the frequency of chromosomal mutations in human cells decreases when exposed to LLLT [10,11].

LLLT stimulates the production of a universal source of energy ATP in mitochondria, accelerates the rate of its formation, and increases the efficiency of the mitochondrial respiratory chain [3]. At the same time, the amount of oxygen consumed decreases. LLLT has an antioxidant effect [11].

Changes in blood microcirculation and oxygenation can be considered the most confirmed body response to laser exposure. The biological effect of LLLT on the microcirculation system [1,2,3,4] is explained by an increase in erythrocyte deformability and blood flow velocity, a decrease in spastic reactions of microvessels, especially in the arterial link, normalization of the permeability of the microvascular wall and elimination of edema, and an improvement in the rheological properties of blood. This is due to both photoreactions of smooth muscle sphincters of arterioles and biological substances stimulated by laser radiation.

Summarizing the data of modern research, it can be said that LLLT causes the activation of energy-binding processes in pathologically altered tissues with metabolic disorders, an increase in the activity of the most important enzymes, a decrease in oxygen consumption by tissues with an increase in the phosphorylating activity of mitochondria, their enrichment with energy, an increase in the intensity of glycolysis (glycogen formation) in tissues, and others.

Secondary effects are a complex of adaptive and compensatory reactions resulting from the implementation of primary effects in tissues, organs and the whole living organism [5,7,8,10,15]:

- anti-inflammatory,
- anesthetic,
- regenerative,
- desensitizing,
- immunocorrecting,
- improvement of regional blood circulation,
- hypocholesterolemic,
- bactericidal and bacteriostatic.

Currently, the high efficiency and safety of low level (not damaging biological tissues) laser therapy has been proven in the treatment of various diseases. Average indicators of the therapeutic efficiency of LLLT in hundreds of thousands of patients with various pathologies, including surgical, in Russia and the CIS for the period 1990-2002. make up 78-95% [1].

The high therapeutic efficacy of LLLT has been shown in studies in surgical patients in the treatment of postoperative complications, anastomositis, postoperative intestinal paresis, wounds, burns, obliterating vascular diseases of the extremities and other surgical diseases [1,8].

Laser light accelerates the regeneration processes, contributes to the reduction of microflora, resorption of infiltrates, normalization of blood counts and ultimately leads to wound healing. The radiation of the helium-neon laser helps to cleanse wounds from microorganisms, accelerates the processes of repair and epithelization, normalizes blood counts and significantly accelerates healing [2, 11]. The data obtained in the studies indicate that the processes of maturation of granulation tissue are more active in the case of irradiation of the wound with LLLT. There is a 2-3-day advance of the processes of maturation of granulation tissue in comparison with the control group, where the cellular reaction is less active.

Thus, LLLT has a pronounced stimulating effect on the processes of reparative regeneration of infected wounds and, therefore, is an effective treatment for such pathology [15].

The photodynamic effect has a powerful bactericidal effect, destroying the purulent-necrotic substrate, stimulating growth factors (TGF-b, PDGF, sFGF) as a result of exposure to granulation tissue. Antimicrobial photodynamic effect does not decrease after long-term treatment of local chronic infectious processes. The bactericidal photodynamic effect is local in nature and does not affect the state of microbiocinosis.

There are two main pathogenetic directions of the action of photon energy in patients with peritonitis: stimulation of the motor function of the gastrointestinal tract and optimization of the processes of reparative regeneration of the peritoneum. The achieved positive effect is explained by the combination and summation of the local and general biological effects of infrared laser radiation on the body. The local effect of the laser beam is to increase the activity of the energy-synthesizing processes of the cells of the nervous apparatus of the gastrointestinal tract, which are the point of application of the factors of the neurohumoral system, and the general biological effect indirectly stimulates the higher autonomic centers of regulation of the sympathetic-adrenal system.

The use of low-frequency laser radiation along with traditional methods of treatment significantly improves the immediate and long-term clinical results in the problem of acute pancreatitis. Laser therapy dramatically reduces the development of destructive forms of acute pancreatitis, potentiating the effect of drugs [13].

The use of laser radiation in the initial stage of lysis of the autodermotransplant terminates this process with further engraftment of the autosplash [6]. A short exposure to laser light with certain parameters significantly enhances the process of repair (restoration) of the structure of damaged cells. By activating reparative enzymes, the cycles of repairing damage to various elements of the cell structure, including its genetic material, are accelerated. It is important that all these stages of repair occur before DNA replication (cell division) [9,12]. At the same time, activation of flaccid granulations with subsequent epithelization without gross scarring is noted, i.e. the tissue becomes organ-specific [6].

To stop the reaction of aseptic inflammation and prevent gross scarring in the first 2 weeks after surgery, a good effect is given by the use of low-energy helium-neon laser radiation. The stimulating effect of laser therapy on regeneration processes in diseases and injuries of peripheral nerves has been experimentally established. Low-energy helium-neon laser radiation has a pronounced positive effect on reparative nerve regeneration [8].

In the focus of inflammation, laser radiation restores microcirculation and improves the outflow of fluid from the intercellular space into the blood vessels. The key role of microcirculation in maintaining homeostasis in tissues, as well as in the implementation of the effect of exposure to tissues and the body as a whole, of various exo- and endogenous factors is beyond doubt [1].

So, the effectiveness of laser light therapy is shown in almost all diseases under consideration. In many works, it is noted that this method is superior in effectiveness to other means and methods previously used to treat these diseases. The unprecedented breadth of therapeutic effects and the practical absence of objective contraindications indicate that laser radiation is not an ordinary physiotherapeutic factor. This is a new treatment method with great potential.

Thus, the stimulating effect of low level laser therapy on the activity of the most important enzymes is a key link in the mechanism of its therapeutic efficacy. Enzyme activation leads to an increase in bioenergetic and biosynthetic processes, stimulation of cell division, acceleration of regeneration, an increase in the activity of the immune system and, ultimately, to the observed therapeutic effect.

Laser therapy can be carried out both as an independent method and in combination with medication, including hormonal and physiotherapy methods. It should be borne in mind that in the course of treatment, the body's sensitivity to drugs changes and it becomes necessary to reduce the usual dosages, sometimes up to 50%, and in some cases even abandon them, while the sensitivity to LLLT does not decrease even with prolonged use for the treatment of chronic pathology.

After analyzing the scientific literature on this topic, we can conclude that the use of LLLT in the clinic for the treatment and prevention of surgical diseases and their complications is a very promising and experimentally substantiated area of modern medicine.

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