

APPLICATION OF A COPPER VAPOR LASER TO ONCOLOGY

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The results of application of the low-intensity Cu-vapor laser radiation to the treatment of oncological patients that have already been treated by traditional surgical, radiological, and cytostatic methods are presented in the paper. A comparative analysis has shown an obvious clinical effect of laser radiation on the skin and mucous membranes of patients exposed to ionizing radiation as well on patients operated radically on carcinoma of the stomach or lung.

To prevent serious complications after radical antitumor treating and to control arising complications of patients with carcinoma of the lung or stomach or tumor of the head or neck, ingenious methods have been developed using a poorly known pulse-periodic copper vapor laser that generates yellow and green lines.

Serious surgical trauma, protracted surgical operations, and multistage treatment should be considered among the reasons contributing to the development of postoperative complications of oncologic patients. More than 70% of patients subjected to surgical operations were older than 50 years and had accompanying pathology. Patients with carcinoma of the stomach have anemia, serious hypoproteinemia, and reduced index of immunity to infections. Ventilation deficiency is typical of patients with carcinoma of the lung and hence they have starting hypoxemia of various forms with the tendency to cellular acidosis; disorders of the drainage function of the bronchi against the background of accompanying endobronchitis has a detrimental effect on the quality of healing of a bronchus stump. Radiotherapy depresses reparation processes in the tissue around the tumor which causes radiation reactions that hinder radical course of treatment. Against the background of combined and complex treatment of oncological patients, adaptation processes are substantially weakened and their organisms poorly resist to any external influence. Therefore, it is important to have means for stimulating both common protective forces of these patients and their local resistance in the region of postoperative wound or irradiated tissue.

Clinical studies were preceded by the experiments that demonstrate the principal feasibility of application of low-intensity laser radiation (LILR) to treat oncological patients. Optimal regimes of laser actions alone and in combination with chemotherapy oppressing tumor and metastasis spread were approbated on animals-tumor carriers (see Fig. 1).

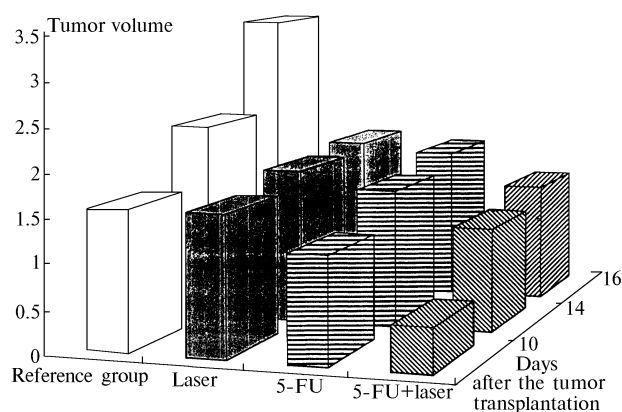


FIG. 1. Effect of combined LILR and 5-FU therapy on the growth of experimental LLC tumor.

Resistance of local tumors of the head or neck to traditional photon radiotherapy methods and their frequent recurrence call for the use of more aggressive corpuscular radiation. At present, protons and fast neutrons are most generally used for radiotherapy. Wide experience has been accumulated on application of remote neutron therapy using cyclotrons and generators. Most researchers pointed out that after neutron irradiation, especially by low-energy beams, high frequency of early and delayed radiolesion of normal tissue around the tumor exposed to radiation were often observed (see Refs. 1 and 2). Analysis of the results of therapy of 71 patients with tumors of the head or neck by a 8-MeV neutron beam revealed serious radiolesion of 17% of them, while traditional radiotherapy complicated by radioresponse only of 4% of patients. The first experiment on application of fast neutrons from the U-120 cyclotron made by H. Eichhorn⁵ was complicated by radiolesion of the skin in 45–65% of cases. Experiments on treatment by low-energy 6.5-MeV neutron beams in the stage of mastering neutron therapy showed high frequency of radiocomplications as well. Early complications like dry and moist epideroma were observed in 75% and 21% of

cases, respectively.² Enhanced frequency of the skin response to tumor treatment by fast neutron beams is explained by the peculiarities of spatial distribution of a dose. Peak of the dose from exposure to neutrons with an average energy of 6.2 MeV is at a depth of 1.2 mm from the skin surface. In addition, specific property of neutrons to damage to a greater extent fat-reach structures, in particular, the hypodermic cellular tissue is of importance.

Development of early acute radiation responses of the skin and mucous membranes forces radiologists to interrupt radiotherapeutic course, which affects adversely the tumor and provokes repopulating and develops radioresistance of tumor cells. Thereby the possibility to achieve complete effect of radiotherapy is reduced.

Radiolesions of normal tissue prevent combining neutron therapy with surgical operations. After the course of neutron therapy, it is recommended to refrain even from biopsy because of bleeding hazard. Necrosis of soft tissue, formation of fistulas, and stripping of the carotid artery requiring its ligation enter the list of postoperative complications of patients that before surgical operation were exposed to fast neutron radiation with a total photoequivalent dose of 45–70 Gr. This list is far from completion. The frequency of postoperative complications was 73%, while that of patients subjected to postoperative combined neutron-photon therapy was as low as 20%.

Almost each patient with carcinoma of the larynx or larynx-pharynx had early acute radiative response of mucous membranes after attempts to apply neutron and combined neutron-photon therapy.

Thus, the problem on improving tolerance of normal tissue in the irradiation zone is of special importance. The means fairly efficient in case of conventional radiotherapy often have no desired effect in case of neutron one.

The group of 121 patients with local, recurrent, and metastasis tumors of the head or neck was treated by us using the U-120 cyclotron. A therapeutic neutron beam was generated in the course of reaction $\text{Be}^9(d, n) \text{Be}^{10}$ running under bombardment of a beryllium target by accelerated deuterons with energies of 13.5 MeV.

The patients were subjected to therapeutic laser irradiation during the entire course of neutron-photon therapy. The Malakhit physiotherapeutic laser system developed at the Laboratory of Laser Physics of the Tomsk State University was used. The laser radiation was generated in a gaseous mixture of neon with pure copper vapor. Copper was evaporated in a hermetic tube made from ceramics and quartz. A pulsed discharge excited the copper atoms and maintained high temperature in the active zone necessary for copper evaporation. The radiation was generated in the pulse-periodic regime with pulse repetition frequency varying from 15 to 20 kHz and a pulse duration of 20–30 ns. The average output power reached 1 W. Lasing occurred on two transitions simultaneously, yellow and

green narrow lines in a 3:1 ratio were presented in the laser beam. The laser output power was easily changed in the range from 50 to 300 mW and the beam could be confined into a waveguide.

The skin and mucous membranes in the zone of neutron action were exposed to laser radiation with energy density between 2.8–3.2 J/cm² during the entire course of radiotherapy.

The frequency and time of occurrence of radioreactions, their forms, and dependence on the absorbed dose of ionizing radiation served as the criteria for the efficiency of laser therapy.

The results of combined application of neutron-photon therapy and the copper vapor laser are presented in Figs. 2 and 3.

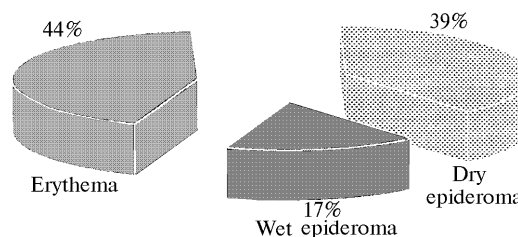


FIG. 2. Frequency of acute radiation response of the skin to neutron-photon therapy according to radical program.

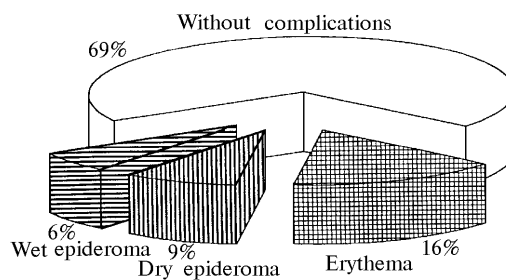


FIG. 3. Frequency of acute radiation response of the skin to neutron-photon therapy in combination with LILR.

Comparison of these results with the data on the reference group obviously demonstrates pronounced clinical effect of the copper vapor laser on the skin and mucous membranes in the zone of ionizing radiation.

According to the data presented in Ref. 3, postoperative period of 15–65% of patients with carcinoma of the stomach is complicated by anastomosis and reflux gastritis, while some authors found these complication in 80–88% of patients subjected to surgical operations. The inflammatory changes in mucous membranes of the stomach and gullet along with secretion and motorics of the stomach fragment remained after the operation depend on the function of digestive anastomosis since its incomplete closure results in eunogastric reflux. The changes in the anastomosis zone are found already during early postoperative period, because even after an ideal surgical operation the anastomosis remains unclosed

during 4–5 months, which is clearly observed during fibrogastroscopy. Fibrogastroscopy provides a means for objective determination of the state of gastric mucous membrane and the operation results. Bile acids, lysolecithin, and pancreatic juice falling on the stomach stump mucous membranes decrease viscosity and elasticity of mucus of gastric epithelium, disrupt the integrity of its membranes, reduce secretion of neutral mucopolysaccharides, exhaust protective properties of gastric mucous membranes, and contribute to the formation of erosions and ulcers.

The above-listed disorders create adverse background for processes of postoperative adaptation and thereby require treatment independently of clinical symptoms. Postoperative rehabilitative procedures are made mainly on patients operated for gastric or duodenum ulcers. Reports on rehabilitation of oncologic patients subjected to gastrectomy and subtotal resection of the stomach are few in number (see, for example, Ref. 4). Treatment at a health resort or sanatorium and physiotherapy are not widely used because of the risk of its stimulating action on metastases missed during operation. As a rule, radically treated oncologic patients are eliminated from the list of persons having the right to take a cure at a health resort or sanatorium. This means that they possess unequal rights in comparison with other patients, although, in some cases their ability to work can be fully rehabilitated. However, the problems of rehabilitation of oncologic patients are of great social importance despite their elderly age, pessimistic spirits, difficulties with employment, and, first of all, questionable clinical prognosis.

With the advance of endoscopic technique, immediate contact of a laser beam with erosion-ulcer

surface of mucous membranes of the stomach and gullet is provided. Reports on phototherapy of gastric and duodenum ulcers using the radiation of various lasers become more and more frequent. In spite of refining the methodology and search for optimal regimes at various laser wavelengths, all authors pointed out that endoscopic laser therapy is an efficient means of curing ulcer and erosion disorders of mucous membranes of alimentary canal organs. The above-outlined treatment method allows one to reduce the time of healing and the time of manifestation of clinical symptoms of the disease as compared to medicinal therapy.

We studied the efficiency of the low-intensity radiation of a copper vapor laser for correction of postresection disorders of patients operated for carcinoma of the stomach. Therewith, the experience on the copper vapor laser operation and the properties of the copper vapor laser radiation to oppress the growth and metastasis of tumors were taken into account.

The Malakhit laser system was used for treatment. Mucous membranes of the stomach and gullet were irradiated during 1 min through a biopsy canal of the Olympus gastroscope using a monofiber optical waveguide. The distance to the object was 0.5–1 cm, the radiation power at the output from the waveguide was as high as 150 mW. The dose did not exceed 10–13 J/cm². A course of treatment included 5–7 procedures repeated in a day. 81 patients after resection of the stomach or gastrectomy for carcinoma were treated. Some of them took combined curing including laser therapy and medicaments commonly used for such diseases. The reference group of patients took only medicinal therapy.

TABLE I. Comparative characteristic of the treatment results in groups from the data of endoscopic inspection.

Character of postresection disorder	Frequency of a symptom in the groups under study, %					
	Medicinal treatment		LILR		Combined medicinal and LILR treatment	
	Before	After	Before	After	Before	After
Anastomatosis	94.4	66.7*	100	82.7*	85.3	58.8*
Gastritis of the first-third degree	44.4	27.8*	72.4	31.3*	35.29	8.82*
Functional deficiency of anastomosis	27.8	22.2	41.4	13.8*	29.4	5.88*
Eunogastric and gastroesophageal reflux	16.7	16.7	34.5	10.4*	32.4	5.88*

* Statistically significant difference.

Thus, the method of rehabilitation of patients radically operated on carcinoma of the stomach with the use of the pulsed green-yellow laser radiation of low intensity in combination with the medicinal treatment or alone allows one to bring efficiently the serious postresection disorders under control. Endoscopic laser therapy can be repeatedly made in out-patient clinics. It allows one to eliminate fast painful perceptions and dysphagia.

In the reference group, patients did not die during a 5-year period, which testified to the absence of undesirable effects stimulating the tumor.

Up to now, the operation is the main method of treatment of carcinoma of the lung in noncelule form. The results of treatment depend largely on the postoperative period. Thus, fatal complications had 16–20% of patients. They arose and developed against the background of chronic bronchitis. Disorders of the drainage function of bronchial tree caused by reduced activity of lashing movement of cilia of respiratory epithelium and mucous glands are complicated by postoperative pneumonia, atelectasis, bronchial fistulas, and pleural empyema. Aggressive pathogenic microflora in bronchi intensifies, mucous membranes

swell thereby causing trophic and blood circulation disorders of the tissue. This affect the quality of healing of the bronchus stump after surgical operation. For this reason, it is very important to prepare the patients before the operation to normalize main functions of the bronchi.

We studied the feasibility of application of the copper vapor laser to prepare 180 patients having sarcoma of the lung to the operation. The operation was combined with intraoperational irradiation of 60 patients, which was additional factor complicating the

postoperative period. Some patients who were prepared before the operation traditionally (they were taken antibiotics, inhalations, and expectorants) were included into the reference group.

It was found that endoscopic laser therapy caused pathogenic microflora to disappear from bronchial secretion, hyperemia and oedema of the mucous membrane of the bronchi to reduce, and their drainage function to improve. These provide the decrease of the number of postoperative complications (see Fig. 4).

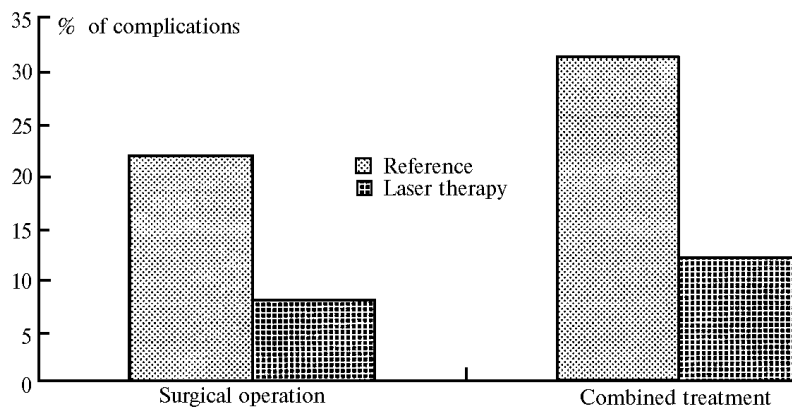


FIG. 4. Results of pre-operational preparation of patients with carcinoma of the lung.

Our study allows us to conclude that the copper vapor laser radiation is highly efficient for prophylaxis and curing of undesirable complications after radical treatment of malignant tumors.

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