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MULTIWAVE MEDICAL DEVICE ON THE DIODE PUMPED SOLID STATE LASER FOR THE MICROBE NATURE DISEASE TREATMENT

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Multiwave laser medical device "Livadia" has been developed for bactericidal and therapeutic impact on the affected organism parts. This device is on the diode pumped solid-state laser and main wavelength radiation conversion 1064 nm into the second harmonic 532 nm and fourth harmonic 266 nm. It has been shown that UV radiation on the wavelength 266 nm on bronchia mucosa with various inflammation types improves regenerative processes in bronchia tissues which decreases treatment deadline.

Keywords: Ultraviolet radiation; bactericidal action; solid-state laser; harmonics.

1. Introduction

During economical crisis, there is an increase in the index of tuberculosis sick-rate and death-rate. In Russia this index has increased two times during 10 years. Moreover, mutant strains of common mycobacteria stable to drugs (Multiple Drug Resistance — MDR) expanded much more rapidly than had been expected. The number of patients suffering from MDR increased constantly and the efficiency of traditional drugs decreased.

Because of this reason, in Prokhorov General Physics Institute together with Central TB Research Institute, the research of laser endocavital UV irradiation based on destroying mycobacterias or preventing their expansion was organized.[1]

Within these researches the death rate dependence of intestinal bacillus on UV radiation wavelength was explored[2,3] (Fig. 1).

The parameter of Y-axis is the inverse quantity to the time, which demands for death of bacillus by the effect of different wavelength UV-radiation.

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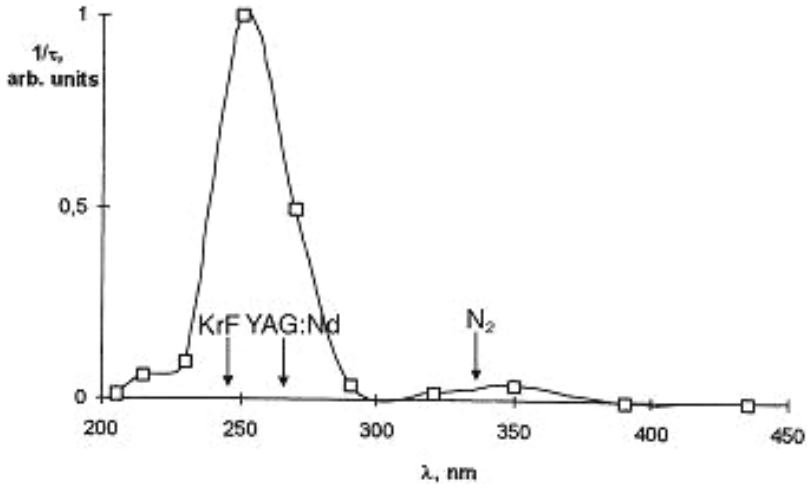

Fig. 1. The dependence of death rate of intestinal bacillus on UV-radiation wavelength.

This graph shows that the bactericidal action peak closely agrees with radiation wavelengths for YAG-Nd laser with conversion of main radiation frequency into fourth harmonic and for KrF_2 excimer laser.

2. Materials and Methods

The laser medical device "Maria" on the basis krypton fluoride excimer laser with the wavelength radiation 248 nm for the treatment of destructive lung tuberculosis forms has been developed in Prokhorov General Physics Institute of the Russian Academy of Sciences together with Genestho-Laser.[4]

In Table 1 there are the results of UV-radiation dose by bactericidal effect for different kinds of microorganisms (Guidelines application germicidal lamps. Lighting engineering, 1995).

It is clear, that it needs much bigger radiation dose for the bacteriostatistical effect for *Mycobacterium tuberculosis*.

Table 1. UV-radiation dose by bactericidal effect.

	UV-radiation dose by bactericidal effect (J/m^2)	
Kind of micro-organisms	90.0%	99.9%
Bacterium:		
Staphylococcus aureus	49	66
Staphylococcus epidermidis	33	57
Streptococcus haemolitcus	21	55
Streptococcus viridans	20	38
Corynebacterium diphteria	34	65
Mycobacterium tuberculosis	54	100
Sarcina flava	197	264
Escherichia coli	30	66
Salmonella typhi	21	41
Shigella	16	42
Salmonella enteritidis	40	76
Salmonella typhimurium	80	152
Pseudomonas aeruginosa	55	105
Enterococcus	40	120
Viruses:		
Influenza virus	36	66
Bacteriofag Escherichia coli	36	66

The opportunity for application of UV-radiation in medical practice is based on the results of Ref. 5. Ten hours after irradiation of mouse cornea with doses of 0.09 to 1.5 J/cm^2 incidence of cells with chromosome aberrations increased linearly with dose and amounted to 11.7% at 248 nm per 1 J/cm^2. No induced chromosome aberrations occurred 72 h following irradiation. In our case, the radiation intensity does not increase above 5 mw while the procedure time is not more than 10 min. The radiation dose is no more than 0.6 J/cm^2 if the irradiation area is 1 cm. It is necessary to avoid the radiation overdose in any therapeutic treatment approach.

Treatment technique with the device use has been developed in Central TB Research Institute of the Russian Academy of Medical Sciences. The laser endocavital irradiation technique includes several steps after X-ray probe to localize the cavern position (a needle is inserted into the cavity). The single use sterile catheter is inserted through the needle hollow. After that the device starts working. This procedure lasts about 10 min.

The results of clinical tests are presented in Fig. 2. There is a treatment dynamic of general clinical manifestations in the main patient group and group of comparison in three months from the beginning of treatment. Operation factors are:

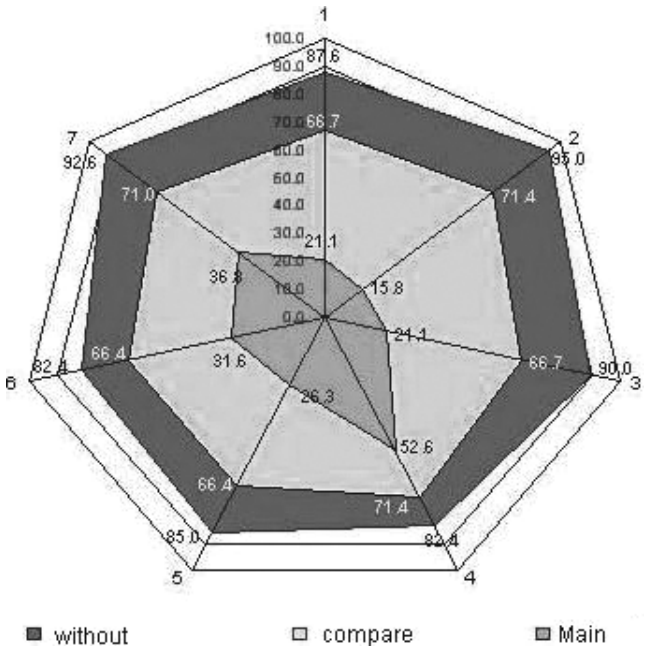

Fig. 2. Dynamics of main clinic illness progress. 1. Weakness, 2. Temperature increase, 3. Hyperhidrosis, 4. Body mass reduction, 5. Cough with phlegm, 6. Short breath and 7. Bronchial rales.

weakness, increase in temperature, hyperhidrosis, body mass reduction, cough with phlegm, short breath and bronchial rales.

The high technique efficiency of endocavernous treatment for destructive tuberculosis forms has been proved. However, the laser medical device "Maria" has not spread properly in medical practice because of its high price. To its disadvantages we can relate clearance, weight and necessity to work with aggressive gas mixtures which demand specialized safety and periodical filling.

The results of clinical tests show that the use of UV laser radiation increases the efficiency of complex treatment of patients with progressing lung tuberculosis accompanied by empyema pleura and pleura thorax fistulas. The use of this device is possible in bronchia tuberculosis treatment with bronchoscope through tracheostome.

Nearly 10% tuberculosis patients have bronchia tuberculosis (its treatment has the same difficulties as lung tuberculosis does). To transport the radiation by means of light guide is very comfortable. It realizes the affected spots of bronchia and trachea. Treatment procedure is followed by a light guide which is brought into the channel of bronchoscope. It is used for biopsy and then slowly taken out together with bronchoscope from bronchi and trachea. This procedure lasts 60−90 s.

Based on the above, a multiwave laser medical device "Livadia" has been developed for bactericidal and therapeutic impact on the affected organism parts.[6,7] This device is on the diode pumped solid-state laser and main wavelength radiation conversion 1064 nm into the second harmonic 532 nm and fourth harmonic 266 nm.

We have shown experimentally that the vanadate a-cut σ-polarized laser has the best parameters for the passive Q-switch with Cr^{4+}:YAG. The features of the laser action, in this case, was investigated. Our laser has polarized radiation with the peak power of 17 kW on 1.06 μ. Excellent laser parameters allow effective conversion into the second and fourth harmonics, even outside the laser cavity. We have obtained 100 mW on the second and 5 mW on the UV laser radiation fourth harmonic with pumping power about 4 W. The set of vanadate crystals was investigated as an active medium for such lasers. The characteristic features of vanadate lasing are different wavelengths for σ and π polarizations.

We used this laser to build a cheap, compact, and effective medical system with a combined

UV-VIS-IR output radiation. This system is certified for medical applications and works in clinics.

Parameters of "LIVADIA" medical device:

Wavelength of radiation, nm	1064	532	266
Mean power, mW	500	100	5
Radiation frequency, kHz		10−20	
Impulse duration, ns		3−10	
Resource, hour		5000	
Radiation outlet		optical fiber	
Fiber diameter, mm		0.6	
Fiber length, m		1.5	
Exposition time, min		0.1−100	
Use power, W		400	
Size:			
Length, mm		500	
Width, mm		450	
Height, mm		300	
Weight, kg		8	
Cooling		air	

Therapeutic effect of the device use is achieved by multiwave radiation function in UV, visible and IR wavelength ranges.[8] There is the opportunity to use either separate wavelengths or their combinations that allows choosing the most optimal radiation regime for each disease. Combined radiation effect can be used for endocavernous treatment of destructive lung tuberculosis forms. The alternative region use is purulent-inflammatory soft tissue processes treatment. Combined radiation effect in soft tissues causes pathogenic microorganisms growth inhibition and simultaneous stimulation in reparative tissue processes. That is actually observed in gynecology, otolaryngology, therapy and especially in purulent surgery.

3. Results

In Central TB Research Institute of the Russian Academy of Medical Sciences the device "Livadia" has been developed for bronchia tuberculosis treatment and nonspecific endobronchitis with endobronchial radiation use.

There were 101 patients in the research who were divided into two groups: the main group of 52

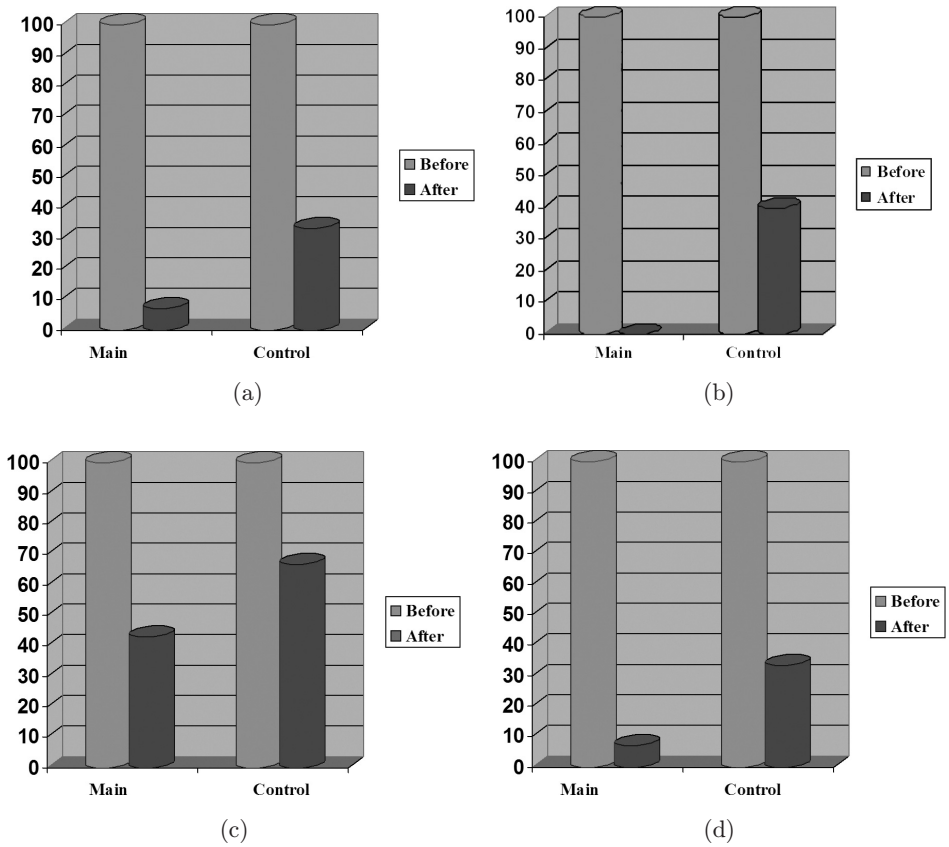

Fig. 3. Dynamic of general clinical manifestations. (a) Infiltration frequency (%) of bronchus wall before and after treatment. (b) Frequency (%) of closing sore defects of patients mucous. (c) Hyperemia frequency of mucous before and after treatment. (d) The presence of cough before and after treatment.

patients and the control one of 49 patients. For the main group, the treatment given was nosology + once a week bronchoscopy with UV-laser. For the control group there was nosology and bronchoscopy (diagnostic and control) without laser use.

The results of clinical tests are presented in Fig. 3. There is a treatment dynamic of general clinical manifestations in the main patient group and group of comparison in three weeks from the beginning of the treatment.

Urgent morphological researches of biopsy materials of bronchus mucous showed the positive dynamic of different degree of manifestations after treatment among all patients. The gradual features disappearance of evident nonspecific inflammation, and in some cases their full disappearance was often noted.

In the control group, the processes proceed slower, and many patients show the evident signs of inflammation by the end of the research.

Among the patients of the main group, there was decrease in the number of dystrophicly exchanged cells of the cylindric ciliary epithelium and the increase of the proliferative activity of epithelium mucous, which stimulates the regenerative processes improvement. The majority of main and control groups had some fibrous exchanges at the end of treatment, however, the group treated with UV-radiation use had less ones.

Thereby, the cytological research assigned that the treatment results were better in the main group where UV-laser radiation was used. In the main group there was either higher percent of cured patients or better treatment quality. Moreover, the cure came at shorter time.

4. Conclusion

According to medical demands the multiwave laser medical device "Livadia" was created. This device allows implementing bactericidal or therapeutic impact on the affected organism parts. It is easy to use, reliable and resourceful. Clinical trials confirmed its high efficiency for infectious disease treatment.

It has been shown that UV radiation on the wavelength 266 nm on bronchia mucosa with various inflammation types improves regenerative processes in bronchia tissues that comes to treatment deadline decrease.

Acknowledgment

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