OPTICAL PROPERTIES OF SOME TISSUES AND ORGANS WITH RESPECT TO LASER BEAMS WITH WAVELENGTHS OF 632.8 AND 488 nm

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UDC 61:621.378.3+57

The attenuation factor and equivalent depth of penetration for radiation of helium-neon and argon lasers with wavelengths of generation of 632.8 and 488 nm respectively were determined. Ability to absorb the energy of laser radiation was found to be strongest for blood and organs with a large number of capillaries. With a decrease in the wavelength of generations, there was a sharp increase in the partial absorbance of the blood. This suggests that greater photoreactivity of blood can be expected to radiation of lasers generating in the short-wave region of the visible spectrum.

KEY WORDS: *Laser; absorbance of tissues; photoreactivity.*

The use of photoselectivity of absorption of laser radiation by different tissues and organs is evidently a promising future application of lasers in biology and medicine [3]. This is particularly true of the "nonthermal" effects of biological action of laser radiation which, according to some workers [1, 6], are due to resonance absorption of energy by certain tissues and organs. In this connection, assessment of ability of biological structures to absorb laser radiation with different wavelengths can be used as a means of selecting optimal spectral characteristics of radiation.

EXPERIMENTAL METHODS

Albino rats (40 animals) weighing 180-220 g were the test objects. The LG-36 laser with wavelength λ_r = 632.8 nm and the LG-106 M laser with a principal wavelength of generation λ_b = 488 nm, were used as the sources of radiation. The diameter of the spot on the transilluminated objects (preparations) was 5 mm. The power flux density of the radiation did not exceed 500 mW/cm^2. To measure the power of the radiation the F-10 photoelectric cell with a set of neutral filters was used.

In the experiments on depilated rats the attenuation factor (K_{at}) of the power of radiation of the lasers as the beam passed through different points of the body of the animals (Fig. 1, Table 1) was measured. The rats were fixed to a platform perpendicular to the axis of the beam. During the measurements the skin at the point of incidence of the beam was fixed parallel to the platform. The projection of the axis of the beam passing through the animal was directed to the center of a photocathode with diaphragm up to 35 mm.

To measure the optical properties of individual tissues and organs of the rats, preparations obtained immediately after decapitation of the animals also were transilluminated by LG-36 and LG-106 M lasers. In this case the diameter of the diaphragm of the photoelectric cell also was 5 mm.

The attenuation factor was calculated as the ratio between the power of the radiation falling on the object and the power of radiation passing through the object, and was recorded by means of the photoelectric cell. The equivalent depth of penetration (L) of radiation with λ_r = 632.8 nm and λ_b = 488 nm was calculated from the ratio between the thickness of the preparation (in nm) and ln K_{at}.

Central Research Laboratory and Department of Pathological Physiology, Tomsk Medical Institute. (Presented by Academician of the Academy of Medical Sciences of the USSR D. D. Yablokov.) Translated from Byulleten' Éksperimental'noi Biologii i Meditsiny, Vol. 85, No. 5, pp. 537-539, May, 1978. Original article submitted March 15, 1977.

 0007-4888/78/8505-0582$07.50 © 1978 Plenum Publishing Corporation

TABLE 1. Attenuation Factors of Radiation of LG-36 and LG-106 M Lasers with Wavelengths of 632.8 and 488 nm, Respectively, at Different Points of Body of Depilated Rats ($M \pm \sigma$)

No. of points	Thickness of substrate, mm	Attenuation factor	
		λ_r = 632.8 nm	λ_b = 488 nm
1	21,1±1,0	35 600±5400	100 000
2	23,4±1,3	19 000±2560	100 000
3	24,0±1,6	21 110±3810	100 000
4	27,7±0,9	34 030±1300	100 000
5	26,1±1,2	47 560±6580	100 000
6	25,9±0,9	49 200±7950	100 000
7	18,4±0,8	2 690±310	100 000
8	18,2±0,7	2 530±230	100 000
9	12,9±0,6	168±4,9	40 300±6350
10	13,0±0,9	172±5,6	39 900±4980
11	9,1±0,5	91±3,8	18 960±2890
12	9,0±0,4	87±2,9	19 310±2900

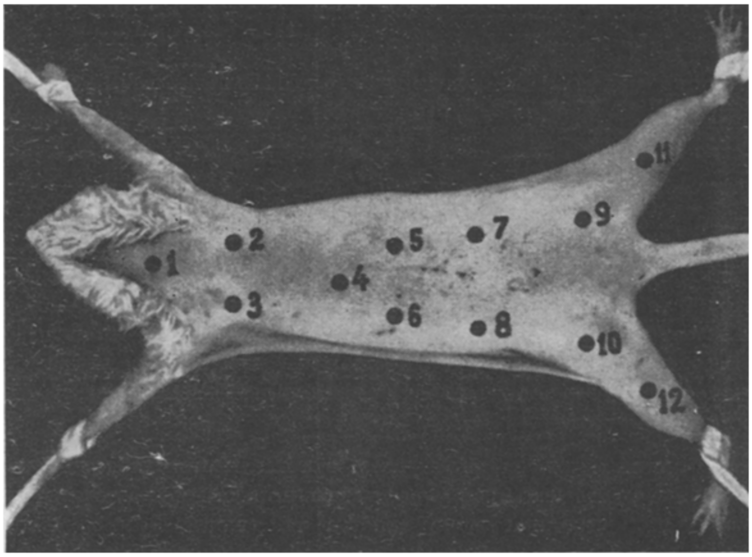

Fig. 1. Arrangement of conventionally chosen points transilluminated by beams from LG-36 and LG-106 M lasers.

EXPERIMENTAL RESULTS

Comparison of the value of K_{at} for red (λ_r = 632.8 nm) and blue-green (λ_b = 488 nm) parts of the spectrum (Table 1) showed that the red component was absorbed by the tissues of the body to a much lesser degree than the blue-green component. During transillumination of points 1-8 in the rats (Fig. 1) by the LG-106 M laser the radiation passing through the animal caused fluctuations of current of the photoelectric cell which did not exceed its noise values. The values of the attenuation factor and of the equivalent depth of penetration, given in Table 2, provide an explanation for these differences on account of a change in photosensitivity of the individual tissues and organs of the animals. For instance, the skin of the rats absorbed both red and blue-green radiation about equally. Meanwhile, blood and organs with a large number of capillaries were characterized by a sharp increase in absorbance in the short-wave part of the spectrum.

The existence of responses of the blood system to laser radiation in the red region of the spectrum [2, 5] suggests that the partial increase in absorbance of the blood in the blue-green region could lead to a marked increase in its photoreactivity. However, the absence of any data at the present time on morphological and functional changes in the blood following

TABLE 2. Optical Properties of Some Tissues and Organs of Rats for Radiation from LG-36 and LG-106 M Lasers with Wavelengths of 632.8 and 488 nm, Respectively (M±σ)

Tissue	Thickness of preparation, mm	LG-36 (λ_r = 632.8 nm)		LG-106 M (λ_b = 488 nm)	
		attenuation factor	equivalent depth of penetration, mm	attenuation factor	equivalent depth of penetration, mm
Thigh muscles	1,0±0,1	4,07±0,92	0,75±0,130	5,59±1,92	0,631±0,140
Liver	1,0±0,1	7,74±0,92	0,49±0,030	20,10±3,16	0,337±0,019
Lungs	1,0±0,1	23,17±2,41	0,32±0,005	74,46±4,94	0,233±0,004
Brain	1,0±0,1	11,21±1,33	0,42±0,020	16,90±0,97	0,355±0,008
Heart	1,0±0,1	9,30±1,10	0,46±0,025	33,17±5,60	0,287±0,015
Kidneys	1,0±0,1	8,53±0,97	0,47±0,025	58,56±3,14	0,248±0,002
Spleen	1,0±0,1	27,35±3,12	0,31±0,015	200,59±19,02	0,190±0,004
Cranial bones	0,60±0,09	7,40±0,41	0,30±0,010	34,1±0,58	0,170±0,001
Blood	1,0±0,1	136,50±12,10	0,21±0,005	3980±280	0,121±0,005
Skin with hair:					
dorsal	3,4±0,5	45,42±7,31	—	54,21±4,58	—
abdominal	2,6±0,2	23,22±5,19	—	34,06±3,97	—
cranial	2,7±0,3	24,45±2,82	—	38,9±3,36	—
Skin of depilated animals:					
dorsal	0,89±0,02	8,29±1,22	0,43±0,030	11,13±0,48	0,416±0,008
abdominal	0,82±0,04	6,98±0,81	0,43±0,025	9,27±0,78	0,450±0,020
cranial	0,51±0,01	5,17±0,84	0,32±0,035	8,96±0,72	0,457±0,009

exposure to argon lasers makes such a comparison difficult. The possibility of differences in primary cortical responses to laser radiation, which have already been established for the red and the infrared region [4], must also be taken into account. On the whole, the characteristics of the optical properties of tissues and organs for radiation with λ_r = 632.8 nm and λ_b = 488 nm described above suggest the greater biological effectiveness of radiation from lasers generating in the short-wave region of the visible spectrum.

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