EXPERIMENTAL STUDY OF THE EFFECT OF ULTRAVIOLET LASER RADIATION ON PULMONARY, TRACHEAL, AND BRONCHIAL TISSUE

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Laser radiation in the ultraviolet region of the spectrum has a beneficial effect on pathologically changed tissues [2, 4] and, in particular, on burn wounds [3]. At the same time, the excessively damaging action of coherent UV radiation also has been described [1, 8], and the direction of action of UV laser radiation has been shown to depend on its dose [6]. Because of the contradictory nature of the available data, UV lasers have to be used with caution; this is evidence that further research is essential, especially in relation to pulmonary and bronchial tissues, for these have been studied only clinically [5, 7].

It was accordingly decided to study the action of UV laser radiation on the structural features of pulmonary, tracheal, and bronchial tissues resulting from irradiation under varied conditions.

EXPERIMENTAL METHOD

Altogether 38 acute experiments were conducted on 13 male rabbits weighing 2400-6200 g, anesthetized with pentobarbital (1% solution, intravenously, 40 mg/kg body weight). Manipulations were carried out under controlled respiration (using the bag of the anesthetic apparatus). The animals were divided into two groups: 1) eight rabbits whose lung tissue was irradiated, 2) six rabbits in which the mucous membrane of the trachea and bronchi was irradiated. An LGI-21 nitrogen laser with wavelength of 0.337 μ was used: the power at the output of the source was 3 mW, the diameter of the spot on the object 3 mm, the irradiated area 0.075 cm^2, quasimomentum mode of irradiation with frequency of 100 Hz, power density (H) = 4×10^{-2} W/cm^2, irradiation dose (W, J/cm^2) calculated by the equation: W = HT, where T is the duration of irradiation (in sec).

The emitter of the laser was placed vertically at right angles to the test object and at a distance of 30 cm from it.

Material for histological investigation was taken intravitally and placed in 10% formalin solution. Paraffin sections were stained with hematoxylin and eosin and with picrofuchsin by Van Gieson's method.

The lungs of the animals of group 1 were artificially ventilated through a tracheostomy after incubation with a siliconized tube. Thoracotomy was performed on the right or left side in the 7th intercostal space. The lower lobe of the lung was exteriorized into the wound and irradiated with exposures of 3, 6, 9, 12, 15, 21, 30, and 45 min to the experimental point. The lungs were artificially ventilated with adequate gas exchange and minimal excursion of the lung. The lungs were wetted with physiological saline (37°C). Before the animals' lung tissue was irradiated, the visceral pleura was removed over a small area. Blood was washed off with physiological saline and swabbed dry. The exposure lasted 3, 15, and 30 min. Histological material in areas treated with the laser beam was tagged with a thin silk thread on an atraumatic needle along the borders of the irradiated area.

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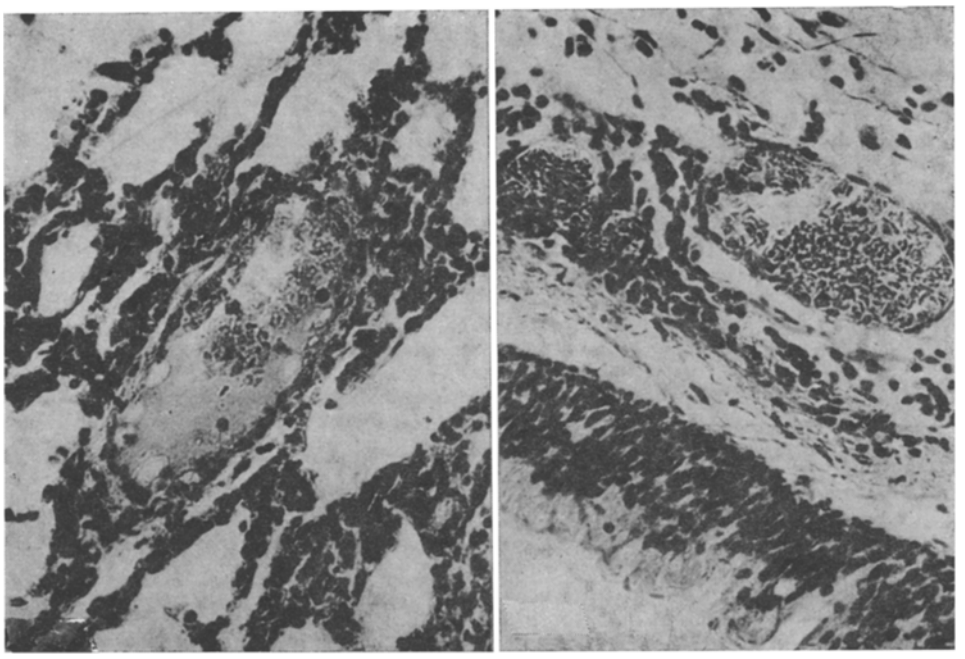

Fig. 1 Fig. 2

Fig. 1. Separation of plasma from blood cells in the veins. Exposure of lung tissue to low-energy nitrogen laser. Exposure 9 min, dose 21.6 J/cm^2. Here and in Figs. 2-4: stained with hematoxylin and eosin, 250 ×.

Fig. 2. Picture of hyperemia and "sludging" in vessels of the submucosa of large bronchi. Epithelial lining intact. Action of low-energy nitrogen laser on bronchial wall. Exposure 15 min, dose 36 J/cm^2.

The three animals of group 2 underwent tracheotomy 3 cm below the thyroid cartilage of the larynx, and the anterior wall of the trachea was removed. The animal was placed in the supine position and the posterior wall of the trachea was irradiated. The exposure was 3, 6, 9, 15, 21, and 30 min. Endobronchial structures (bronchi of the I, II, and III order) were irradiated in three animals. Thoracotomy was performed in the 4th right intercostal space. After blunt dissection of the corresponding bronchi from the lung tissue, bronchotomy was performed. Edges of the bronchotomy wound and the bronchus to be irradiated were securely fixed by forceps so that the long axis of the bronchus coincided with the path of the beam, thereby ensuring uniform irradiation of the bronchial wall. Blood and mucus were removed from the lumen by means of a syringe through a thin catheter, and this was followed by lavage with physiological saline. Exposure to irradiation lasted 3, 6, 12, 21, and 30 min.

EXPERIMENTAL RESULTS

During laser irradiation of pulmonary, tracheal, and bronchial tissue no visual changes could be seen in the color, consistency, or shape of the trachea, and there was no increase in the production of secretion and no bleeding.

Histological examination of irradiated areas of the lungs revealed disturbances of the circulation in vessels of the microcirculatory bed, more marked in the venous portion, in all animals of group 1. The veins were congested with blood, with sludging observed in most of them. In some vessels the plasma was separated from the blood cells (Fig. 1) and small foci of atalectasis were discovered, alternating with foci of inflation, which was not observed in the control. Hyperemia of the vessels and stasis in the capillaries were more marked in the zones of atalectasis. In some cases, after exposure of 30 min to irradiation, the venules showed dystonia whereas the arteries remained normotonic. A picture of stasis was observed in the capillaries.

In the animals of group 2, histological investigation of irradiated areas of the trachea and large bronchi, also of the lung tissue, revealed disturbances of the circulation in the form of hyperemia, sludging (Fig. 2), and the development of edema in the submucous layer

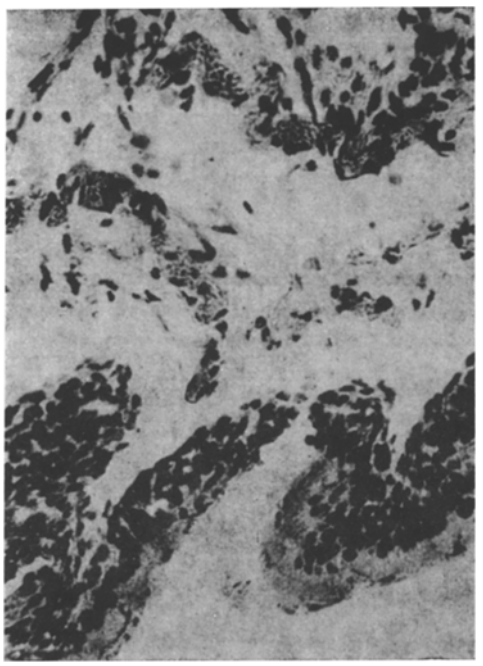

Fig. 3. Edema of submucose and sludging in small vessels of trachea. Exposure of tracheal wall to low-energy nitrogen laser for 21 min, dose 50.4 J/cm^2.

(Fig. 3). No differences in histological structure of the tissues were found in the submucous layer of the trachea and large bronchi after irradiation for 6, 9, 12, 15, 21, 30, and 45 min (doses from 14.4 to 108 J/cm^2). In all cases the changes were similar in character irrespective of exposure (dose).

Moderate congestion of the capillaries and small vessels was observed in areas of irradiation of the lungs, bronchi, and trachea with an exposure of 3 min (dose 7.2 J/cm^2).

The results thus indicate a definite response to UV laser-irradiation of bronchopulmonary structures and the trachea, which is nonspecific in character and includes the development of acinar dystelectasis, moderate edema, and mobilization of macrophages. No gross morphological changes such as destruction, hemmorrhage, necrosis, or separation of layers of tissue were present.

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