Effect of Low-Intensity Laser Radiation on Capillaries in the Rat Brain

V. M. Chertok, and D. V. Bykov

UDC 591.415:591.481:615.849.19

Translated from *Byulleten' Eksperimental'noi Biologii i Meditsiny*, Vol. 115, № 2, pp. 219–221, February, 1993
Original article submitted May 26, 1992

Key Words: *capillaries; brain; lasers*

The influence of laser radiation (LR) has been discussed from two opposite points of view. According to one, LR stimulation of the cerebral hemodynamics improves the metabolism of the neuroglial complex [1,4]. According to other data, exposure to a laser beam either does not induce any significant changes in the microcirculation or has a negative effect on the permeability of the blood-brain barrier [6].

In the present work we aimed to study the reaction of the capillary bed (CB) in the brain of rats subjected to low-intensity radiation with a helium-neon laser (HNL).

MATERIALS AND METHODS

The investigation was carried out on 34 mature rats weighing 170-180 g. An HNL-108 with a wavelength of 632.8 nm and a power density of 0.76 mW/cm^2 was used as the radiation source. A single exposure of the right parietal zone was performed in the experimental animals during 0.5, 1.5, 15, and 30 min and 1 and 3 hours. A group of animals not exposed to radiation was used as the control. A musculocutaneous flap was preliminarily cut at the site where the beam passed through the soft tissues of the head. The brain was extracted immediately after the rats were decapitated. The CB was studied in cryostat sections, where the magnesium-activated ATPase was demonstrated by the method of Koenig and Vial [7]. A morphometric study of the capillaries was carried out by known methods [5]. The CB of the right parietal zone of the cortex was studied in eight visual fields of five consecutive sections of the brain in 6 animals at each time of LR exposure.

Department of Human Anatomy, Vladivostok Medical Institute (Presented by O. S. Adrianov, Member of the Russian Academy of Medical Sciences)

RESULTS

In the animals not exposed to radiation, capillaries stained with the aid of the ATPase method look like thin, straight, bent, or slightly convoluted tubules which are relatively uniformly arranged in the projection of the section (Fig. 1, *a*). The product of the histochemical reaction precipitated unevenly in the walls of the capillaries. In some segments of capillaries the precipitate was less thick, staining the vessels yellowish-brown or yellow. The color of other segments, whose enzymatic activity was high, changed to dark brown, almost black. The majority of capillaries, however, were reddish-brown, with moderate ATPase activity.

Analysis of the results obtained during the investigation of CB in the cortex of rats subjected to LR suggested that the enzyme-positive capillaries demonstrated an early and marked reaction to LR (Fig. 1, *b*, Table 1). After the beginning of irradiation (0.5 min), the number of microvessels exhibiting a high

0007–4888/93/0002–0228$12.50

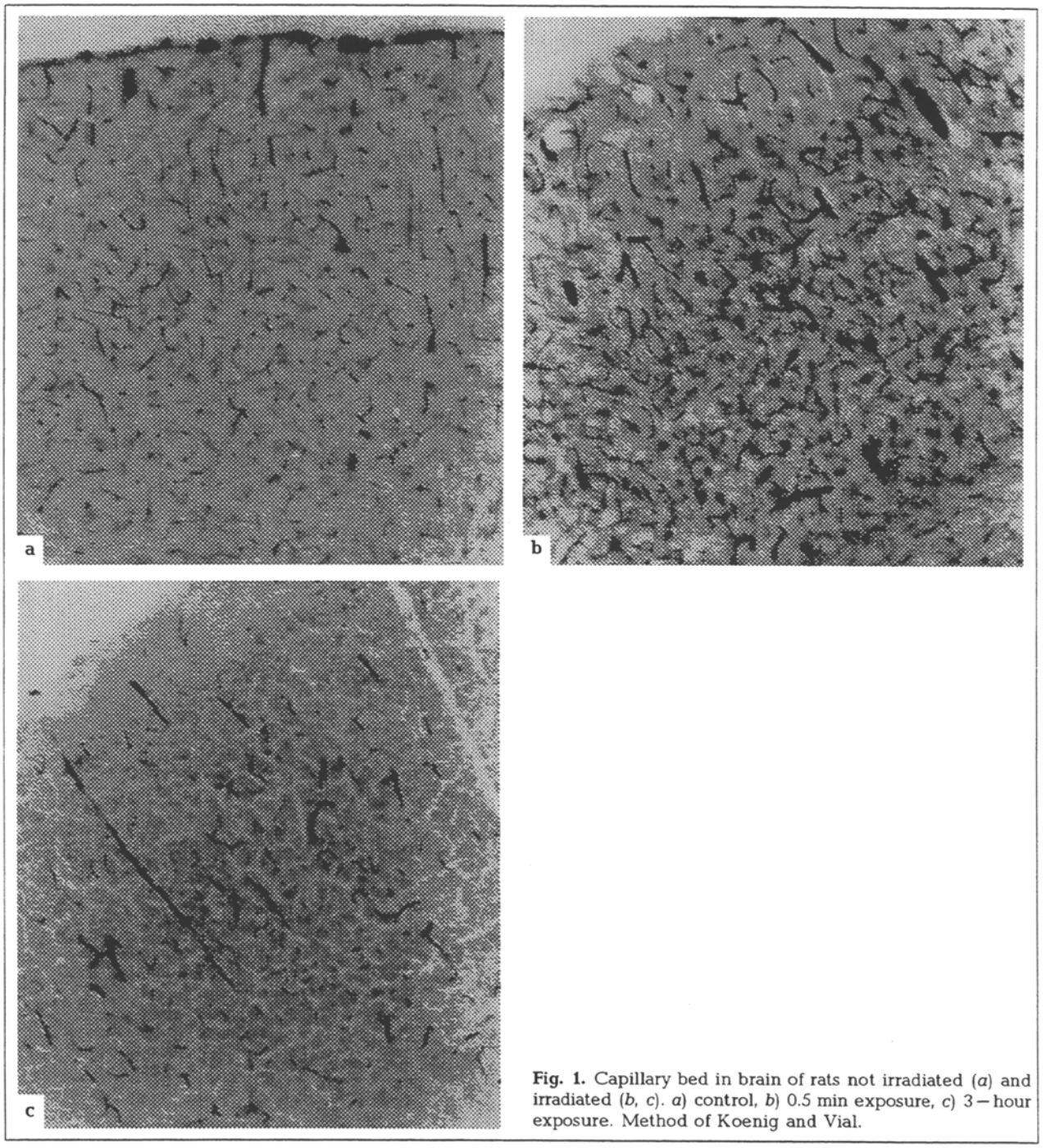

Fig. 1. Capillary bed in brain of rats not irradiated (*a*) and irradiated (*b*, *c*). *a*) control, *b*) 0.5 min exposure, *c*) 3−hour exposure. Method of Koenig and Vial.

density of precipitation rose significantly, this leading to an increase of more than one third in the average values of enzyme activity in the CB vis-a-vis the control group ($p<0.001$). By this time, the total length of the CB increased by 9.6% ($p<0.05$). A certain tendency toward an increase of the average diameter of the capillaries was also noted, although this was not significant ($p<0.05$). The value of the mean level of enzyme activity at the CB exchange surface (MEAS) changed more than other parameters. Characterizing the most significant aspects of the metabolism, MEAS was calculated by multiplying the area of the CB exchange surface by the mean enzyme activity in the capillary wall [5]. Judging by the variation of the values of MEAS, the rate of the exchange between blood and tissue rose by more than 50% ($p<0.001$) 0.5 min after irradiation. A still more significant increase of this parameter was observed after one-minute exposure to LR.

After LR lasting 5-30 min, the average values of ATPase activity, capillary diameter, and MEAS fell somewhat (by 8-10%) ($p>0.05$), while there was a re-

TABLE 1. Variation of Morphometric Indexes of Rat Brain CB for Laser Radiation

Index	Control	Duration of exposure						
		0.5'	1'	5'	15'	30'	1 h	3 h
Enzyme activity, units of active density	6.26±0.27	8.21±0.34	8.27±0.19	7.76±027	7.40±0.29	6.06±0.31	5.51±0.25	5.13±0.17
Mean capillary Diameter, μ	5.73±0.24	6.01±0.19	6.07±0.21	5.61±0.34	5.44±0.26	6.11±0.18	6.84±0.24	6.87±0.18
Total length of capillary bed, mm	556±13	609±18	620±16	678±29	734±27	718±19	604±12	496±24
MEAS, conv. units	62.6±2.1	94.3±4.8	97.3±3.1	92.7±2.4	92.6±3.2	83.8±2.7	71.4±4.2	54.9±3.1

liable increase in the total length of the capillaries ($p<0.01$). The capillaries became convoluted, sometimes coiled into spirals, small swellings and evaginations being found along their length (Fig. 1, *c*). However, despite a decrease in most of the parameters, their values remained either significantly (18-30%) higher (enzyme activity and MEAS) or corresponded to the control values (diameter), evidence, therefore, of a stimulation of capillary permeability under the influence of LR [3,5]. A stimulating effect of short-term (1-18 min) HNL radiation on cerebral microvessels has also been confirmed in biomicroscopic investigations [2].

Continuous irradiation of the brain during 1-3 hours evoked a stable increase of capillary diameter ($p<0.05$) but a marked decrease of ATPase activity in the wall ($p<0.01$). In the projection of the section, the majority of capillaries exhibited a low density of precipitation (Fig. 1, *c*). The total length of the capillaries reached maximum values at the 15th min of exposure to LR, after which it began to decrease, but its value became significantly ($p<0.05$) lower than in the control only in the third hour (Fig. 1, *d*).

These results suggest that the CB of the cerebral cortex is highly sensitive to LR. At the same time, the opposite effect can be observed depending upon the duration of radiation. A short-term (0.5-15 min) exposure has a biostimulating influence on the CB. A more prolonged exposure is shown to suppress ATPase activity in the capillary wall and to induce a decrease of the total length of functioning capillaries together with a diminishment of the rate of metabolic processes between blood and tissue.

REFERENCES

1. S. I. Karabaeva and D. M. Artykasheva, *Vascular Pathology in the Brain* [in Russian], Alma-Ata (1986), pp. 139-146.
2. V. I. Kozlov, F. B. Litvin, V. S. Sinyakov, and V. N. Vdovichenko, *Byull. Eksp. Biol. Med.*, **106**, № 9, 309-311 (1988).
3. P. A. Motavkin, A. V. Lomakin, and V. M. Chertok, *Brain Capillaries* [in Russian], Vladivostok (1983).
4. I. A. Chernyshevskaya, *Problems of Electromagnetic Neurobiology* [in Russian], Moscow (1988), pp. 31-41.
5. V. M. Chertok, *Arkh. Anat.*, **88**, № 2, 28-35 (1985).
6. Heng De Ren, Y. W. Chan, W. W. Li, and D. T. Yew, *Anat. Ans.*, **163**, № 2, 111-117 (1987).
7. C. Koenig and D. Vial, *Histochem. J.*, **5**, № 6, 503-518 (1973).