ANTIDROMIC VASCULAR AND PUPILLARY REACTIONS IN RABBITS UNDER THE INFLUENCE OF RADIATION

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Evaluation of the functional changes in the peripheral innervation apparatuses is of real interest to the study of ionizing radiation's effect on the organism. Correct treatment of the disturbances in a complex chain of reflex reaction is impossible without data on these changes. In an earlier study of the reactions of a rabbit's ear vessels provoked by stimulation of the preganglionic fibers of the cervical sympathetic nerve, we discovered an increase in the lability of the vasomotor apparatus and change in the force of the vascular reactions 1-3 days after irradiation. Parabiotic reactions were observed during this same period by Z. N. Nakhil'nitskaya [10] in experiments with irradiated cats in which she studied the contractile reaction of the nictitating membrane of stimulation of the postganglionic sympathetic fibers.

Therefore, the study of the function of the sympathetic innervation apparatuses has disclosed rather marked changes occurring soon after the action of ionizing radiation.

The purpose of this work was to determine the effect of ionizing radiation on the antidromic effects which play a substantial part in the mechanisms of vasodilation. We studied the reaction of the ciliary tract vessels and the pupil to stimulation of the first branch of the trigeminal nerve.

EXPERIMENTAL METHOD

The work was performed on 22 male rabbits weighing 2.5-3.5 kg each. A 12-tube apparatus with three of the tubes connected was used for total irradiation of the animals in a dose of 800-1000 r. Conditions of irradiation were as follows: voltage 180 kv, current force 14 ma, 0.5 mm Cu and 1 mm Al filters, output 29.3-30.4 r/min.

The vascular and pupillary reactions to stimulation of the trigeminal nerve were studied in acute experiments. The animal was prepared for the experiment under anesthesia (0.3-0.5 cc/kg weight of a 10% solution of sodium amytal in 0.1 N NaOH, given intravenously). To gain access to the first branch of the trigeminal nerve, we resected one of the hemispheres, usually the left, and cleared the median cranial fossa. Needle electrodes were inserted at the medial edge of the fossa, as near to the sella turcica as possible. The oculomotor nerve was transected to facilitate observation of the pupil. The pain reaction was excluded in a number of experiments by transection of the trigeminal nerve roots.

The pupillary reaction was observed through a Zenit-S photo-apparatus with a micrometric scale set on frosted glass [5]. A thermopile attached to a mirror galvanometer [1] was placed under the tunica albuginea, next to the ciliary body, to record the vascular reaction.

The trigeminal nerve was stimulated for 30 seconds with a rhythmic series of discharges (12 per second) from the condensors of a type IR-2 chronaximeter.

The functional condition of the experimental structures was judged by the character of the pupillary and vascular reactions in response to stimulation of the nerve and by how the degree of the reaction depended on the duration of the current pulses. For this purpose, after deciding the stimulation force, we switched on condensors of 0.005, 0.05, 0.5 and 5 microfarad capacity in turn.

The data obtained with the control rabbits matched those described in the literature [1-4, 11]. Stimulation of the trigeminal nerve usually produced reactions of long duration (15-30 min) consisting of stenocoriasis and vascular dilatation. We should mention that the painful effect attending stimulation of a non-transected trigeminal

nerve hindered observation of the vascular antidromic effects although it usually did not affect the pupillary reaction. In this case, vascular constriction was usually observed, probably because the adrenal glands reacted before the antidromic effect could develop, which indicates the great sensitivity of vascular effects to adrenalin. A marked dilatation reaction of the ciliary tract vessels was observed in response to stimulation of the trigeminal nerve only after preliminary transection of the latter's roots.

The degree of the antidromic effect depended on the capacity of the condensor used to stimulate the trigeminal nerve. A condensor 0.005 microfarad in capacity usually elicited no reaction, and only a slight reaction, if any, was detected with the use of the 0.05 microfarad capacity. Stimulation by discharges from condensors 0.5-5 microfarad in capacity usually produced marked pupillary and vascular reactions. Fig. 1 gives a typical example.

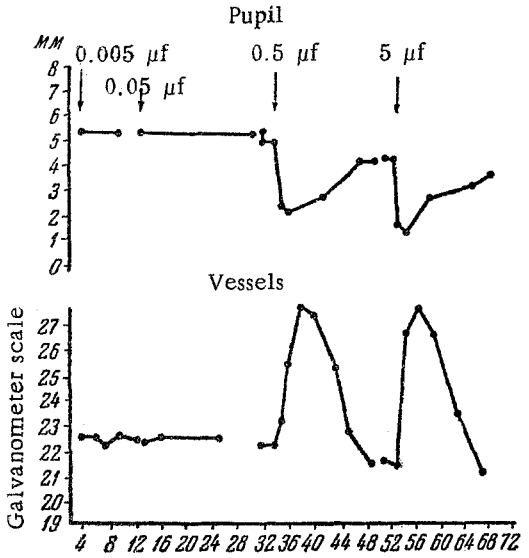

Fig. 1. Reaction of pupil and ciliary tract vessels to stimulation of trigeminal nerve by discharges from condensors of different capacities.

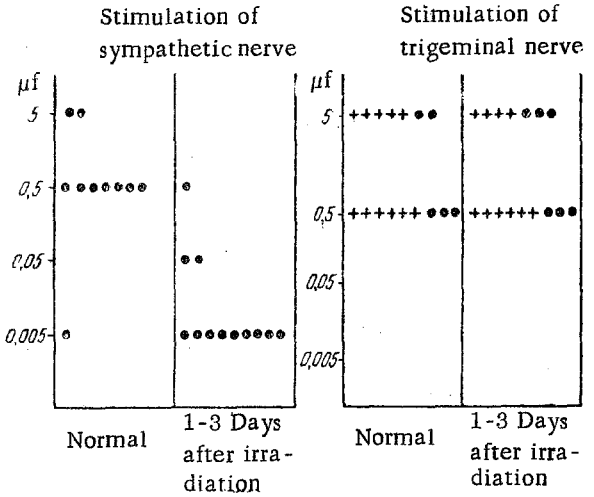

Fig. 2. Optimal stimulation of cervical sympathetic and trigeminal nerves by condensors of different capacities before and after irradiation; • — vascular reactions; + — pupillary reactions.

The experiments on irradiated rabbits were conducted under the same conditions. The experiments were performed 1-3 days after irradiation. In the irradiated animals, as in the control, stimulation of the trigeminal nerve induced prolonged stenocoriasis and dilatation of the ciliary tract vessels. The same relationship was observed between the degree of the reaction and the duration of the stimulating current impulses. Therefore, these methods disclosed no functional changes at early intervals after irradiation.

In Fig. 2 the results obtained are compared with those of our previous work. It gives data as to the development of the effects with stimulation of the cervical sympathetic and trigeminal nerves by discharges from condensors of varying capacities. As Fig. 2 shows, the discharge cycle [literally "duration of discharges"] of a 0.5 microfarad condensor was found to be optimal for stimulation of the cervical sympathetic nerve in the control animals. One to three days after irradiation, maximal vascular reactions could be observed in response to stimulation by discharges from condensors of even the least capacity (0.005 μf). In the irradiated animals, therefore, the system sympathetic nerve — vessel became reorganized so that its lability increased. The optimal cycle of condensor discharges for stimulation of the trigeminal nerve, however, was a 0.5-5 microfarad capacity both before and after irradiation, i.e., its lability did not change.

Consequently, one can conclude that this innervation apparatus is less sensitive to the action of ionizing radiation than is the sympathetic one.

The data obtained can be interpreted in the light of the idea expressed by A. V. Lebedinskii, Yu. G. Grigor'ev and G. G. Demirchoglyan [9] as to the role of synaptic structures in the nervous system's reaction to this agent. Since nerve conductors are known to be relatively insensitive to ionizing radiation, these authors propose that early functional changes in the central nervous system are due to changes in the conditions of synaptic transmission of excitation. The authors believe the synapses to be the structures in which the first symptoms of injury develop with exposure to less than massive doses of radiation.

The certain resistance of antidromic effects can be explained from this point of view. In fact, L. A. Orbeli [12] considers the ability of contractile tissue to react to afferent nerve stimulation an indication that such tissue belongs to a lower stage of evolution than tissue which has lost this ability. The transmission of excitation to the

effector in an antidromic reaction is accomplished by an early and primitive mechanism. This is suggested by certain characteristics of antidromic reactions: their longer duration, greater chronaxy and long latent period [6,7,8].

SUMMARY

Rabbits were subjected to total x-ray irradiation in a dose of 800-1000 r. 1-3 days later a study was made of the reaction of the ciliary tract vessels and of the pupil to stimulation of the trigeminal nerve (its first branch) by discharges of different capacity condensors. There were no significant differences from the control. Comparison of the data obtained with the results of previous investigations concerning the vascular reactions in response to the stimulation of the cervical symphathetic nerve leads to a conclusion that the innervation apparatus studied was less sensitive to the action of ionizing radiation than the sympathetic one.

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