INVESTIGATION OF EFFERENT IMPULSES IN POSTGANGLIONIC SYMPATHETIC FIBERS DURING THE ACTION OF IONIZING RADIATION

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A quantitative description is given of changes in the bioelectrical activity in the central ends of the divided mesenteric, renal, splanchnic, and other nerves during the 3-4 h immediately after whole-body x-ray irradiation of animals.

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The object of this investigation was to study the functional state of the sympathetic innervation of certain viscera (intestine, spleen, kidneys, urinary bladder) in the early period after exposure to ionizing radiation (the first few minutes and hours). One of the objects of the study was to determine the quantitative

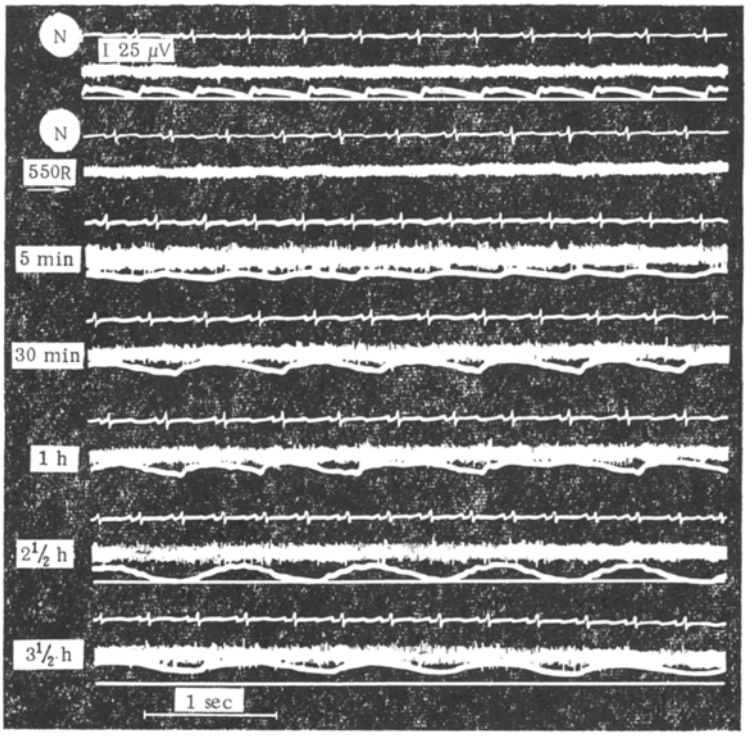

Fig. 1. Changes in efferent impulse activity in mesenteric nerve of a cat during experiment (experiment No. 86). On frames from top to bottom: successive recordings after intervals indicated. N – initial level of impulse activity. The arrow denotes the time of action of ionizing radiation. Time counted from end of irradiation. On each frame from top to bottom: ECG, neurogram, pneumogram.

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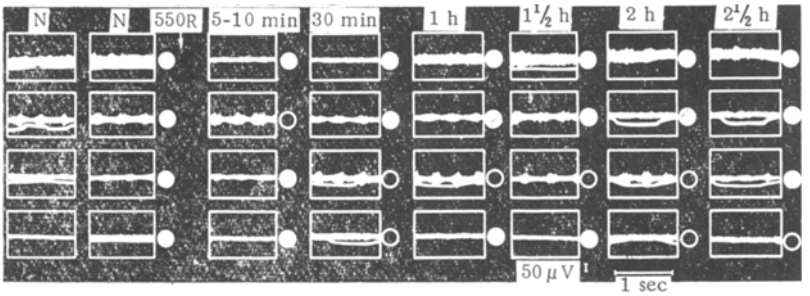

Fig. 2. Various changes in impulse activity in sympathetic nerves to viscera in one experiment (experiment No. 87). On frames from top to bottom: impulse activity in mesenteric, renal, splenic, and splanchnic nerves. White circles – initial level of impulse activity, black circles – increase, shaded – decreased activity. Remainder of legend as in Fig. 1 (but ECG not present).

characteristics of the centrifugal influences responsible for the onset of early autonomic responses of the body to irradiation: changes in the level of arterial pressure, in intestinal motor activity, in tissue respiration, in the blood sugar level, and so on.

EXPERIMENTAL METHOD

Experiments were performed on 30 cats in which several mesenteric, renal, and splanchnic nerve branches and also the splanchnic nerve (6-10 nerve twigs altogether in each experiment) were dissected under urethane anesthesia.

Potentials from the central ends of the divided nerves were picked up by means of silver electrodes (interelectrode distance 3-4 mm, diameter 0.5 mm), and recorded on a four-beam cathode-ray oscillograph with the aid of a type YaBNK amplifier. The ECG (lead II), respiration, and time marker were recorded simultaneously with the action potentials on photographic film.

Electrical activity in the central ends of the divided postganglionic sympathetic fibers were recorded twice or three times before irradiation began, at intervals of 30 min, and 5-10 min after whole-body x-ray irradiation, and thereafter every 30 min for 3-4 h.

Whole-body x-ray irradiation of the animals was carried out with the RUM-11 apparatus under the following conditions: voltage 187 kV, current 15 mA, filters Cu 0.5 + Al 1 mm, total length 60 cm, dose rate 17-18 R/min, total dose of irradiation 550 R.

EXPERIMENTAL RESULTS AND DISCUSSION

The principal electrical activity in the nerve branches to the various viscera was found to undergo changes in the earliest stages after irradiation. As a rule, these changes were found 5-10 min after stopping irradiation (Fig. 1), and they may even have taken place during irradiation. Such early changes were observed in 60% of cases (after irradiation impulses were investigated in 150 nerve branches). In the other cases, the changes developed 30 min or more after irradiation.

The changes in efferent impulse activity 5-30 min after irradiation varied in direction: in most postganglionic fibers, irrespective of the organ to which they belonged, the electrical activity was increased (Fig. 2), while in a smaller number of fibers, the activity was weakened or unchanged. In my opinion, this result reflects variation in the functions of the central structures of the sympathetic nervous system. Under normal conditions the functional structure of the sympathetic centers is heterogeneous [4], but the heterogeneity is exhibited only in response to different influences [5]. Irradiation is evidently a factor revealing the structural heterogeneity of the sympathetic links on account of changes in the flow of efferent impulses from the visceral receptors during irradiation.

After irradiation the modified electrical activity of each particular sympathetic nerve did not remain on the same level, but changed in the course of several hours of the investigation. Fluctuations of impulse activity after x-ray irradiation have been observed in most investigated postganglionic sympathetic fibers.

Fluctuations of the potentials were also found in unirradiated animals. However, in the animals subjected to x-ray irradiation, the range of fluctuations of activity was considerably increased. The varied direction of the changes and the fluctuations of impulse activity as a whole created a mosaic pattern of changes in impulse activity after irradiation.

Hence, contrary to the widely held view that the sympathetic nervous system responds to a harmful influence by a generalized reaction [6], I observed differential changes in impulse activity in different sympathetic nerves, and I therefore share the view [3, 7] that activity in the sympathetic nerve branches is not uniformly distributed when the sympathetic nervous system participates in different reactions.

The results of the study of efferent sympathetic impulse activity showed that after irradiation it is increased in most sympathetic branches in each experiment. This increase in the action potentials may coincide in time with a change in the arterial pressure level, but it may also be observed when the pressure remains unchanged. In the latter case, evidently, the increased impulse activity in the sympathetic nerves is unconnected with a change of pressure and takes place as a reflex in response to an increased inflow of afferent impulses in the sympathetic fibers by the action of irradiation [1, 2].

This investigation showed that the level of the tonic activity in the sympathetic centers changes during the action of ionizing radiation. However, centrifugal effects on different organs change in different ways: in relation to some (the intestine, in particular) they are predominantly increased, while in respect to others they may be weakened.

It may therefore be concluded that changes in the sympathetic regulation of the viscera play an important role in some visceral responses during irradiation.

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