THE EFFECT OF DECORTICATION ON RADIATION SENSITIVITY AND RADIATION RESISTANCE*

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The high sensitivity of the nervous system to ionizing radiation and its important effect in the response of the organism has been demonstrated by a number of authors, most of them Soviet [4-7]. There has been a contradiction between the original finding that nervous tissue was resistant to penetrating radiation, and more recent work indicating the exceptional sensitivity of nervous structures. Many authors [2, 8, et al.] have proposed that the nervous system combines a high radiation sensitivity with a high radiation resistance.

É. A. Asratyan has shown that removal of the cerebral hemispheres greatly reduces the range of possible adaptation of the organism, rendering the nervous system both less sensitive and less resistant to external and internal influences [1].

It therefore seemed interesting to determine how the response of the organism to the action of penetrating radiation was altered by bilateral removal of the cerebral hemispheres.

METHOD

The experiments were carried out on 15 control and 11 decerebrate adult rabbits which received 100, 400, and 800 r of total irradiation. The animals were divided into groups, according to dose, as follows: 100 r, 5 control and 3 experimental; 400 r, 8 control and 6 experimental; 800 r, 2 control and 2 experimental rabbits.

Both hemispheres were removed at one operation. In the control rabbits, the skull was trepanned, and the meninges were cut and then sewn up. After the rabbits had died from radiation sickness, or at the end of the investigation on the surviving animals, the brain was examined to confirm that the whole of the cerebral hemispheres had been removed, and that the subcortical structures appeared macroscopically to be undamaged.

A histological study of frontal and longitudinal sections of the brain was made by O. V. Shnyrenkova, senior specialist of the Morbid Anatomy Department. The typical appearance of the decorticate brain, as described by I. V. Davydovskii and his co-workers [3], was found. The most severe dystrophic changes were found in the healed regions of the hemispheres. In the nerve cells of the subcortical structures, the dystrophic changes were the more marked the greater the time that had elapsed after the operation.

The rabbits were irradiated two weeks after extirpation of the hemispheres, or after the skull had been trepanned. We considered this period optimal because, at this time, first the direct effects of the operation had disappeared and, secondly, there has as yet been no compensatory central reorganization due to the decortication, nor any degenerative changes in the lower parts of the brain.

Irradiation was carried out by means of a RUM-3 apparatus, under the following conditions: potential, 180 kV; current strength, 15 mA; focusing distance, 50 cm; filters 0.5 mm Cu + 1 mm Al; dose rate 20.3 r/min.

To determine the changes in, and the degree of severity of, the radiation sickness we observed alterations in the blood, body weight, temperature, amount of food consumed, condition of the gastrointestinal tract, and survival

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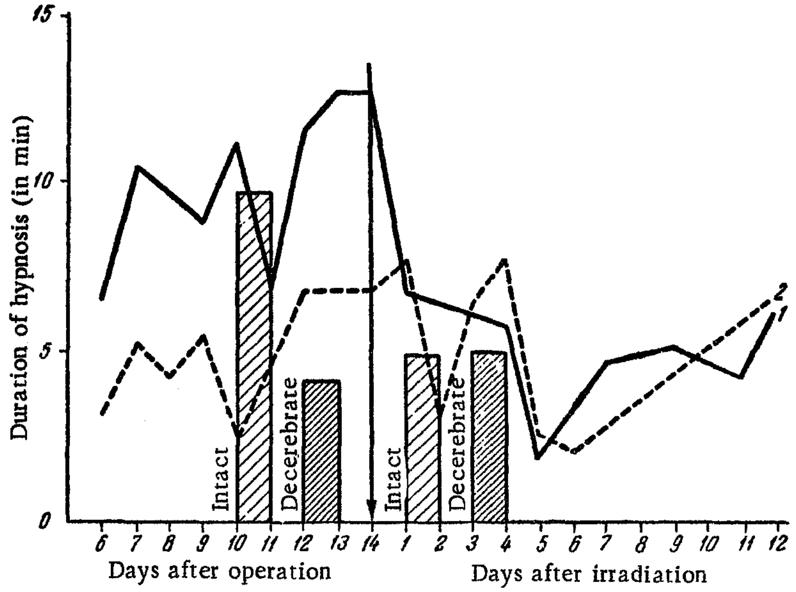

Fig. 1. Variation of the mean duration of hypnosis of (1) control and (2) decerebrate rabbits before and after irradiation with 100 r. Column, total mean duration of hypnosis.

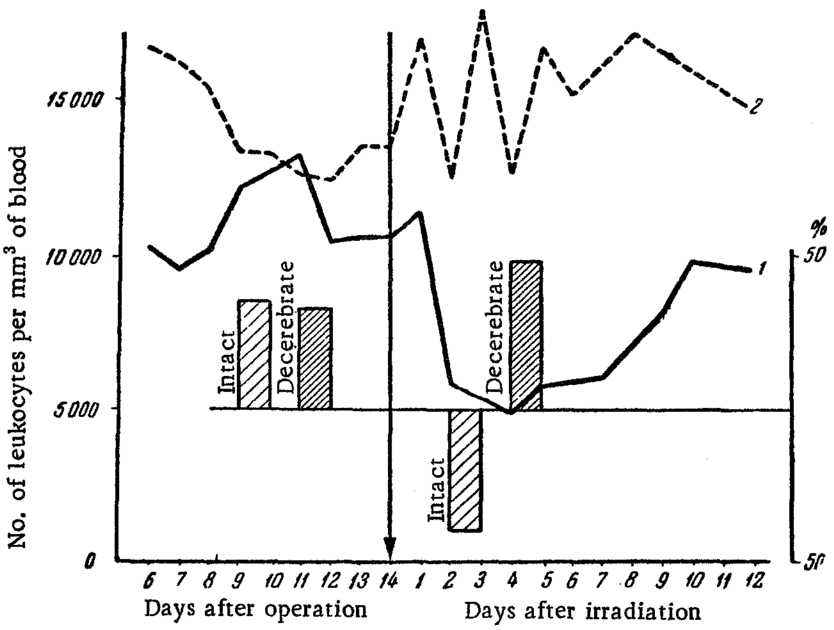

Fig. 2. Changes in the mean number of leukocytes per mm^3 of blood in (1) control and (2) decerebrate rabbits, before and after irradiation with 100 r. Columns, mean value of the leukocytic response to the injection of 1 ml of a 5% solution of sodium nucleate (as percentage of original value).

time. In all the irradiated animals a systematic study was made of the leukocytic response to the injection of sodium nucleate; a 5% solution of sodium nucleate was injected subcutaneously into the back. Blood from an ear vein was collected immediately before the injection of the sodium nucleate, and 1, 3, and 6 hours after it, and again on the next day. As a rule, 1-3 days were left between injections to a rabbit. No account was taken of a variation of less than 1000 in the leukocyte count. The extent of the reaction was measured in terms of the difference between the maximum or minimum number of leukocytes after the sodium nucleate injection and the initial number of leukocytes per mm^3 of blood.

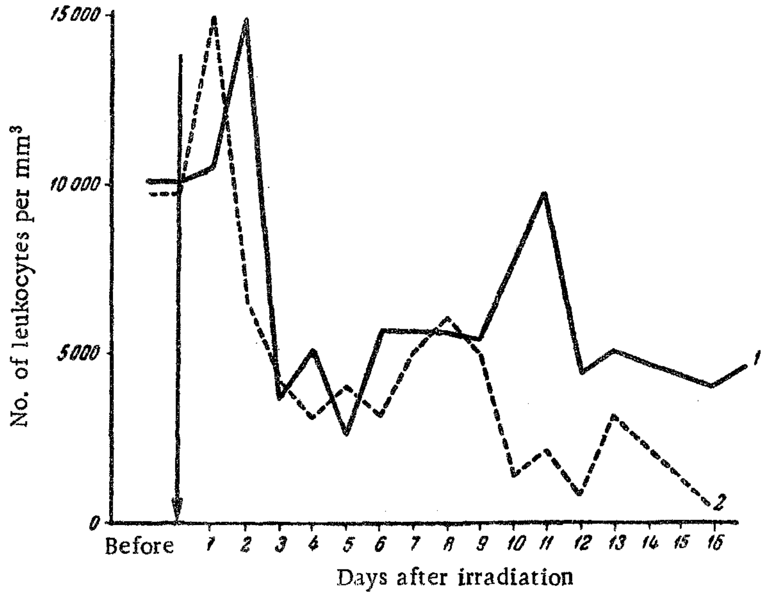

Fig. 3. Changes in the mean number of leukocytes per mm in (1) control and (2) decerebrate rabbits after irradiation with a dose of 400 r.

As an index of the functional condition of the higher nervous centers, we made use of the duration of the so-called hypnosis. The experiments with hypnosis were always carried out at the same time of day. The animal was placed with the limbs stretched out in a position to which it was not accustomed, and was maintained thus for precisely 1 min. It was then set free, and with a stopwatch the time was measured for it to jump onto its feet to regain a normal posture. We selected as the signal of end of hypnosis the change of posture (the jump onto the feet), and not any other preliminary movements heralding awakening, such as increased respiration rate, or movements of the eyes and ears.

RESULTS

The experiments showed that decerebrate and control animals react differently to comparatively small and to large total x-ray doses. Figure 1 shows the effect of 100 r on the duration of hypnosis in control and decerebrate rabbits. It can be seen that irradiation shortened considerably the period of hypnosis in the control animals, but was practically without effect in the decerebrate group. This difference emerges particularly clearly when a comparison is made of the mean duration of the hypnosis before and after irradiation.

The results of the measurements were treated statistically, and the root mean square deviation, the mean error, and the significance of the difference between the means was calculated from the formula

$$\frac{M_1 - M_2}{\sqrt{m_1^2 + m_2^2}}.$$

By comparing the mean duration of hypnosis before and after irradiation of the control rabbits, the error of the mean was found to be 5.5 (i.e., greater than 3), showing that the difference between the mean values was significant. In the decerebrate animals the same difference was 1.01 (less than 3), and, therefore, in them the duration of hypnosis was not changed by the irradiation.

Similar results were obtained from a comparison of the leukocyte counts (Fig. 2). In the control animals a dose of 100 r caused a short and a comparatively slight leukopenia. The number of leukocytes in the blood of the decerebrate rabbits varied within the same limits as were found before irradiation. The only alteration was an increased instability of the leukocyte count, and some tendency to a leukocytosis. In the decerebrate group, after irradiation the response to the injection of sodium nucleate was completely maintained. In the control animals the change in the leukocytic response was altered in the same way as by anesthesia: the response to the injection of 3 ml of a 5% sodium nucleate solution was still present, but when 1 ml was injected the number of leukocytes fell instead of increasing.

Thus, as judged by the duration of hypnosis, the number of leukocytes, and the reaction of the vascular system to the injection of sodium nucleate,the control animals were more sensitive to penetrating radiation than were the decorticate group.

Fundamentally, different results were obtained with greater doses. Figure 3 shows the changes in the mean number of leukocytes per mm in control and decerebrate rabbits irradiated with 400 r. It can be seen that for the first 9 days (latent period) the leukocyte curves for the control and decerebrate rabbits were approximately the same. Then in the decerebrate group a sharp fall in the leukocyte count started. The effect corresponds to a more severe condition of radiation sickness in the decerebrate group, as judged by body weight, temperature, condition of the gastrointestinal tract, and appearance of hemorrhages. In the decerebrate group, the leukocytic response to the injection of sodium nucleate was altered by the 5th to 11th day after irradiation, but in the control group the effect did not occur until the 13th to 19th day. Of the 6 decerebrate rabbits receiving a dose of 400 r, 5 died from radiation sickness by the 11th to 17th day. All the 8 control rabbits survived.

Similar results were obtained with an irradiation dose of 800 r. Of the control animals of this group, one survived. Both decerebrate rabbits died by the 9th day.

The results therefore indicate that decerebration renders the animal less sensitive and less resistant to penetrating radiation. The high radiation sensitivity of the nervous system cannot therefore be regarded as an index of "fragility," "susceptibility," or "vulnerability." Still less have we any reason to consider the higher nervous centers as some kind of "initiators" of pathological changes in the irradiated organism. It must be supposed that the high radiation sensitivity of the nervous system is responsible for the early and timely involvement of the protective and compensatory mechanisms, so that in an animal with an intact brain the ultimate effect is to produce a high radiation sensitivity of the organism as a whole.

SUMMARY

Experiments were carried out on 15 control and 11 decorticate rabbits. Low x-ray doses (100 r) caused a change in a number of physiological functions in the control animal, but had no effect on them in decorticate rabbits. Nevertheless the decorticate animals proved to be less resistant to greater irradiation doses of 400 and 800 r. We conclude that decortication diminishes the range of adaptive possibilities of the body, rendering it less sensitive and less resistant to the action of ionizing radiation.

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All abbreviations of periodicals in the above bibliography are letter-by-letter transliterations of the abbreviations as given in the original Russian journal. *Some or all of this periodical literature may well be available in English translation.* A complete list of the cover-to-cover English translations appears at the back of this issue.