EFFECT OF X-RAY IRRADIATION ON OFFSPRING OF RATS IRRADIATED IN A DOSE OF 200 R ON THE NINTH DAY OF EMBRYONIC DEVELOPMENT

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One of the most powerful factors capable of causing abnormalities in embryonic development is ionizing radiation. To examine its effect on the offspring, most investigators [1, 2, 5-9, 11-13, 15-18] have studied the first generation. Comparatively few investigations have been made of the effect of irradiation on the offspring of several generations and on the offspring of parents irradiated during the period of embryogenesis [3, 4, 10, 14].

The object of the present investigation was to study the duration of pregnancy, the number, weight and size of the newborn rats, their development (increase in length, increase in weight, time of appearance of hair, of opening of the eyes, of spontaneous movement about the cage and eating food), and the survival rate following irradiation of the parents in a dose of 200 R on the ninth day of embryonic development.

EXPERIMENTAL METHOD

The investigation was carried out on 42 female rats aged 6-7 months. Of the total number of rats, 24 were irradiated on the ninth day of embryonic development in a dose of 200 R on the RUM-II apparatus (180 kV, 18 mA, filters 0.5 mm Cu + 1 mm Al, skin-focus distance 40 cm, dose rate 42 R/min). The irradiated rats were divided into two series, each consisting of 12 rats. In the experiments of series I the irradiated females were mated with males from unirradiated parents. In series II the irradiated females were crossed with males irradiated on the ninth day of embryonic development. In series III (control) 18 unirradiated females were crossed with unirradiated males.

EXPERIMENTAL RESULTS

In 11% of the animals birth took place on the 22nd day, and in 89% —on the 23rd day of pregnancy, and the mean duration of pregnancy was 22.9 days (control series of experiments). When irradiated females were crossed with unirradiated males (experiments of series I) birth began with all the rats on the 23rd day of pregnancy.. When irradiated females were crossed with irradiated males (experiments of series II), birth began with 25% of the rats on the 23rd day of pregnancy, with 58.3% on the 24th day, with 8.3% on the 25th day, and with 8.3% on the 26th day. Hence, in the experiments of series II, an increase in the duration of pregnancy was observed, on the average by 1.1 day ($P < 0.001$). In the control rats, parturition took 65 min, while in the experimental animals its duration was increased to 3-5 h, and in addition, pathological labor was observed in the latter, accompanied by bleeding and uterine inertia.

Irradiation of the parents had no significant effect on the number of newborn rats. In the experiments of series II 30 rats were stillborn or died during the first 2-3 h of life. A 100% perinatal mortality was observed in the offspring of three rats in the experiments of series II, following crossing of males and females of the same litter. Evidently in these experiments the action of radiation was aggravated by the crossing of closely related animals, as a result of which the offspring was not viable.

The change in the survival rate of the rats born to parents irradiated on the ninth day of embryonic development is of considerable interest. The results showing the effect of x-ray irradiation on the survival of the offspring are shown in Fig. 1.

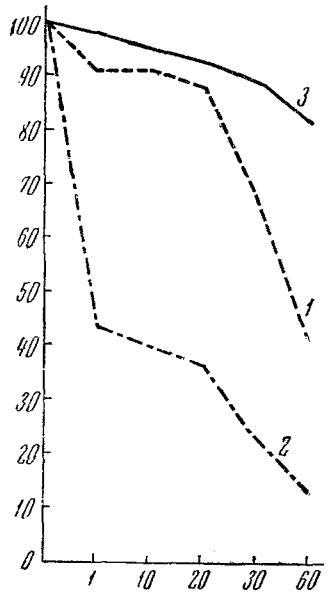

Fig. 1. Survival of offspring of rats irradiated with x-rays in a dose of 200 R on the ninth day of embryonic development. Here and Figs 2 and 3: along axis of abscissas—age (in days), along the axis of ordinates—survival rate (in percent). 1) Crossing of irradiated females and unirradiated males (series I); 2) of irradiated females and males (series II); 3) of unirradiated females and males (control).

Fig. 2. Increase in length of young rats in litter of rats irradiated with x-rays in a dose of 200 R on the ninth day of embryonic development.

In the experiments of series I, 8.8% of the young rats died on the first day after birth. During the next 10 days there was no mortality among the rats, and by the 20th day of life the number of surviving young rats had fallen to 88.2%. They continued to die after this time and by the 60th day 41.2% of the animals of the total number born had survived. The differences between the survival rate of the young rats in the experiments of series I by comparison with the control were statistically significant starting with the 30th day of life ($P < 0.001$).

Analysis of the results obtained shows that the survival rate among the young rats was least in the experiments of series II, in which males were crossed with females irradiated on the ninth day of embryonic development. The largest number of young rats of this series died on the first day (66.7%). During the next 30 days the mortality rose by 10%, while at the end of the 2nd month of life only 13.3% of the total number of newborn animals survived, compared with a survival rate in the control series of experiments at this period of 82.6%. The difference in the survival rate between the experiments of series II and the control series was significant at all times ($P < 0.001$).

The length of the newborn rats in the different series of experiments was approximately the same. Evidently irradiation of the parents had no significant effect on this index. X-rays led to a significant ($P < 0.05$) fall in the body weight of the newborn animals in the experiments of series II.

Despite the fact that the mean weight and length of the newborn rats in the experiments of series I and II were only slightly different from the weight and length of the control rats, as is clear from Fig. 2, on the fifth day of life the increase in length of the young rats in the experiments of series I was 16.7% greater than in the control series, while at the tenth day, by comparison with the fifth, it had fallen by 32.1%, on the 15th day it showed a slight increase, and on the 20th day—a further decrease by 18.7%. Only by the 60th day had the increase reached 93.8% of the control value. A significant difference with the control was observed on the 10th, 25th, 30th and 40th days ($P < 0.05$, $< 0.01 < 0.05$, and < 0.05 respectively) of life. In the experiments of series II the increase in length of the young rats was less than in the controls. During the first five days of life it amounted to only 33.3% of the control value, after which the gain in length showed an increase with variations between individual measurements of not more than 5%, and by the 60th day it reached 70.8%. Compared with the control series, the difference was significant ($P < 0.001$). Individual young rats of this series were sharply distinguished from the controls by their dwarfed growth.

The results showing the influence of irradiation on the gain in weight of the developing offspring are given in Fig. 3. In the rate of the experiments of series I, during the first day of development the gain in weight was much less than in the controls, namely 67.8%, but by the tenth day it had risen to 91.8%, and by the 20th day had fallen again to 87.3%. On the 25th day after birth, it was equal to the gain in weight found in the control series. The fluctuations thereafter considerably diminished, and by the age of two months the gain in weight of the young rats in the experiments of series I was almost indistinguishable from the gain in weight in the control series. The difference was significant only at the age of five days ($P < 0.05$). The most marked reduction in the gain in weight of the offspring was observed in the experiments of series II. The young rats of this series, born with almost the same body weight as the controls, gained on the average 0.9 g in

Fig. 3. Increase in weight of young rats in litter or rats irradiated with x-rays in a dose of 200 R on the ninth day of embryonic development.

weight during five days. Starting with the 6th day, the gain in weight rose rapidly, and by the 20th day it had reached 66.1% by comparison with the controls, after which it remained at this level until two months. By comparison with the control series the difference was significant ($P < 0.001$). The offspring of parents irradiated on the ninth day of embryogenesis characteristically showed marked fluctuations in the gain in weight and length during the first two months of development. By the 60th day, in the experiments of series II, "dwarfed" rats were observed.

Besides the lower indices of length and weight, the young rats of the irradiated parents also showed other manifestations of delay in development by comparison with the rats born in the control series of experiments. They developed hair one or two days later (on the 11th-12th day), their eyes were not opened until the 18-19th day, they moved about spontaneously later, and they showed delay in feeding themselves. The signs of delay in development described above were found equally in the experiments of series I and of series II.

Hence, whole-body irradiation of rats in a dose of 200 R on the ninth day of embryonic development has an adverse action on their offspring: the survival rate was lowered, a marked retardation of development was observed, and the power of the animals to adapt themselves to the conditions of existence was diminished. These phenomena were particularly marked in the offspring resulting from the crossing of irradiated females with irradiated males.

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