

RECOVERY OF THE CONDITION OF CUTANEOUS VESSELS OF THE MONKEY A LONG TIME AFTER RADIATION SICKNESS

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By means of a most varied number of biochemical [13], physiological [2, 7, 8] and morphological [5, 14, 15] methods we have accumulated a rich yield of experimental evidence bearing on disturbances induced by penetrating radiation.

When the degree and the nature of the damage was manifest, the second and more important problem of treatment and prophylaxis arose [1, 3, 4, 6 and others].

A detailed study of the compensatory processes in the body has to be made, and the recovery of impaired function investigated (A. V. Lebedinskii).

The present work is a study of the compensatory processes in monkeys. We studied such indices of the condition of the peripheral vessels as cutaneous temperature and arterial tone (the latter was determined from changes of the pulse pressure).

These indices were chosen because they undergo considerable changes in radiation sickness.

In previous work on dogs and frogs as well as on monkeys it has been shown [9-12] that in acute radiation sickness, particularly in the last days of life, the cutaneous vessels are constricted.

We have shown previously in monkeys that one or even two years after irradiation the tone of the cutaneous vessels is very high. This effect is particularly well shown in animals irradiated with 600 or with 760 r.

METHOD

The investigations were made after 1, 2, 3, 4, and 5 years on 6, 2, 7, 4, and 1 apes, respectively, after they had been exposed to penetrating radiation. Altogether we used 23 macaque rhesus monkeys, of which three were used as controls. Irradiation was from a 2-tube X-ray apparatus. The conditions of irradiation were as follows: 180 kv, current 15 ma, dose rate 21.8 r/minute, filter 0.5 mm Cu, focusing distance 78 cm.

For the first 5-10 minutes of the experiment, the monkey became adapted to room temperature which was maintained at 20-21°. Then the skin temperature was measured, and the plethysmogram was recorded from the middle finger. Immediately afterwards the whole front surface of the body was radiated three times at intervals of 3-5 minutes with infrared radiation; the first exposure was 3 minutes, and the next two 5 minutes each. After each stimulation, the skin temperature was measured, and the plethysmogram recorded. The procedure was repeated four times on each monkey.*

RESULTS

In the control monkeys, and usually before the first application of the heat stimulus, the pulse pressure was well shown on the plethysmogram (Fig. 1, Fig. 2, I), and the skin temperature of the finger varied between 22 and 32°. After the first heat stimulation, the finger temperature rose to 31-34°. The next two heat stimulations raised this temperature to 34-36°.

In four monkeys irradiated one year previously with 300 r, and in two exposed to 550 and to 624 r, the plethysmograms differed greatly from those of the control animals.

*A more detailed description of the method is given in [12].

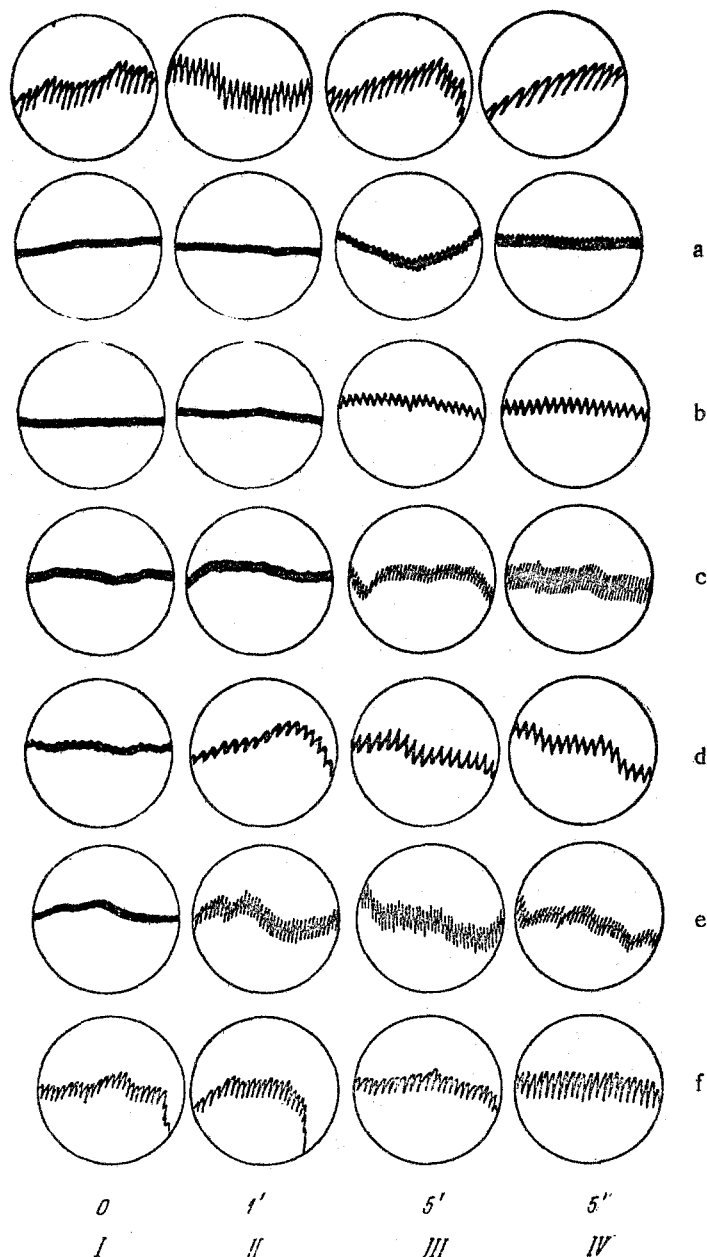


Fig. 1. Plethysmograms of monkeys, recorded at various times after irradiation sickness. a-f) Explanation in text; I) before exposure to stimulation; II) after applying stimulation for the first time; III) after the second stimulation; IV) after the third stimulation.

In some of the animals there was no discernible pulse amplitude before the first or after the first and subsequent heat stimulation. In others, it appeared either after the second or after the third stimulation, but it was always much smaller than normal (Figs. 1,a, Fig. 2, VII). The cutaneous temperature varied over fairly narrow limits, and before exposure to heat it lay between 19 and 24°.

In two monkeys irradiated two years previously with 300 r of x-rays, changes were observed similar to those described above, but rather less well shown. Thus, the pulse pressure and cutaneous pressure (30.9°) in many cases nearly reached normal values after the second heat stimulation, and in one monkey did so sometimes after the first exposure (Fig. 1,b, Fig. 2, VI). In these monkeys, before exposure to heat the cutaneous temperature varied between 17.9 and 23°.

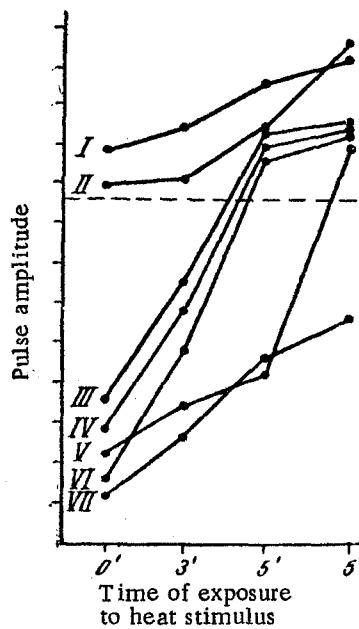


Fig. 2. Pulse amplitude in monkeys investigated at various times after radiation sickness. I-VII) Explanation in text. Dotted line — lower limit of normal pulse pressure variation.

In animals irradiated three years previously, there was a difference between the plethysmograms, which depended on the dose of radiation received. In three monkeys irradiated with 760 r, the increased vascular tone was quite well shown. Exposure to the first, and in most cases also to the second heat stimulus did not restore the normal pulse amplitude, and it was only the third stimulation which was always effective in increasing it to normal limits (Fig. 1,c, Fig. 2, v). From Fig. 3 it can be seen that whereas two years after radiation sickness a triple exposure to heat stimulation did not increase the pulse amplitude and therefore lowered the tone of the cutaneous arteries, after three years, in two cases, the second exposure to heat restored the pulse amplitude to normal.

In four animals which had also been irradiated three years previously with 300 r of X-rays, the pulse amplitude attained the value observed in the controls, sometimes after the first, but always after the second heat stimulation (Fig. 1,d; Fig. 2, IV).

In the first group which received 760 r the cutaneous temperature reached values characteristic of the nonirradiated group, sometimes after the second heat stimulation, when it rose to 26-36°, and always after the third stimulation, when the values were 26-36.2°. In the second group of animals receiving 300 r, sometimes even the first application of heat raised the temperature to 28-31°. The second and third stimulations caused an increase to 24-34°.

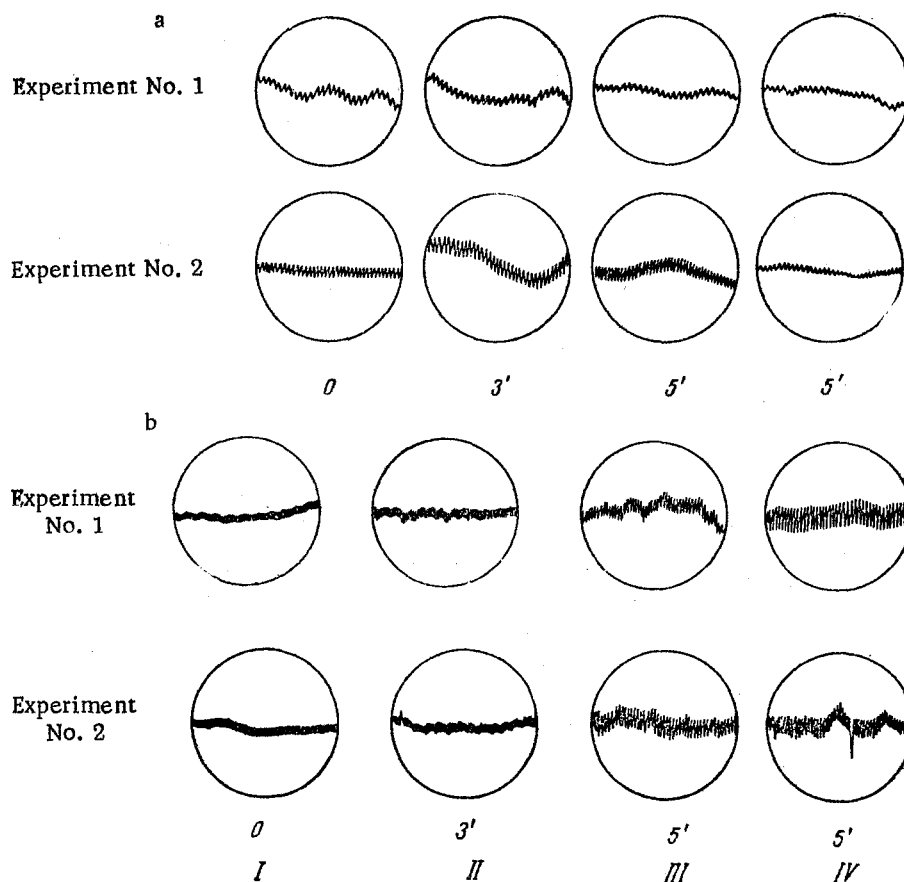


Fig. 3. Pulse amplitude in one monkey taken (a) two and (b) three years after radiation sickness. 1) Experiment No. 1; 2) experiment No. 2; I-IV) same as in Fig. 1.

In four monkeys irradiated four years previously with 550 r of X-rays, in many cases the pulse amplitude had the same value as in the control animals before heat stimulation, and was almost always the same after application of the second and third stimulations (Fig. 1,e; Fig. 2, III). In most cases, after the first heat stimulation the cutaneous temperature rose to 29-33°. In all the animals, after the second and third stimulations it attained 33-36°.

Of the animals which had been irradiated five years before the experiment, only one, which had received 600 r of x-rays, remained alive. Before the heat stimulation both the pulse amplitude and the skin temperature of 26.5-32.4° were almost normal. After the first, second and third heat stimulations the skin temperature lay between 34 and 37.5°, and the pulse amplitude either nearly or completely attained normal values (Fig. 1,f; Fig. 2, II).

We therefore obtained results indicating a long-term constriction of the cutaneous vessels, as shown by a reduction of skin temperature, an increased vascular tone, and a reduced response to thermal stimulation. It would be extremely interesting to determine the mechanism of this constriction and the reason for the restoration of the vascular tone 4-5 years after irradiation. Unfortunately, after the present time no definite information on this point can be given.

From the experimental results given here we may conclude that not only in the acute phase of radiation sickness, but also long afterwards, vascular tone remains at high values not found in normal animals. After several years, there is a gradual return to normal. The degree of recovery depends both on the time elapsing after irradiation, and on the radiation dose.

SUMMARY

A study of arterial tone in monkeys at various times after acute radiation sickness showed that vascular tone and cutaneous temperature undergo characteristic changes. These two indices returned to normal within the first three years only if the dose did not exceed 300 r, but with a dose of 600 r return to normal was delayed for 4-5 years.

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