

PATHOLOGICAL PHYSIOLOGY AND GENERAL PATHOLOGY

THE MOTOR FUNCTION OF AN ISOLATED SEGMENT OF SMALL INTESTINE IN DOGS WITH ACTURE RADIATION SICKNESS

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In radiation sickness the condition of the alimentary tract undergoes a number of disturbances, and for this reason the study of the motor function of the small intestine in radiation sickness arouses particular interest. At the same time this problem is rarely discussed in the literature. There are only isolated investigations on small laboratory animals. Conard [7], for instance, demonstrated an increase in the motor function of the intestine of rats exposed to a dose of only 100 r; under these conditions there is an increase in the muscle tone and in the amplitude of the contractions. An acceleration of the passage of the contents through the gastrointestinal tract in rats was reported by Goodman, Lewis and Schuck [8]

EXPERIMENTAL METHOD

Our experiments were carried out on 3 dogs on which the Thiry-Vella operation had been performed and an area of the small intestine 20 cm long isolated in the region of the lower part of the duodenum and the proximal jejunum. The movements of this isolated segment were recorded for 4 hours every other day by means of a pneumatic system with a rubber balloon, the pressure inside which was constant and amounted to 20 mm of mercury. In normal conditions before irradiation the motor activity of the isolated intestine was studied in dogs with an empty stomach and also after a meat meal (200 g).

EXPERIMENTAL RESULTS

In the animals before feeding we observed periodic contractions of the isolated intestine, which were particularly well marked in the dog Iula. In the remaining dogs — Pirat and Anakonda — the rest period was associated with smaller contractions of the loop of intestine. The periods of activity of the intestine in the hungry dogs lasted 2-3 minutes. The size of the contractions at the height of the period of activity was usually equivalent to 15-20 mm of mercury. The number of contractions per minute was constant and amounted to 14-16. The tone of the isolated area of intestine changed in an undulating manner; during a period of work the tone increased and at rest it fell to a minimum. The greatest value of the tone, which was observed when the contractions were maximal, was 2-6 mm of mercury. The periods of rest lasted 1-2 minutes. In some experiments we were unable to determine the periodicity of the movements of the isolated intestine.

The results which we obtained are in full agreement with the experimental findings of L. S. Girshberg [2] and L. G. Voronin [1].

When the dogs were feeding on meat, which was given immediately before the experiment, the isolated intestine responded to this stimulus by a slight increase in the motor activity. Under these circumstances the period of activity was lengthened to 4-6 minutes, and the period of rest was shortened.

In order to obtain experimentally an increase in the motor activity of the isolated intestine, the dog was injected subcutaneously with proserin (prostigmin methylsulfate). Proserin was given to Pirat in a dose of 0.1 mg. Clinically this dose caused hardly any change. The motor activity of the intestine was intensified 6 minutes after the injection of proserin. Anakonda and Iula were injected with the same dose of proserin — 0.1 mg. In all cases we observed an increase in the motor function of the isolated intestine.

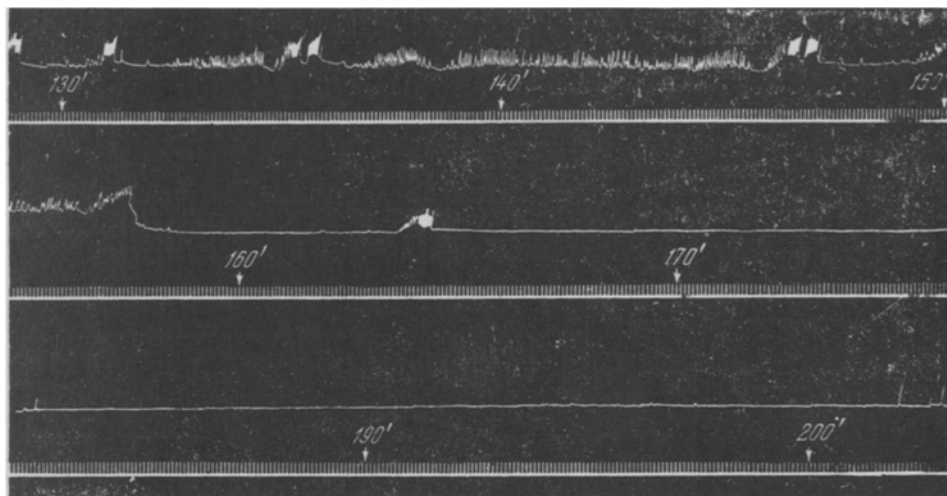


Fig. 1. Motor activity of the isolated intestine in the dog Pirat on the first day after irradiation with x-rays.

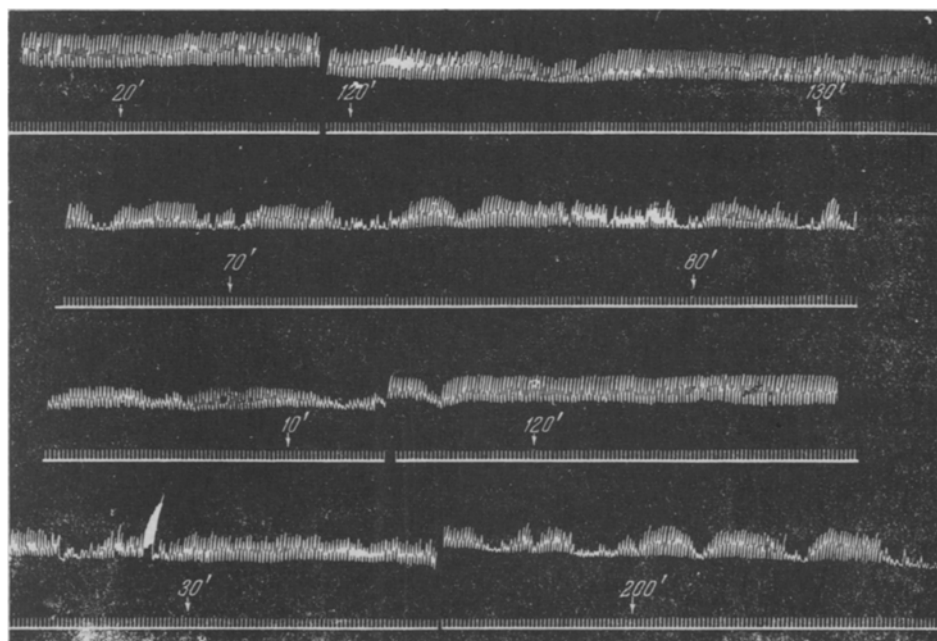


Fig. 2. Movements of the isolated intestine in the dog Anakonda on the 1st, 2nd, 8th and 14th day after irradiation.

In order to produce an artificial reduction in the motor function of the isolated intestine the dogs were injected subcutaneously with atropine in a dose of 1 ml of a 1 : 1000 solution. The injection of atropine to the dog Pirat was followed by prolonged rest of the isolated loop of intestine, which came on after 2 minutes 20 seconds. The suppression of motor activity of the intestine lasted 103 minutes 40 seconds. It must be pointed out that under these conditions we were unable to observe complete rest. At definite intervals of time we could observe isolated contractions of the loop of intestine. Injection of atropine to Anakonda and Iula also gave rise to depression of the motor function of the isolated loop of small intestine. These findings are also in agreement with the research of L. S. Girshberg [2] and L. G. Voronin [1].

Acute radiation sickness was produced in the dogs by total irradiation with x-rays (in a dose of 400 r). Three

dogs were irradiated. In Pirat the disease took a severe course and the animal died on the 22nd day after irradiation; in Anakonda and Iula the acute radiation sickness developed in a slight form.

We give below the results of investigations with the individual animals.

The dog Pirat. Tracing of the movement of the isolated loop of small intestine began 50 minutes after irradiation. At once a significant fall in the motor activity of the isolated intestine could be observed. The number of contractions per minute remained normal, but their strength fell to 12 mm of mercury. Fifty-eight minutes after irradiation the strength of the contractions had reached the level of 5 mm of mercury, and after 85 minutes it had fallen to 2 mm of mercury. Side by side with the depression of peristaltic movements spasms were recorded, lasting for 3-4 minutes. On the 150th minute the animal was observed to vomit. Two minutes after vomiting, the strength of the contractions increased; at the same time the tone of the intestinal musculature rose considerably, in some cases to 24 mm of mercury. Beginning on the 208th minute after irradiation, and continuing to the end of the experiment, a prolonged and almost complete rest of the isolated intestine developed; very occasionally isolated, single contractions with a magnitude of 2mm of mercury could be observed.

Thus, on the first day after irradiation the motor function of the isolated intestine was sharply inhibited (Fig. 1).

On the 2nd day after irradiation, in the first hour of the experiment the motor activity of the intestine was still depressed, but to a far lesser degree. The strength of the contractions reached 12 mm of mercury, but their frequency had fallen to 10 per minutes. In the second hour a violent motor activity was observed in the isolated intestine, with a contraction strength of 27 mm of mercury and an increase of tone to 28 mm of mercury. This sharply increased motor activity terminated in vomiting, after which it was considerably inhibited. The strength of the contractions reached at this moment 8 mm of mercury, and their rate fell to 4 per minute. This condition lasted until the 108th minute from the beginning of the experiment, after which quite prolonged periods of activity with contractions of varying strength were noted. The periods of contraction lasted for 5 minutes and sometimes even longer.

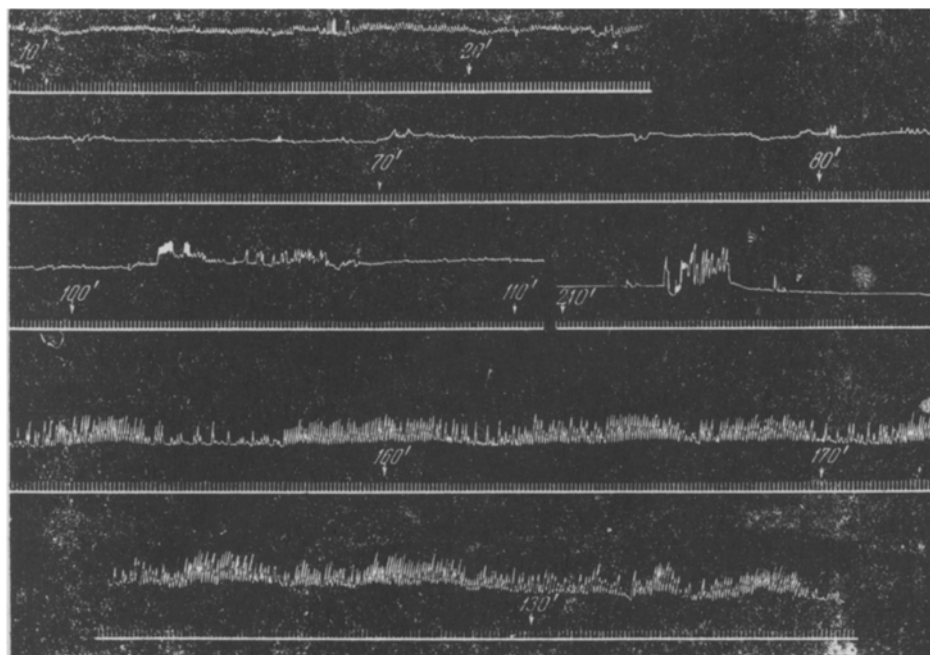


Fig. 3. Motor activity of the isolated intestine in the dog Iula on the 1st day (upper 3 curves) and on the 3rd and 5th days after irradiation.

On the 4th day after irradiation the motor activity was almost normal, i.e. the strength of the contractions was equal to 20 mm of mercury and their frequency 15 per minutes. On the 5th day the motor function of the

isolated intestine was slightly weaker; the maximum strength of the contractions was 16 mm of mercury but their rate had fallen to 14 per minute. On the 9th day after irradiation the contractions were uncoordinated. On the 14th day very powerful motor activity of the isolated loop of intestine was observed: the work periods were lengthened to 4-5 minutes, the contraction strength reached 30-35 mm of mercury, and their frequency was within normal limits - 15 per minute; the tone of the isolated intestine was raised to 14 mm of mercury. On the 17th day the tone was raised still further (27 mm of mercury), the number of contractions had fallen to 10 and their strength had increased to 48 mm of mercury. The increased motor activity of the isolated intestine continued until the 22nd day. At the beginning of the premortal period (22nd day after irradiation) the motor function diminished sharply; it then ceased altogether; the tone of the loop of intestine fell to zero. This condition lasted until the death of the animal.

The dog Anakonda. In the first hours after irradiation of the animal with x-rays an increase in the motor function of the isolated intestine could be detected. No changes in the intestinal tone were observed in the first 24 hours. The number of contractions per minute remained normal. The increase in the motor activity was the result of an increase in the strength of the intestinal contractions (to 32 mm of mercury), a lengthening of the periods of activity, and to an almost complete absence of periods of rest (Fig. 2).

The motor activity continued to remain high until the 14th day after irradiation. The strength of the contractions was 28 mm of mercury. On the 27th day the motor function of the isolated intestine fell to normal. On the 40th day a lowering of the motor activity could already be observed. The number of contractions per minute continued to remain normal, but their strength diminished to 4-8 mm of mercury. On the 48th day the strength of the intestinal contractions after the second hour of the experiment rose to 30 mm of mercury. On the 55th day the motor activity of the isolated intestine fell sharply; the number of contractions per minute was between 15 and 18, but their strength had fallen to 3-4 mm of mercury. On the 76th day after irradiation the motor function of the isolated loop of intestine was within normal limits.

The dog Iula. Only 20 minutes after irradiation of this animal with x-rays depression of the motor activity of the isolated area of intestine was observed. The contractions of the intestinal loop were uncoordinated. The strength of the intestinal contractions at this time was 4 mm of mercury, and 1 hour later - 2 mm of mercury. Side by side with the considerable reduction in the peristaltic movements, the tone of the isolated intestine was very often raised for a long time, usually to 4-6 mm of mercury.

It is in this manner that the intestinal spasms, so frequently observed in acute radiation sickness, can be explained. During vomiting, the tone of the loop of intestine was increased to 16-28 mm of mercury.

On the 3rd day after irradiation the strength of the intestinal contractions was raised to 30 mm of mercury. The periods of work were lengthened, sometimes to 10 minutes and longer. On the 5th day the same features were observed (Fig. 3).

On the 11th day after irradiation the motor function of the isolated intestine was at the normal level; the 18th day was characterized by a significant depression of the motor activity of the isolated loop of intestine. The maximum strength of the contractions at this time was 6 mm of mercury. The number of contractions fell to 10-11 per minute, and the periods of work were considerable shortened. On the 22nd day the motor function of the isolated intestine rose sharply. The number of intestinal contractions remained normal, but their strength increased to 30 mm of mercury; the tone rose to 14-18 mm of mercury. On the 51st day after irradiation with x-rays the motor activity of the isolated intestine almost reached the normal level. On the 65th day the motor function of the loop of intestine was slightly lowered; the strength of the contractions was 8-14 mm of mercury, and their frequency 9-12 per minute.

Thus, during acute radiation sickness in dogs, caused by irradiation with x-rays in a dose of 400 r, the motor function of an isolated area of the small intestine is quite considerably altered in the direction of depression and also of intensification. It should be pointed out here that under these circumstances there mainly takes place a prolonged increase in the motor activity of the isolated loop of intestine. The motor function of the isolated intestine in different dogs as a rule increases or diminishes at the same time. Thus, for example, between the 3rd and 8th days after irradiation with x-rays the motor activity of the intestine increased in all 3 experimental animals. The same thing could be observed on the 14th-17th, 21st-28th and 31st-48th days. Depression of the motor function in Anakonda and Iula was noted on the 55th-56th day.

The periodicity (phasing) of the secretory processes and absorptive processes of the intestine observed in acute radiation sickness [3-5] are also characteristic of the motor function of the isolated loop of small intestine.

Disturbances of the motor function of the isolated loop of intestine depend evidently on changes in the cholinesterase activity of its tissue. Certain workers have established [6] that under the action of ionizing radiation inactivation of the cholinesterase of the intestine takes place. For this reason the acetylcholine which is continually being liberated is less subjected to destruction, appears in a higher concentration and the motor activity of the intestine which it causes, is increased. Conversely an increase in the cholinesterase activity at certain stages of radiation sickness leads to a fall in the acetylcholine concentration and causes depression of the motor function of the small intestine.

In our experiments the changes in the motor activity of the intestine in normal, unirradiated animals due to proserin and atropine are very reminiscent of the trends of the motor function of the loop of intestine which we observed at various stages of acute radiation sickness. In view of this, we postulate that the disturbances of the motor activity of the intestine in the irradiated dogs may depend on changes in the acetylcholine - cholinesterase system developing in radiation sickness.

SUMMARY

The motor function of the isolated intestinal loop (by Thiry-Vella's method) was studied with the aid of an air-balloon transmission. Experiments were carried out on 3 dogs. Radiation sickness was caused by x-ray irradiation in the dose of 400 r. The results of experiments demonstrated that the motor activity of the isolated intestine is greatly intensified in acute radiation sickness. However, periods of depression and normalization of the motor function were also noted.

LITERATURE CITED

- [1] L. G. Voronin, *Izv. Nauchn. inst. imeni, Lesgofta*, 21, 1-2, 3, 71 (1938).
- [2] L. S. Girshberg, *Russk. Fiziol. Zhur.* 10, 6, 497-511 (1927).
- [3] S. R. Perepelkin, *Proceedings of the Eighth All-Union Congress of Physiologists, Biochemists and Pharmacologists*, pp. 473-474 (Moscow 1955).*
- [4] K. V. Smirnov, *Proceedings of the Tenth Session of the Institute of Nutrition*, pp. 78-79 (Moscow, 1956)*.
- [5] V. A. Shaternikov, *Med. Radio.* 4, 61-67 (1956).
- [6] J. H. Burn, P. Kordik and R. H. Mole, *J. Physiol.* 1952, Vol. 116, N. 2, p. 5-6.
- [7] R. A. Conard, *Am. J. Physiol.* 1951, Vol. 165, pp. 375-385.
- [8] R. D. Goodman, A. E. Lewis and E. A. Schuck, *Ibid.* 1952, Vol. 169, pp. 242-247.

* In Russian.