

THE EFFECT OF PENETRATING RADIATION ON THE SUCCINIC DEHYDROGENASE ACTIVITY OF THE PARENCHYMATOUS ORGANS OF WHITE RATS

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There are many reports on the effect of penetrating radiation on the activity of the oxidation-reduction processes in the tissues in both the Soviet and foreign literature. It is a well known fact that in radiation sickness there is inactivation of the free SH-groups, which occur in the coenzyme groups of the majority of enzymes. However the information on the activity of the various thiol oxidizing enzymes, which includes succinic dehydrogenase, in various stages of radiation sickness is highly controversial. Whereas according to some workers [4] the activity of the thiol enzymes falls within a few hours of irradiation with x-rays, in the opinion of others [6-8] it is unaltered. Finally, according to Kunkel and Phillips [5], the activity of the thiol enzymes is markedly increased in the first few days after irradiation with even lethal doses of x-rays.

In this connection it appeared of interest to carry out a histochemical investigation of the succinic dehydrogenase activity in the course of radiation sickness caused by single and repeated irradiation with x-rays.

EXPERIMENTAL METHOD

We divided into 2 groups 96 white rats whose initial weight was 160 g, and which were kept on a standard diet: the first group was irradiated with a dose of 150 r, the second with 450 r. Irradiation was performed with an RUM-3 apparatus, with a tube voltage of 180 kv, current 15 ma, filters 1 mm Al and 0.5 mm Cu, and a dose strength of 56 r/min. The animals were killed by decapitation after 3 and 24 hours and 7, 15, 30, 35, 45, 50 and 60 days of irradiation. At each interval of time 4 rats were taken, one of which was the control (not irradiated). After clinical recovery, the remaining rats were exposed to further irradiation with the same dose of x-rays. They were killed after the same intervals. After clinical recovery from the second attack of radiation sickness the animals were irradiated with the same doses a third time. The neotetrazole reaction for succinic dehydrogenase was carried out by Shelton's method [2] on fresh sections of the heart, liver and kidneys of the killed animals.

EXPERIMENTAL RESULTS

Three hours after the first irradiation the succinic dehydrogenase activity of the parenchymatous organs (heart, liver and kidneys) is unchanged by comparison with that of normal animals. Twenty-four hours afterwards the activity of the enzyme is considerably increased in the liver and kidneys (Fig. 1, b), but remains at its original level in the heart muscle. Later the succinic dehydrogenase activity begins to fall, and it reaches its normal level at the onset of radiation sickness, i.e. on the 7th day; in the course of development of the radiation sickness the activity continues to fall (on the 15th day it is below normal). A fall in the activity of the enzyme also takes place in the period of clinical recovery of the animals, and even after the restoration of all the clinical criteria which we studied (blood, body weight, urine, conditioned reflexes and so on), and the succinic dehydrogenase activity of the liver and kidneys falls in response to both dosages of x-rays; (Fig. 1, c) we did not observe inactivation in this form in the cardiac muscle. After the first repetition of irradiation the same features

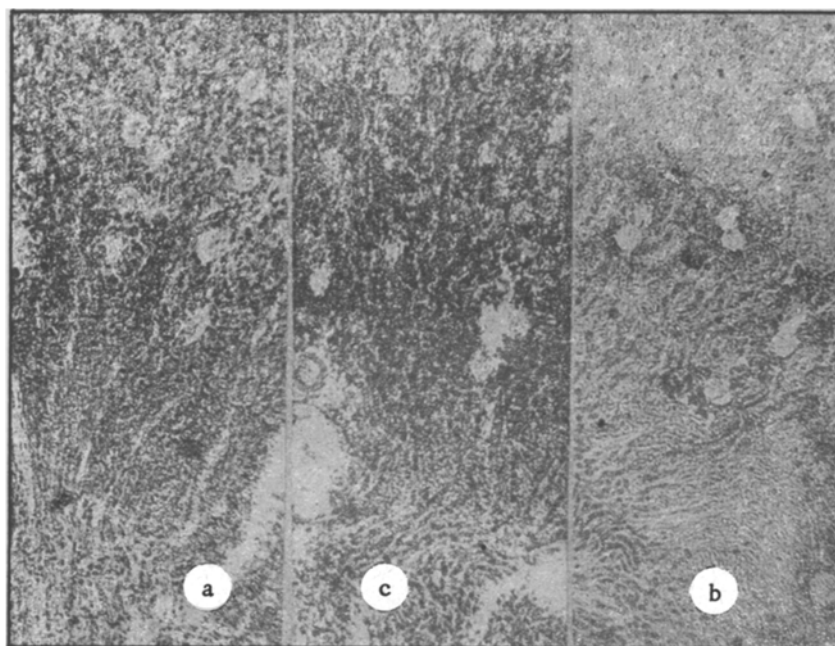


Fig. 1. Succinic dehydrogenase in the kidneys of rats after irradiation with x-rays in a dose of 450 r. (Microphotograph. Neotetrazole, magnifying glass).
a) Before irradiation; b) 24 hours after the first irradiation; c) 60 days after the first irradiation.

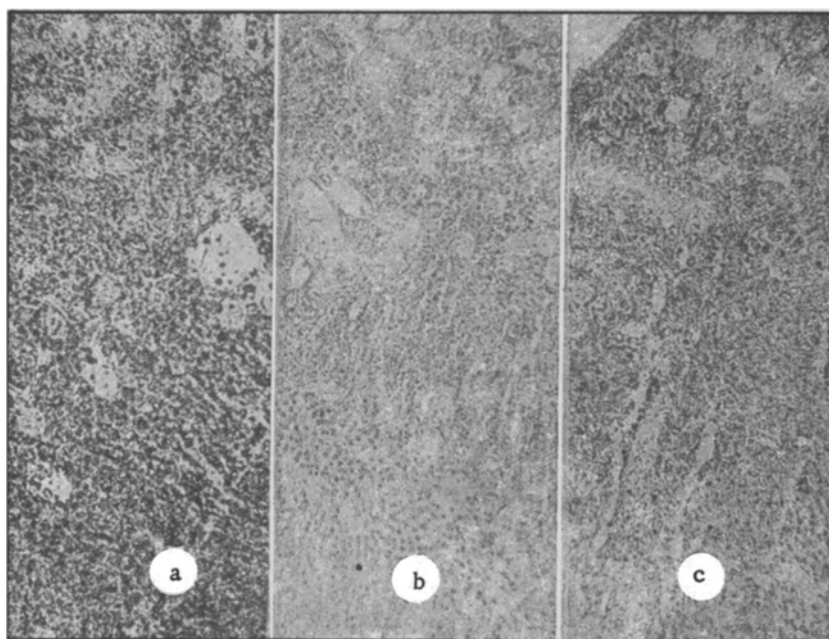


Fig. 2. Succinic dehydrogenase in the kidneys of rats after irradiation with x-rays in a dose of 450 r. (Microphotograph. Neotetrazole, magnifying glass).
a) Twenty-four hours after second irradiation; b) 45 days after second irradiation; c) 24 hours after third irradiation.

were observed, with an initial rise in succinic dehydrogenase activity (Fig. 2, a) and a subsequent fall (Fig. 2, b). However, the degree of increase after the second irradiation was significantly less, and it only reached the normal

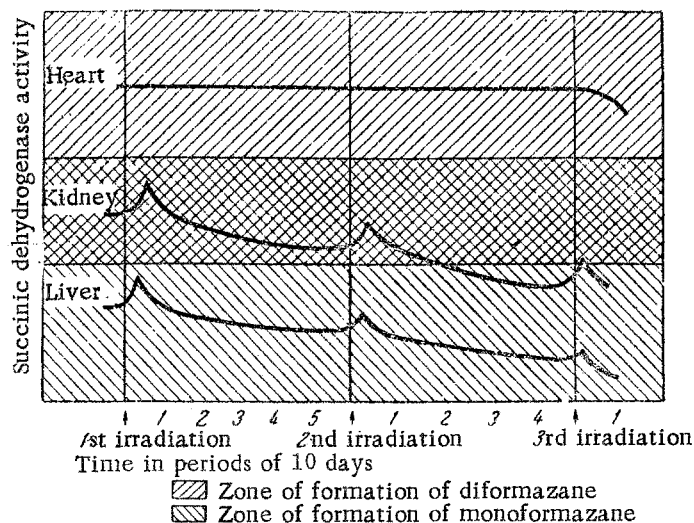


Fig. 3. Succinic dehydrogenase activity of the parenchymatous organs of white rats after the first and repeated irradiation with x-rays in a dose of 450 r, at intervals of 10 days.

level. The third irradiation resulted in death of the majority of the animals. Twenty-four hours after the third exposure, activation of succinic dehydrogenase was again observed in the experimental rats (Fig. 2, c), but the level of the increased activity was much lower and did not reach the initial — normal — level. In the animals which survived the third irradiation (with a dose of 150 r), after a brief rise, a prolonged fall was observed in the activity of the enzyme, and this was shown not only in the liver and kidneys but also in the cardiac muscle.

The changes in the succinic dehydrogenase activity after single and repeated irradiation may be represented conventionally in the form of a graph (Fig. 3).

The fall in succinic dehydrogenase activity at the height of radiation sickness in our experiments agrees with the findings of the majority of workers, and is possibly connected with interference with the new formation of enzymes by the radiation sickness [1]. The fact that at the moment of restoration of the clinical indices which were studied, after the first and subsequent irradiation, the activity of the enzyme remains lowered, may evidently be explained by the fact that for restoration of the power of the cell to form succinic dehydrogenase more time is required than for restoration of the usual clinical indices during recovery from radiation sickness.

The activation of succinic dehydrogenase in the first 24 hours after the first and second irradiations, in our opinion, may be connected to some degree with the first phase of the adaptation syndrome of Selye [9], i.e. with the alarm reaction, during which there takes place a nonspecific mobilization of all the defensive powers of the body — including, possibly, the processes of oxidation-reduction — against the pathogenic agent.

SUMMARY

The succinic dehydrogenase activity was studied on the sections from the heart, liver and kidney of albino rats exposed to repeated x-ray irradiations. The animals were sacrificed during the course of the 1st, 2nd and 3rd radiation sicknesses and during their temporary recovery. It was found that the enzyme activity does not change in 3 hours after the primary and the secondary x-ray irradiations. However, it seems to increase in 24 hours.

At the onset of the radiation sickness (i.e. on the 7th day) and during its course the enzyme activity diminishes and remains on the lowered levels after the clinical recovery. The degree of elevations and falls of the enzyme activity depends upon the dose and the number of x-ray irradiations. The theoretical concepts underlying the above-mentioned results are discussed.

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