CHANGES IN THE GLYCOGEN CONTENT OF THE NERVOUS SYSTEM AND MUSCLES IN ANIMALS INFECTED BY VIBRION SEPTIQUE

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We know that in muscle infected with gas hangrene there is a decrease in the amount of glycogen decomposed to form lactic acid, as a result of which acidosis develops in the tissues [1, 2]. It has been shown histochemically that the muscle fibers in the infected focus are lacking glycogen [7]. The content and distribution of glycogen in the various divisions and the various cells of the nervous system in gas gangrene have not been studied. There are grounds for the belief that glycogen has an essential influence on the activity of the nervous system, and evidently takes part in the restitution of the nerve cell and the regeneration of Nissl's granules [6]. Along with the gross changes undergone by the nervous system in gas gangrene [3, 4, 8], the degree of accumulation and distribution of glycogen in the nervous system may evidently be an indication of its condition.

These considerations provided a motive for the histochemical investigation of the muscles and the various divisions of the nervous system in white rats infected with vibrion septique in various experimental conditions that could have a bearing on the outcome of the infection.

EXPERIMENTAL METHOD

Observations were made on 4 groups of white rats (with 10 animals in each group), all of which were infected at the same time. They were each given an injection of one MLD of vibrion septique, mixed with 2.5% calcium chloride solution, into the calf muscle. Into the same muscle, either before or after infection, was injected 0.1 ml of a 0.25% solution of a long-acting preparation of novocain in apricot oil, or the same volume of sterile apricot oil alone. The animals of group I were injected with novocain 24 hours before infection, those of group II – 1 hour after infection, the group III animals were injected with apricot oil 24 hours before infection and the animals in group IV were infected without any further treatment (controls)*

From 4 rats of group I, 4 rats of group II, 3 rats of group III and 3 rats of group IV (killed 1, 7 and 45 days after infection), both calf muscles, both sciatic nerves, both S_1 spinal ganglia, the spinal cord, the medulla and the anterior lobes of both cerebral hemispheres were removed for histochemical investigation of the glycogen by the method of A. L. Shabadash. The presence of glycogen was demonstrated by treatment with diastase.

EXPERIMENTAL RESULTS

Complete loss of glycogen was observed in the muscle fibers of both calf muscles 24 hours after infection of the control rats. Glycogen was found only in the cells of the infiltrates and of the connective tissue on the right, and in the form of occasional granules in the endomysium on the left. In the rats of groups I, II and III

*Infection of the animals was carried out by Candidate Med. Sci. Z. I. Sobieva.

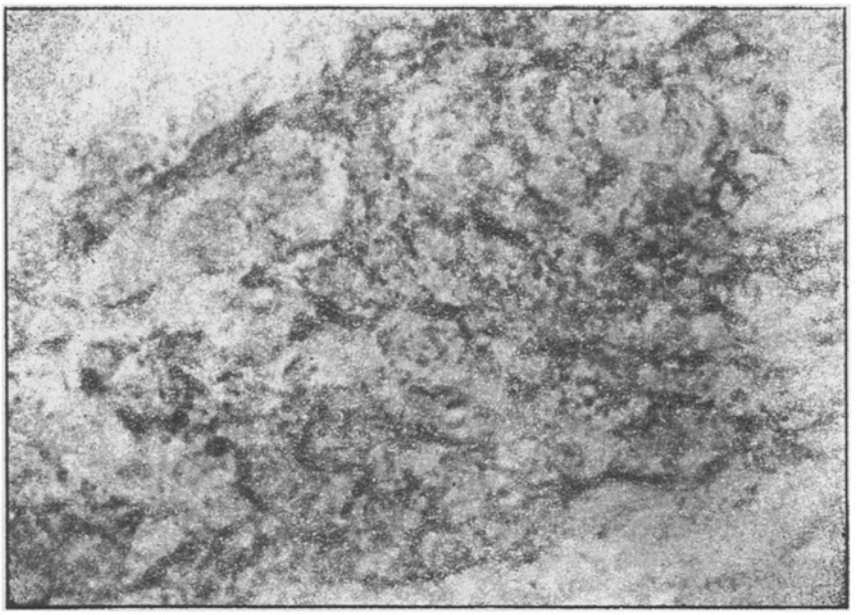

Fig. 1. Glycogen in the ependyma and in the wall of the lateral ventricle of the right cerebral hemisphere in a rat of group II on the 7th day after infection. (Shabadash method. Microphotograph 798 ×).

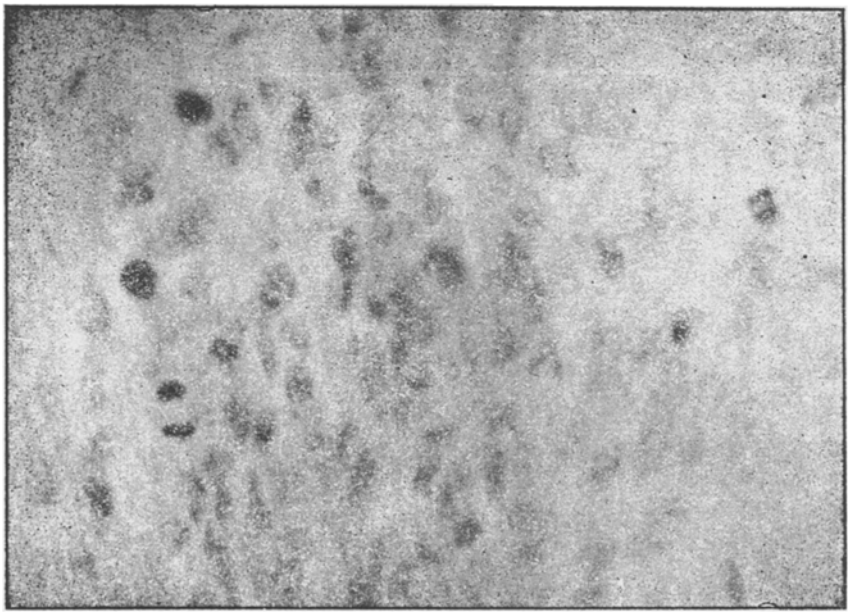

Fig. 2. Mitoses in the ependyma and in the wall of the lateral ventricle of the left cerebral hemisphere of a rat of group III on the 7th day after infection. (Shabadash method. Microphotograph 798 ×).

this loss of glycogen by the muscle fibers was not observed. In the rats of group I glycogen was found in both muscles in the dark Q disks; in addition it was observed in the endomysium and the vessel walls. In the rats of group II, on the right there was no glycogen in the muscle fibers; it was seen in the form of isolated granules in the endomysium, the vessel walls and the cells of the infiltrates; on the left it was present in a few muscle fibers and also in the endomysium and vessel walls. In the rats of group III, glycogen was found on the right in the dark Q disks, the sarcoplasm, the endomysium and the cells of the infiltrates in a larger quantity than in the

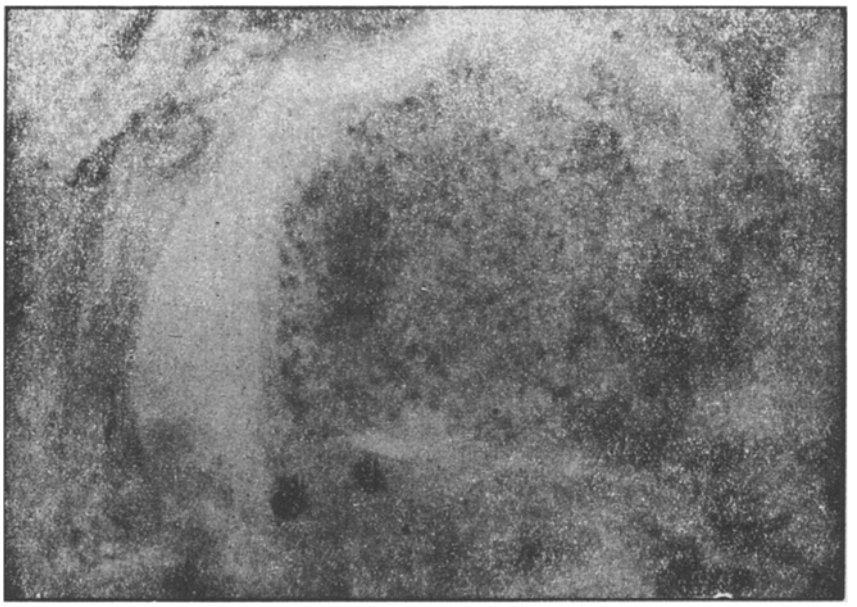

Fig. 3. Mitosis in the capsule of a nerve cell of the right spinal ganglion in a group II rat on the 45th day after infection (Shabadash method. Microphotograph 1260×.

previous rats; on the left there was less of it than on the right. Restoration of the normal content and distribution of glycogen in the various histological structures of the muscle tissue took place more completely in the rats given additional treatment than in the controls.

On the 7th day after infection glycogen was found in both muscles of a control rat in the dark Q disks of a few fibers; on the 45th day after infection it was also found in a few muscle fibers and in the endomysium.

In the rats of groups I, II and III on the 7th and 45th days after infection the glycogen content of the muscle on the right was higher than that of the control rats; sometimes it was higher on the right than on the left. Glycogen was found in the dark Q disks of many muscle fibers, and sometimes in the sarcoplasm and endomysium and also in the histiocytes and lipoid cells.

Naked eye and histopathological examination of the right and left calf muscles [5] showed that the course of the pathological process was most favorable and accompanied by intensification of proliferation of certain connective tissue cells and the appearance of mitoses therein, in animals receiving injections of oil, followed by those receiving an injection of novocain 24 hours before infection, then by those injected 1 hour after infection, and it was least favorable in the control animals (group IV).

Thus the content and distribution of glycogen in the muscles of the various groups of animals corresponds to our findings by histopathological examination of these animals: the course of the process is most favorable in the rats of group III, then in groups I and II, and least favorable in the control rats.

In the sciatic nerves and spinal ganglia glycogen was found only inside the lumen of vessels, in the cells of the blood or polyblasts. In the central nervous system glycogen was seen in the ependymal cells, in the walls and lumen of vessels, in the leucocytes and, rarely, in the glial cells. Its accumulation in the central nervous system was greater in animals injected with oil and novocain than in the controls, infected without any addtional treatment. This difference showed up most clearly on the 7th day after infection, and the highest glycogen content was found in the ependyma and wall of the lateral ventricles of the cerebral hemispheres in animals receiving novocain. In the rats of group I killed on the 7th day after infection, for instance, considerable deposits of glycogen were discovered in the ependyma and wall of the lateral ventricles. Still more glycogen was found here in the rats of group II, also killed on the 7th day (Fig. 1). In a control rat killed at the same time as these, there was a small quantity of glycogen in the ependyma of the left lateral ventricle, but none in the ependyma of the right ventricle. This difference is shown less clearly in animals killed on the 45th day after infection, for

in rats of groups I and II there was less glycogen in the ependyma of the lateral ventricles than in the rats of the same groups on the 7th day after infection, and glycogen was also found in the control rat, but in the form of solitary granules.

One more feature deserves attention. The number of cells undergoing mitotic division was higher in the various phases of division than normal in the ependyma and the wall of the lateral ventricles of the brain in the rats of groups I and III on the 7th day and in all the rats on the 45th day after infection (Fig. 2). Sometimes mitoses were found more often in the left hemisphere than in the right, i. e. in the hemisphere innervating the infected limb. Under these circumstances there appears to be a definite connection between the number of mitoses and the glycogen content. In a hemisphere with a high glycogen content there are few mitoses, and conversely, it is low where mitoses are common. In a group II rat killed on the 45th day after infection, we also observed mitosis in the capsule of a nerve cell in the right spinal ganglion (Fig. 3).

From information in the literature [9], in all vertebrates the ependyma and its derivatives are neurosecretory organs. Their neurosecretion is a complex of mucopolysaccharides and proteins. This secretion of the ependymal cells is transported from the basal area of the cells into the vessels, and from the apical area into the cerebrospinal fluid. In all probability the glycogen too, which we found in the ependyma of the lateral ventricles, is partially secreted or transported by the ependymal cells into the ventricular system, thereby demonstrating the possible participation of the cerebrospinal fluid in the pathological process.

The increased accumulation of glycogen in the ependyma and wall of the lateral ventricles of the cerebral hemispheres may be evidence of increased synthesis of glycogen or of its inadequate utilization on account of the lowered metabolic activity of the nerves when the animal emerges from a pathological state. If we bear in mind that the increased accumulation of glycogen in the wall of the lateral ventricles is expressed to the highest degree in the animals receiving injections of novocain and oil, and in which the pathological process followed a more favorable course than in the controls, then it must be concluded, it seems to us, that increased synthesis of glycogen is taking place here in association with the improved condition of the infected animal, as a phenomenon of a compensatory nature. Under these circumstances, the greater the mobilization of energy resources which arises, probably, to provide for the demands of the metabolism of the nerves, the more severe the course of the pathological condition. This is illustrated by the fact that in the rats injected with novocain one hour after infection, the accumulation of glycogen observed in the recovery period in the ependyma and wall of the lateral ventricles was greater than that in the animals receiving novocain and oil 24 hours before infection; the course of the pathological lesion was more severe in the former than in the latter.

The diminution which we observed in the accumultion of glycogen in the walls of the lateral ventricles during intensification of mitosis here, was presumably evidence of utilization of this resource of energy by the increased mitotic activity. In our view, the latter was probably connected with intensification of the compensatory reactions of the body. Hence in this case also, the glycogen content of the central nervous system evidently reflects the degree of compensation by the body of the disturbances resulting from the pathological process.

SUMMARY

A culture of vibrion septique was injected into the gastrocnemius muscle of white rats. A stable preparation of novocain on apricot oil, or apricot oil alone were injected into the same muscle.

Control animals were infected without any additional interventions. Glycogen was examined by A. L. Shabadash's histochemical method. A more favourable outcome of the infection was noted in the experimental animals in comparison with control. The loss of glycogen by the muscles during the most acute stage of the pathological process (24 hours after the infection) was less intense in experimental animals. The accumulation was also more intense in the muscles and in the central nervous system, especially in the ependyma of the lateral ventricles (in 7 days after the infection) in experimental animals. In reconvalescing experimental and control animals there were more mitotic figures in the wall of the lateral ventricles than in normal condition.

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*Original Russian pagination. See C. B. Translation.