THE STATE OF THE PERICELLULAR APPARATUS OF SYMPATHETIC GANGLIA UNDER CONDITIONS OF CHRONIC LEAD POISONING

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Disorders of the autonomic nervous system and, primarily, functional changes of the digestive tract and cardiovascular system are at first observed in the clinical picture of chronic lead poisoning. The data of a morphological investigation of the elements of the autonomic nervous system make it possible to evaluate the complex, developing process which consists of destruction, recovery, and the repeated damaging action of lead. However, in the literature devoted to lead poisoning very little is devoted to the structure of the autonomic neurons, and the few investigations that were carried out were mainly done so 30-40 years ago and information characterizing the state of the interneuronal synapses in the autonomic nervous system are completely absent, in particular, in them. But such data are presently of particular interest since it has been proven that these structures determine the normal functional state of the nervous system. A number of authors have pointed out the need for studying the interneuronal synapses in pathological processes [3, 4, 6].

Therefore, we undertook to study the reaction of the interneuronal synapses at various periods after the start of injecting lead salts into an organism.

METHOD

Two series of experiments were carried out on 15 mature rabbits weighing 2.5-3 kg. Lead poisoning was induced by enteral injection of a 10% aqueous solution (suspension) of lead acetate in a dose of 0.025 g/kg. The experiments of the I series were carried out in the following manner: 25 injections of lead, then an 18 day break, and again 12 injections of lead. The rabbits were killed $3^1/_2$ months after the start of the experiments. In the II series of experiments (duration 6 months) the rabbits were poisoned with lead acetate for 37 days and then after a 3 week break, for another 33 days. The degree of evidence of lead poisoning was judged by the changes of the blood (total number of erythrocytes, number of baso-erythrocytes and reticulocytes). For the characterstic of the synaptic structure under normal conditions we used the data based on our own observations of synapses in mammals [1, 2], source material [5, 7], and also a study of the synaptic terminations in the healthy rabbits that served as the control.

RESULTS

Two types of synapses were found on the neurons of the sympathetic ganglia: terminal synapses had the appearance of small rings, loops, or patches measuring 1-3 μ. To these terminal structures approach extremely fine presynaptic fibrils which are characterized by a straight direction of the terminals and a light brown color. The transitory synapses represent thin terminal arborizations of the preganglionic fibers, which along their course contact the bodies and processes of the peripheral neurons. Elongated patches or structures in the form of small rings situated at a distance of 10-15 μ from one another along the length of the fiber are at the sites of contact.

Usually the neuron has 1-3 synapses. The opinion exists that in pathological conditions the number of synapses on nerve cells increases. We were not able to confirm these observations. A month after the start of the experiment

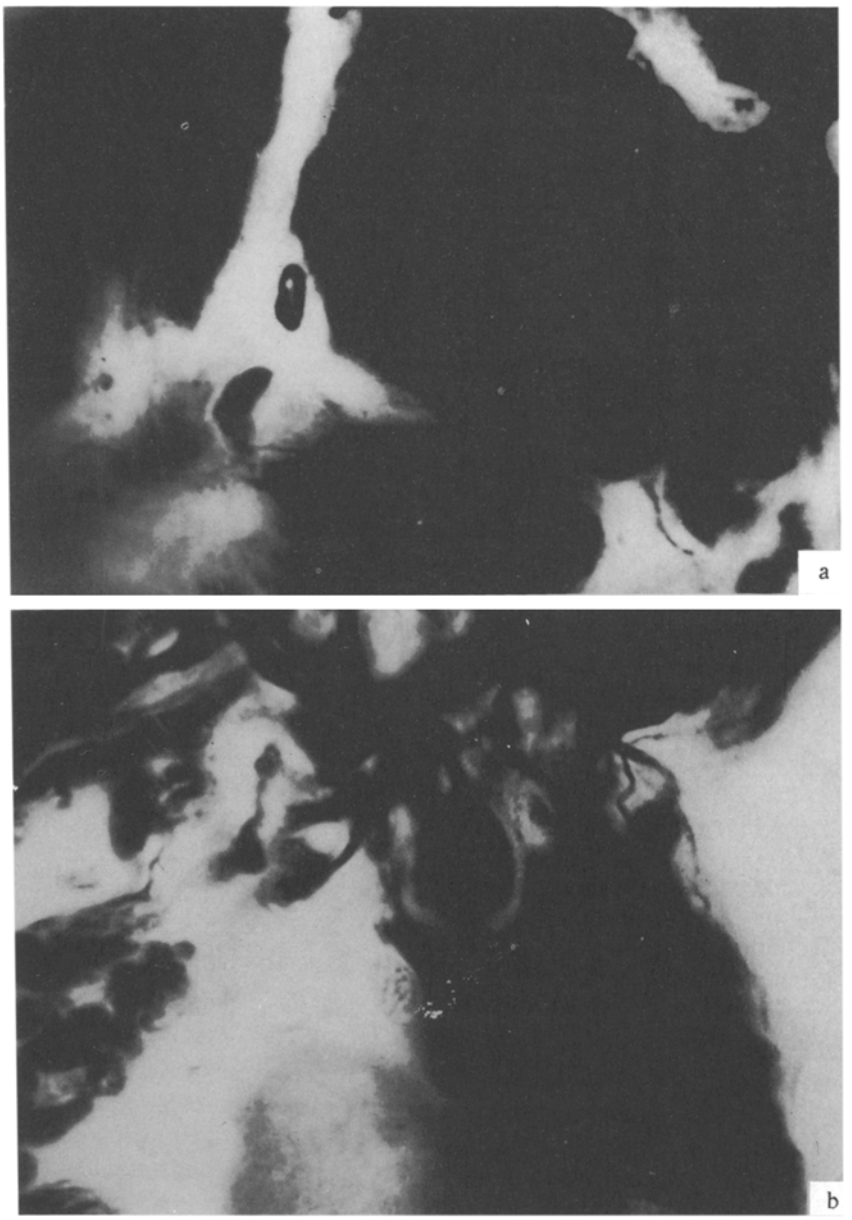

Fig. 1. Lesion of the pericellular apparatus of the sympathetic ganglion in lead poisoning. a) Markedly argentophilic and thickened synaptic ring 3 months after the start of the experiment. Bielschowsky-Gros. Objective 90, ocular 7; b) giant terminal cone with distinct light zone of unstained neuroplasm. Golgi-Deineke. Objective 90, ocular 7.

many of the synapses elicited were markedly argentophilic, the size of the synapses increased to 5-7 μ. The synaptic rings were pronouncedly thickened (Fig. 1a). Disorders in the synapses began from the fibrils directly adjacent to the terminal ring or cone. These fibrils rapidly underwent degerative changes and lost the capacity to be elicited by silver salts. The overwhelming majority of synaptic structures under pathological conditions proved to be without afferent fibers. However, to assert that the synapses are actually without these fibrils [8] seems unfounded to us, since these structures continue to exist for at least 2-3 months and undergo during this period complex changes which can hardly be explained by the processes of autolysis or disintegration. Thus, after 3 months the small, delicate synaptic rings transform into gigantic cones up to 12-14 μ in diameter (we observed the gradual transitional gamut of their sizes and shapes). The preterminal fibrils, which were markedly argentophilic and hypertrophied, were retained along with these large terminal cones. Around most of them there was a distinct light zone (Fig. 1b) of the

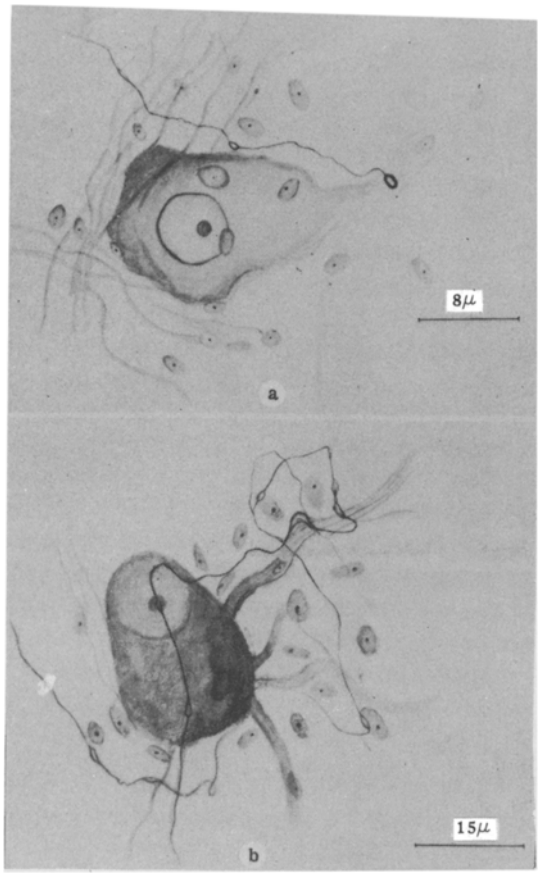

Fig. 2. Changes of the terminal ends in lead poisoning. a) Altered terminal synaptic ending with thickenings along the course of the presynaptic part of the fiber. Bielschowsky-Gros. Objective 100, ocular 20; b) regenerating preganglionic fiber near nerve cell. Six months after start of experiment. Bielschowsky-Gros. Objective 90, ocular 15.

unstained neuroplasm of the termination—the perifibrillar substance [2, 8]. Around the neurofibrillar framework we noted a granular substance which was stained in light tones.

The change of the synaptic termination can also occur without an appreciable increase of the mass. If in such cases it is possible to elicit the presynaptic fibril, then it proves to be unevenly thickened and argentophilic and usually terminates directly next to the end structure. Thus, the degenerative changes of the synaptic ring or patch can be accompanied by preservation or destruction of the preterminal fibril at the very start of the process. The later fate of the end structure depends on at what stage of the pathological process it loses connection with the center: early loss of central regulation by the ring or patch leads to destruction of the structures which is evidenced in granular disintegration (without their hypertrophy); with preservation of the connection with the body of the neuron, the synaptic terminations begin to be pronouncedly hypertrophied. With the simultaneous development of these processes some synaptic terminations are subjected to destruction and gradually disintegrate, whereas others, conversely, are hypertrophied and are retained for a very long time. It is possible that the latter fulfill the functions of the destroyed structures. But even the hypertrophied synapses at a certain stage of the process can lose connection with the fibers forming them and be subject to destruction.

Three months after the start of the experiment it was possible to observe terminal preganglionic fibers with appreciably altered synaptic rings. At a certain distance from the end structure we saw light thickenings along the course of the fiber (Fig. 2a).

According to the evidence in the literature [8, 9] and our data, the fine presynaptic sections of the preganglionic fibers are easily subjected to degeneration under the effect of injurious agents. A certain part of the terminal preganglionic fibers can be subjected to degeneration (depending on the degree of effect of the unfavorable factors). Regeneration then begins from the uninjured part of the preganglionic fibers. After 3-6 months we were able to note around the neurons fine fibrils with delicate rings; these fibrils, changing their direction several times, meandered in 3 planes (Fig. 2b). The fibrils appreciably differ in their tinctorial properties from the bodies of the neurons and were frequently stained even in those cases where the processes of the ganglion cells were not elicited at all. This confirmed our hypothesis of the possibility of regeneration of the preganglionic fibers; their appearance resembled regenerating preganglionic fibers after mechanical trauma.

Consequently, if the changes of the synaptic structures were not irreversible, they regenerated by a gradual change of tinctorial properties, shape, and size. Thus, the synaptic endings that were noted 6 months after the start of lead poisoning, were greatly increased, but were stained more weakly than the surrounding nerve cells. Along their periphery were seen small argentophilic granules. Apparently at later stages which were beyond the limits of the experiment, the size of the cones decreased and their tinctorial properties returned to normal.

Thus, regeneration of the state of the pericellular apparatus of the sympathetic ganglia in lead poisoning can proceed in a dual manner: in the case of irreversible changes following the disintegration of these structures ensues their regeneration similar to that after mechanical trauma (transection, excessive pressure) of the preganglionic fibers; in reversible changes argentophilia of the synaptic terminations is gradually lost and a decrease of their size ensues.

SUMMARY

Adult rabbits were given a 10% solution of lead acetate (0.025 gm per 1 kg of the body weight) per os daily during a month (in the 1st series of experiments) and during 3 months (in the 2nd series of experiments).

The animals were observed for 3-6 months.

The destructive changes in synapses became most noticeable 1 or 2 months after the beginning of the experiment. Three to 6 months later the regenerating synapses in the survived animals were observed in addition to the destructive changes of the pericellular apparatus.

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