MORPHOLOGICAL CHANGES IN THE MUCOUS MEMBRANE OF THE SMALL INTESTINE AFTER REMOVAL OF THE SENSORY SPINAL GANGLIA

M. D. Zaidenberg
Department of Histology and Embryology (Head, Professor T. A. Grigor'eva),
N. I. Pirogov Second Moscow Medical Institute
(Presented by Active Member AMN SSSR N. A. Kraevskii)
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We know that the small intestine, like the other internal organs, receives sensory fibers from the sensory spinal ganglia. Previous experimental work has shown [4, 5] that neurons of the spinal ganglia in the thoracic and lumbar regions take part in the sensory innervation of the small intestine. The largest number of sensory fibers to the small intestine arise from the spinal ganglia D8-D12.

In her studies of the reactions of organs and tissues to removal of their afferent innervation, T. A. Grigor'eva [3] showed that the sensory neurons play an important role in the maintenance of the structural integrity and an adequate level of differentiation of the parts of the body which they supply.

The removal of its afferent connections from an organ or tissue leads, on the one hand, to dilation of the blood vessels in the denervated areas, to the accumulation of polymorphonuclear leukocytes in the vessels, and to edema and infiltration of the tissues by these leukocytes, and on the other hand, to the dedifferentiation of the cells and tissues of the denervated organ.

There is some evidence in the literature that the organs of the alimentary tract react to loss of their sensory innervation in a manner common to all organs so treated [1, 2, 4, 6, 7, 8]. The tissue changes arising in the wall of the small intestine after a purely sensory denervation, i.e., after removal of the sensory spinal ganglia, have not been investigated.

In the present research our purpose was to study the pattern of the changes in the tissue components of the wall of the small intestine, especially of its mucous membrane, after removal of the corresponding sensory spinal ganglia.

EXPERIMENTAL METHOD

As experimental animals we used healthy fully grown cats, which were sacrificed by narcosis with ether at intervals of from 1 day to 3 months after the operation. The afferent nerve supply of the small intestine was removed by the one-stage extirpation of from 3 to 6 adjacent sensory spinal ganglia in the region of the middle and lower thoracic segments, unilaterally or bilaterally. Altogether 18 cats were subjected to the operation.

The animals were kept in identical conditions; they were sacrificed at the same time after taking a standard meal. The conclusion regarding the tissue changes in the wall of the small intestine was made after comparison with the controls.

The severity of the postoperative course after removal of the spinal ganglia was determined by the trauma to the bones of the vertebral column. Usually the animals were kept in recumbency during the first 24 hr after the operation, after which they moved about with difficulty. However, starting on the 3rd or 4th day, their movements gradually became freer. Subsequently, starting with the end of the first week after operation, no further disturbances of the animals' movements were found. No suppuration or other postoperative complications were observed in the experimental animals. In the course of time, however, they developed slight wasting, despite their high standard of feeding and care. External signs of digestive disorders (liquid stools) were observed extremely rarely.

When the animals were examined post mortem, the state of their organs was examined. Marked hyperemia of the small intestine was always present, especially after the bilateral operation. Sometimes petechial hemorrhages,

Fig. 1. Changes in the epithelium of a villus 24 hr after removal of the spinal ganglia of segments D10-D12 on both sides. Eye-piece 10, objective 100.

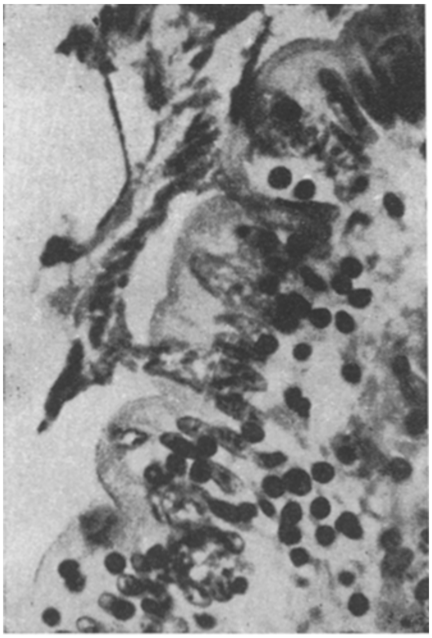

Fig. 2. Edge of a villus of the small intestine 3 months after removal of the spinal ganglia of segments D12-D13 on both sides. Eye-piece 10, objective 45.

or even small hematomas, appeared in the intestinal mucosa. The same areas of the proximal, middle, and distal thirds of the small intestine were always investigated histologically. The small intestine was incised along the border opposite the attachment of the mesentery. The excised fragments were spread out on paraffin wax, fixed in a 12% solution of neutral formalin and Zenker's fluid, embedded in paraffin wax, and stained by the usual histological methods.

EXPERIMENTAL RESULTS

Examination of the histological specimens revealed that the changes arising after sensory denervation affected all the tissues of the wall of the small intestine, including the intramural nerve plexuses.

In the early stages (1-2 days) after removal of the sensory spinal ganglia, dilation of the blood vessels of the whole wall of the small intestine was observed. Polymorphonuclear leukocytes were collected in the dilated vessels, engorged with blood, with a tendency toward pavementing of the leukocytes. In the later stages after the operation, the leukocytes from the dilated vessels began to penetrate into the surrounding tissue, including the nerve ganglia. During the first days after the operations the moderate total number of leukocytes in the dilated blood vessels corresponded to their moderate escape into the tissues. From 10 to 12 days after removal of the lower thoracic spinal ganglia, leukocytes from the arteries, veins, and capillaries, overfilled with these cells, began to penetrate into surrounding tissue intensively and in large numbers, often infiltrating it to a considerable extent.

It should be noted that dilation and congestion of the blood vessels, leukocytosis, and infiltration by neutrophils lasted throughout the experimental period (in our case up to 3 months). In association with the general changes (vascular reaction, neutrophilic infiltration) in all layers of the intestinal wall, changes also arose in the mucous membrane.

The cuticular epithelium (Fig. 1) showed very marked changes. Its cells were greatly swollen, the borders between them were obliterated, the cuticles of many cells had disappeared, their oval nuclei had become round and enlarged and their outlines irregular and wrinkled, nuclear membranes were thickened, and staining properties of the nuclei were diminished. In some areas the cuticular epithelium had liquefied. Leukocytes, and also cells from the base of the mucous membrane, penetrated into these areas in greater numbers. Among the latter cells, forms resembling plasma cells were numerous. The pattern of microscopic changes described above is characteristic of areas of ulceration.

After removal of the afferent innervation, increased mucus formation was observed in the epithelium and the number of goblet cells increased. This increased mucus secretion led to the formation of a thick layer of mucus on the surface of the epithelial layer (Fig. 2).

The epithelial cells in the crypts of the small intestine showed an increase in the number of karyokinetic divisions.

At the base of the mucous membrane, changes in the reticular tissue could be seen only 24 hr after the operation (Fig. 3): these cells were much more numerous and many of them were freed from their usual syncytial connections. The reticulum cells became rounded, their cytoplasm was more basophilic, and the chromatin in their nuclei was arranged in large granules or masses. The nucleus was eccentrically situated. Near it in the cytoplasm, a more lightly stained area appeared. These cells resembled plasma cells (Fig. 4). They began to migrate into the lumen

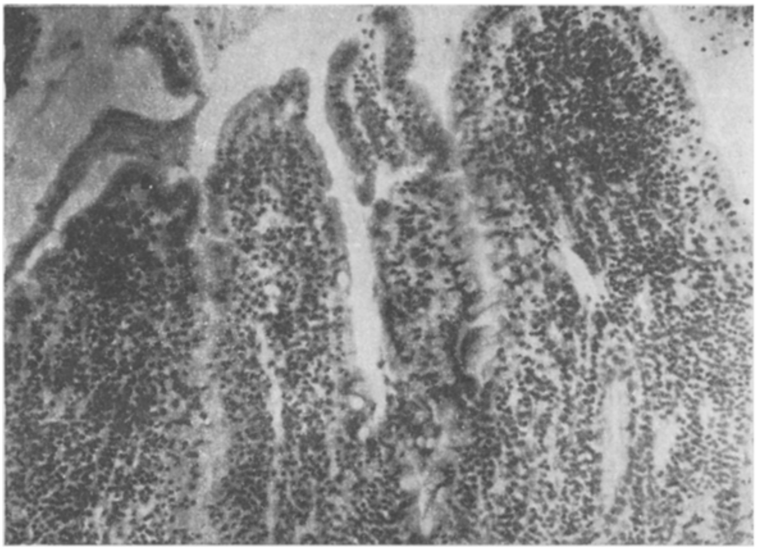

Fig. 3. Cellular elements of base of mucous membrane of the small intestine 24 hr after removal of spinal ganglia of segments D9-D13 bilaterally. Eye-piece 10, objective 10.

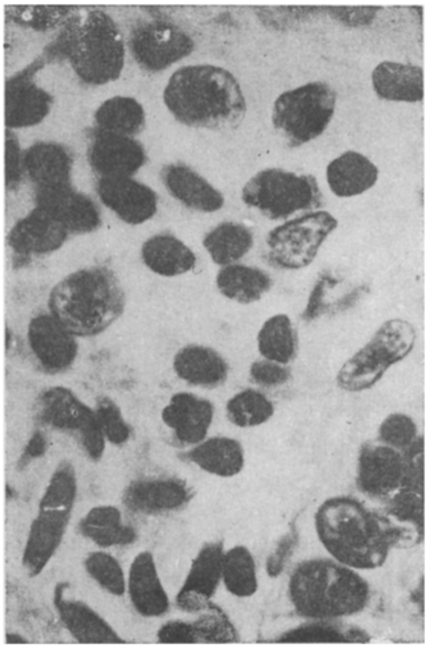

Fig. 4. Base of mucous membrane of the small intestine 3 months after removal of spinal ganglia of segments D8-D12 bilaterally.

of the intestine and, as mentioned above, were seen in large numbers in the cuticular epithelium (Fig. 1). They could also be seen in the lumen of the intestine between the villi and in the depth of the crypts. Many of the plasma-like cells were in a state of mitotic division.

To sum up, we must point out that the sensory denervation of the small intestine is always accompanied by inflammation, which does not proceed beyond the destructive phase, by dedifferentiation of the epithelium, and by the appearance of tiny ulcers.

At present we can do no more than draw attention to a new phenomenon — the plasmatization of reticulum cells and the replacement of the specific cuticular epithelium by cells producing an abundance of mucus. Further investigations are needed to reveal the nature of these phenomena.

SUMMARY

A study was made of the changes occurring in the small intestine at various periods after uni- or bilateral excision of the spinal cord ganglia of the medial and inferior thoracic segments. Loss of the sensory innervation by the small intestine is accompanied by inflammation, which is limited to a destructive phase, and by dedifferentiation of the tissue elements. Reticular cells are transformed into cells of the plasmatic type.

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