6. J. B. Black, E. M. Bloom, and R. W. Hamill, Proc. Nat. Acad. Sci. USA, 73, 3575 (1976).
7. B. Burnside, Ann. New York Acad. Sci., 253, 14 (1975).
8. J. A. Hendry and L. L. Iversen, in: Proceedings of the 5th International Congress on Pharmacology, New York (1973), p. 100.
9. F. O. Schmitt, in: Cellular Dynamics of the Neuron, New York (1969), pp. 245-260.
10. D. S. Smith, Ul. Järlfors, and B. F. Cameron, Ann. New York Acad. Sci., 253, 472 (1975).
11. L. E. Westrum and E. G. Gray, Brain Res., 105, 547 (1976).

EFFECT OF VAGOTOMY ON MORPHOLOGY AND FUNCTION OF THE ADRENAL MEDULLA IN RATS

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Marked dilatation of the venous sinusoids, a decrease in area of the chromaffin tissue, and a stronger chromaffin reaction in the adrenal medulla were found 7 and 45 days after bilateral subdiaphragmatic vagotomy in male albino rats. Considerable changes were found in the ultrastructural organization of the secretory cells and endothelium. Injection of glucose into these animals caused only slight fluctuations in the adrenalin content in the chromaffin cells.

KEY WORDS: vagotomy; adrenals; chromaffin tissue; hyperglycemia.

Previous investigations showed that bilateral subdiaphragmatic vagotomy depresses functional activity of the insulin system of the pancreas [1] and of the adrenal cortex [3]. The object of this investigation was to study the effect of bilateral subdiaphragmatic vagotomy on the adrenal medulla.

EXPERIMENTAL METHOD

Altogether 90 male albino rats weighing 120-140 g were used. Under ether anesthesia bilateral subdiaphragmatic vagotomy was performed on the animals. The rats were killed 7 and 45 days after the operation after starvation for 24 h and 1, 2, 3, and 6 h after administration of 20% glucose solution by gastric tube in a dose of 2 g/kg body weight. Glucose was chosen because of the need to synchronize the secretory process of the chromaffin cells of the adrenal medulla to some degree, for hyperglycemia inhibits catecholamine secretion. At each time of the investigation five control and five experimental animals were studied. The adrenal medulla was studied by Yaglov's combined histochemical method [2], whereby adrenalin and noradrenalin can be detected simultaneously in the chromaffin cells, unsaturated phospholipids in the adrenocorticocytes, and DNA in the cell nuclei. To compare the areas of the chromaffin tissue and venous sinusoids of the adrenal medulla in the control and vagotomized animals, a gravimetric method was used, with sections obtained from the middle part of the organ. The adrenalin and noradrenalin content was judged from the intensity of the chromaffin reaction. Material for electron-microscopic investigation was taken from three experimental and three control animals at each time.

EXPERIMENTAL RESULTS

In all experimental animals considerable dilatation of the venous sinusoids was observed 7 days after the operation, amounting to 92%. Homogeneous contents were seen in their lumen and stasis of erythrocytes, giving a positive reaction for catecholamines, was observed. The area occupied by the chromaffin tissue was 20.8% smaller than in animals of the control group. Analysis of the state of the chromaffin cells in the experimental animals showed that most cells in the medulla were in the phase of accumulation of secretion and gave a strong chromaffin reaction. Vacuolation of the cytoplasm was observed in many noradrenocytes and some adrenocytes. Administration of glucose caused changes in the catecholamine content in the chromaffin cells

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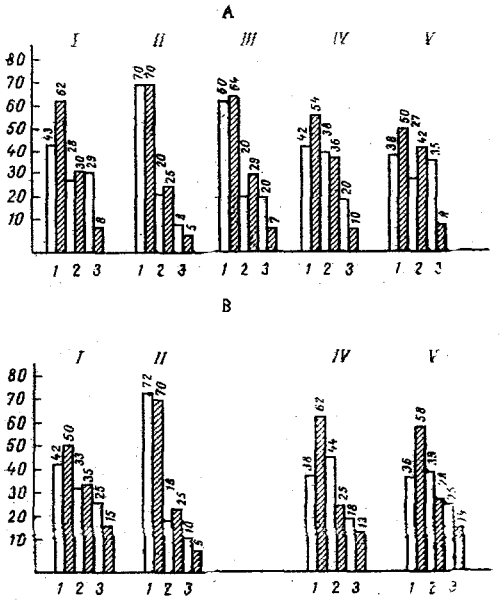

Fig. 1. Number of adrenocytes in various phases of secretory cycle in animals 7 days (A) and 45 days (B) after bilateral subdiaphragmatic vagotomy. I) State after starvation for 24 h; II) 1 h, III) 2 h, IV) 3 h, V) 6 h after administration of glucose; 1) phase of accumulation of secretion; 2) phase of hydration of secretory granules; 3) cells which had liberated their secretory product. Shaded columns denote state after vagotomy, unshaded columns control.

of both the control and the experimental animals, but in the latter the changes were not significant. The number of cells in the phase of accumulation of secretion 1 and 2 h after administration of glucose was increased more in the control than in the experimental animals, for the number of these cells in the latter was considerable in a fasting state also. Groups of cells liberating a secretory product appeared in the medulla of the control animals 3 and 6 h after administration of glucose. In the vagotomized rats the number of these cells was small (Fig. 1a). Electron-microscopic study of the medulla 7 days after the operation revealed changes in the endothelial cells of the capillaries: widening of the perinuclear space and of the tubules of the cytoplasmic reticulum and swelling of the mitochondria. Besides unchanged gland cells, adrenocytes and noradrenocytes with irregularly shaped nuclei also were found (Fig. 2a). The perinuclear space of such nuclei was only very slightly widened. Dilatation of the tubules of the smooth cytoplasmic reticulum also was observed. The lamellar complex was poorly developed. The mitochondria were scattered haphazardly throughout the cytoplasm, and increased translucency of the matrix and reduction of the cristae were observed in many of them (Fig. 2c). Most of the adrenocytes and noradrenocytes were filled with secretory granules, many of which were mature (the contents had high electron density). Edema of some secretory granules was found in the noradrenocytes, as shown by an increase in the electron-transparent border around their contents (this was ill-defined in the control animals) (Fig. 2b).

Some degree of normalization of the state of the adrenals was observed 45 days after vagotomy. The degree of reduction in area of the chromaffin tissue was 8%, whereas the sinusoids were dilated by 73% compared with the control. As before, however, stasis of erythrocytes and homogeneous contents were observed in their lumen. The chromaffin reaction was weaker than 7 days after the operation, but stronger than in the control animals.

On analysis of the state of the secretory cells at different times after injection of glucose considerable fluctuations were found in the catecholamine content in the adrenocytes (Fig. 1b).

Administration of glucose had no marked effect on the noradrenocytes of either the control or the vagotomized rats 7 and 45 days after the operation. Most of them were in the phase of hydration of the secretion.

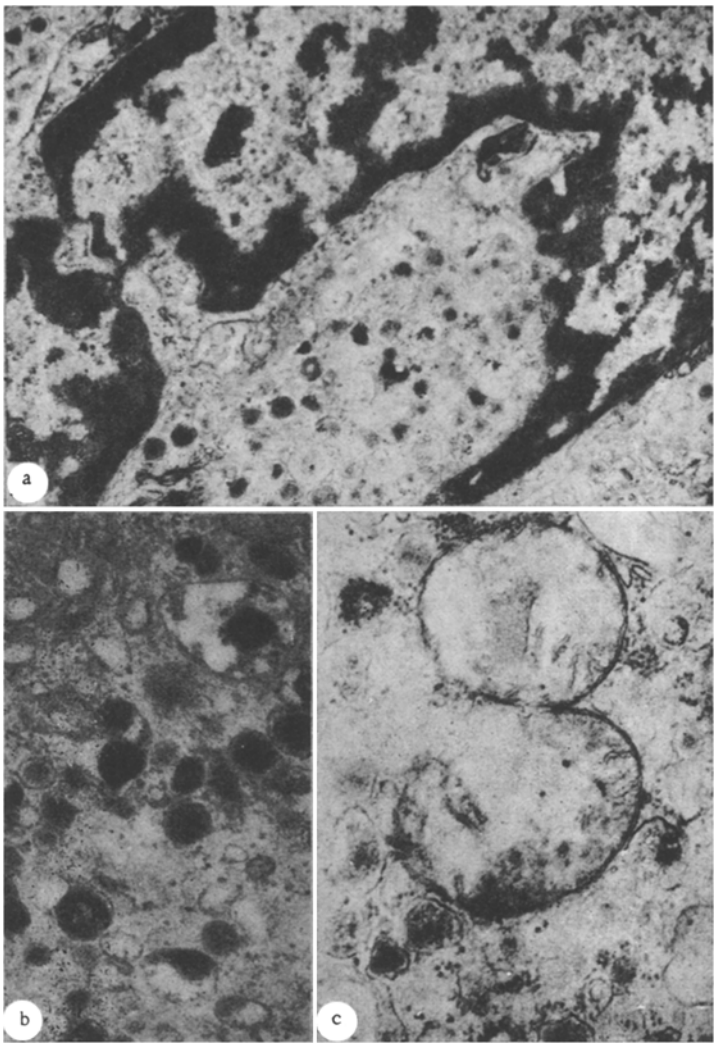

Fig. 2. Chromaffin cells of adrenal medulla 7 days after operation: a) change in shape and fragmentation of adrenocyte nucleus (18,000×); b) widening of electron-transparent border of secretory granule of noradrenocyte (34,000×); c) increased translucency of matrix, reduction of cristae, destruction of outer membrane of mitochondria (40,000×).

Investigation of the ultrastructure of the chromaffin cells 45 days after the operation revealed cells whose nuclei were irregular in shape, with dilated cisterns of their cytoplasmic reticulum, and with a translucent matrix and reduced cristae of their mitochondria. The cytoplasm was filled with many mature secretory granules, with some clustering of immature granules also. Myelinized structures were found in the lumen of the capillaries and in the cytoplasm of the chromaffin cells. The changes in the endothelial cells persisted.

The results of this investigation indicate that bilateral subdiaphragmatic vagotomy causes sharp changes in the hemodynamics in the adrenal, as reflected in marked dilatation of the venous sinusoids. This leads to edema of the secretory cells: widening of the perinuclear space and tubules of the cytoplasmic reticulum, and swelling of the mitochondria. Analysis of the state of the chromaffin cells in the experimental animals after starvation for 24 h showed that most of the cells were in the phase of accumulation of the secretory product and administration of glucose had no significant effect on their catecholamine content. Vagotomy thus leads to a reduction in the secretory activity of the chromaffin cells and endogenous synchronization of the secretory process in the phase of accumulation.

It can be concluded from the above account that bilateral subdiaphragmatic vagotomy affects the structure and function of the adrenal medulla. Its functional activity is depressed and normal correlations with the

insular apparatus are disturbed, with the consequent stimulation of the contra-insular apparatus. Meanwhile the general biological changes revealed at both the light-optical and ultrastructural levels are less marked than in the organs of the digestive system after these procedures. It can accordingly be concluded that the vagus nerves play a less important role in the innervation of the adrenals.

LITERATURE CITED

1. A. V. Bykov, in: Problems in the Morphology and Experimental Surgery of the Pancreas [in Russian], Stavropol' (1976), pp. 8-9.
2. V. V. Yaglov, Arkh. Anat., No. 8, 79 (1969).
3. N. Ya. Yakovleva, Byull. Éksp. Biol. Med., No. 9, 1128 (1976).

COMPARATIVE ANALYSIS OF PLASTIC ACTIVITY OF MUSCLE AND NERVE TISSUES AFTER TRAUMA AND TRANSPLANTATION OF MINCED MUSCLE

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Repair processes in the body muscle of Varicorhinus capoëta sevangi were studied after removal of part of three muscle segments and after autografting the resulting defect with minced muscle. As a result of trauma a focus of injury developed in the muscle, including the defect and the surrounding zone of degeneration. The inflammatory reaction, resorption of the necrotic masses, and regeneration of the muscle and nerve tissue continued for a long time. The formation of myogenic components did not begin until the 3rd week and single regenerating nerve fibers appeared in the region of injury after 2 months. Filling the defect with minced muscle accelerated regeneration. The transplanted fragments of muscle fibers not only participated themselves in the repair process but also stimulated the plastic activity of the muscle and nerve tissues of the graft bed.

KEY WORDS: regeneration of muscle and nerve tissues; transplantation of minced muscle.

Despite the great interest shown in the regeneration of organs and tissues [4, 6, 7, 9, 14] and, in particular, the problems of regeneration of skeletal muscles [2, 8, 13], the ability of muscle tissue in lower vertebrates to regenerate has received little investigation. For instance, there is brief but contradictory information on the regenerative powers of muscle tissue after minor trauma to muscle in fishes [1, 3, 5, 11, 12]. However, no grafting of muscles whatsoever has been carried out in fishes, nor has the role of the nervous system in muscle regeneration in these animals been investigated. Yet such an investigation is an important stage in the analysis of changes in regenerative activity of the tissues in an evolutionary series of animals.

EXPERIMENTAL METHOD

About 200 specimens of the Lake Sevan khramulya (Varicorhinus capoëta sevangi) 35-40 cm long were used. The experiments were carried out in summer on Lake Sevan. The fish were kept in tanks with running water on the shore of the lake under near-natural conditions. Two series of experiments were carried out: I) removal of part of three muscle segments (1.5 × 1 × 0.5 cm) on the lateral surface of the body below the dorsal fin; II) filling the defect with minced muscle tissue prepared from the piece of muscle removed. The material was fixed at various times (from 7 days to 3.5 months) in Zenker's and Bouin's fluids and in 10% neutral formalin and treated by various histological methods.

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