COMPENSATION AND ADAPTATION IN NERVE CELLS OF INTRAMURAL PLEXUSES OF THE SMALL INTESTINE AFTER HEMIRESECTION

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Complex morphological changes, phasic in character, take place in the nervous plexuses of the small intestine after hemiresection. Neurons of both the intermuscular and the submucous plexuses respond similarly to different stages of compensatory and adaptive changes in the residual intestine. The main method of restoration of the normal morphology and function of the nerve cells after degenerative changes is evidently by intracellular regneration.

KEY WORDS: intramural nervous plexuses; morphometry; resection.

Data on the morphological changes in nervous structures of the damaged small intestine are few in number and mainly descriptive in character [1, 2]. Most investigtors have not described the state of the submucous nervous plexus of the small intestine after injury, whereas others have stated that compared with the severe changes observed in neurons of the intermuscular plexus, the changes in the submucous plexus are slight [5, 7]. It must also be pointed out that information on the possible compensatory and adaptive processes in the nerve cells is contradictory. Some workers [2, 4, 6] have described division of nerve cells in one way or another whereas others [3, 9, 10] totally deny that mature neurons of autonomic ganglia are capable of proliferation.

The object of this investigation was to assess quantitatively the state of the intramural nervous plexuses of the resected small intestine during the development of compensatory and adaptive processes in the organ and to compare changes taking place in the nerve cells of the two plexuses.

EXPERIMENTAL METHOD

Experiments were carried out on sexually mature cats weighing 2500-3500 g. In the experimental animals 50% of the small intestine was resected in its middle part. The divided ends of the remaining intestine were anastomosed side-to-side. No operation was performed on the control animals. All the animals were killed 7, 14, and 21 days and 1, 3, 6, and 18 months after the operation. Pieces of small intestine in the part proximal to the anastomosis were taken after sacrifice for histological examination and fixed in 12% neutral formalin and 96° ethanol. After fixation, total preparations were made of the intermuscular and submucous plexuses from the pieces of tissue and stained by the Bielschowsky–Gros and Nissl methods. To determine the state of the nerve cells, the area of the neurons and of their nuclei and nucleoli was measured and the number of pathologically changed neurons (in 100 cells) and the total number of cells were counted. All measurements for determining area were made by photographing the nerve cells, tracing their outlines on paper, and weighing. After appropriate calculations the true value of the above-mentioned parameters was determined in square microns. The numerical results were subjected to statistical anaysis by the Fisher–Student method.

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TABLE 1. Changes in Area of Nerve Cells, Their Nuclei, and Nucleoli of the Intermuscular Plexus of the Small Intestine at Various Times after Operation

Time of observation	Group of animals	Mean (M) area (in μ^2)					
		of cell	P	of nucleus	P	of nucleolus	P
7 days	Experimental	1518,0	0,002	119,0	0,023	9,0	0,128
	Control	1719,0		129,0		11,0	
14 days	Experimental	1531,0	0,043	87,0	0,001	11,0	0,394
	Control	1614,0		122,0		10,0	
21 days	Experimental	1788,0	0,565	113,0	0,002	12,0	1,000
	Control	1779,0		140,0		12,0	
1 month	Experimental	2789,0	0,000	151,0	0,002	8,0	0,017
	Control	1613,0		129,0		12,0	
3 months	Experimental	1888,0	0,002	158,0	0,001	16,0	0,110
	Control	1607,0		140,0		12,0	
6 months	Experimental	1778,0		120,0	0,631	5,0	0,000
	Control	1658,0	0,002	123,0		11,0	
	Experimental	1707,0		114,0		8,0	
18 months	Control	1746,0	0,347	139,0	0,050	14,0	0,000

TABLE 2. Changes in Area of Nerve Cells, Their Nuclei, and Nucleoli of the Submucous Plexus of the Small Intestine at Various Times after Operation

Time of observation	Group of animals	Mean (M) area (in μ^2)					
		of cell	P	of nucleus	P	of nucleolus	P
7 days	Experimental	1197,0	0,001	110,0	0,000	18,0	0,023
	Control	1346,0		88,0		13,0	
14 days	Experimental	1214,0	0,001	79,0	0,000	9,0	0,003
	Control	1360,0		106,0		13,0	
21 days	Experimental	1250,0	0,001	93,0	0,001	13,0	0,081
	Control	1320,0		110,0		15,0	
1 month	Experimental	1131,0	0,000	136,0	0,001	16,0	0,059
	Control	1338,0		115,0		14,0	
3 months	Experimental	1375,0	0,027	112,0	0,017	15,0	0,374
	Control	1329,0		101,0		14,0	
6 months	Experimental	1184,0	0,001	88,0	0,001	9,0	0,037
	Control	1316,0		106,0		13,0	
18 months	Experimental	1092,0	0,000	108,0	0,128	9,0	0,008
	Control	1346,0		114,0		14,0	

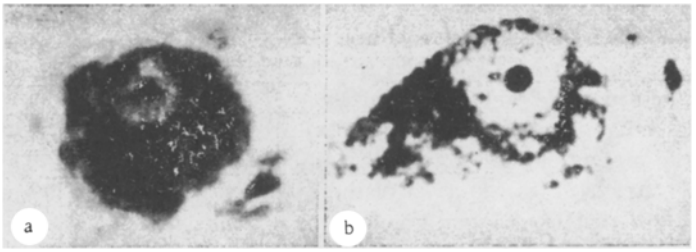

Fig. 1. Nerve cells of intermuscular plexus of proximal part of small intestine under normal conditions (a) and 7 days after operation (b). Perinuclear chromatolysis can be seen. Methylene blue, 1000 ×.

EXPERIMENTAL RESULTS

Three stages could be distinguished in the development of morphological changes in the nerve cells of the resected small intestine: the first until 1 month after the operation, the second from 1 to 3 months, and the third – the remainder (3-18 months).

During the first period, degenerative changes were observed in the nerve cells of both plexuses, and they were progressive until the end of the first month. The area of a neuron of the intermuscular plexus was reduced by 12% 7 days after the operation and by 5% on the 14th day ($P = 0.043$). Vacuolation and chromatolysis developed gradually in the nerve cells during this period (Fig. 1).

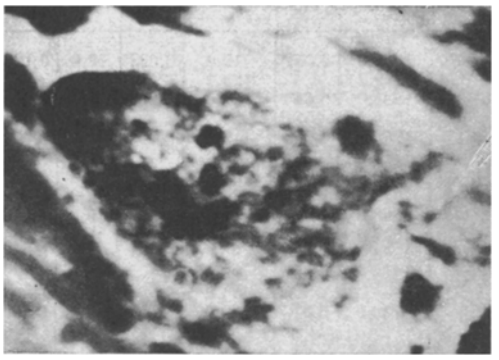

Fig. 2. Nerve cell of intermuscular plexus of proximal part of small intestine 3 months after operation. Two nucleoli are visbile in the nucleus. Methylene blue, 1000 ×.

The area of the nucleus in cells of the intermuscular plexus in this part of the intestine was reduced by 8% on the seventh day and by 28-19% from 14 to 21 days after the operation. The area of the nucleolus in these neurons was reduced only at the end of the first month of the operation (by 33%, P = 0.07; Table 1).

The number of pathologically changed cells was 89% greater than in the control by the seventh day of the experiment, 4-5 times greater on the 14th day, 5-7 times 21 days after the operation, and 4 times greater at the end of the first month. The total number of nerve cells in the ganglia decreased gradually (after the 21st day of the experiment). After 30 days it was 25% smaller than in the control (as a result of death of some neurons).

The area of a neuron in the submucous plexus of the small intestine was reduced by 6-14% 7-30 days after the operation whereas the area of a nucleus was reduced by 25-29% compared with the control after 14-21 days. At this time the area of the nucleolus also was reduced by 13-30% (Table 2).

In the second stage of the experiment the area of the nerve cells and of thei nuclei and nucleoli in both plexuses increased gradually, so that by the third month the values obtained were close to the controls or actually higher. The quantity of basophilic material was increased and it was uniformly distributed among the cytoplasm; the number of nucleoli also was increased (Fig. 2). No neurons dividing by mitosis could be observed.

Despite some restoration of the normal structure of the nerve cells in the resected small intestine, no permanent improvement in their state took place. In the third stage degenerative changes appeared in the nerve cells of both plexuses: vacuolation, chromatolysis, fragmentation of nerve fibers, lysis of the nuclear membrane, and so on, and these progressed in the course of time.

The results thus showed that complex morphological changes, phasic in character, take place in the nervous plexuses of the small intestine after hemiresection. Neurons of both the intermuscular and the submucous plexuses respond similarly in the various stages of the compensatory and adaptive changes in the residual intestine. The chief method of restoration of the normal morphology and function of the residual part of the intestine after development of degenerative changes is evidently by intracellular regeneration [8].

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