

EFFECT OF PARTIAL RESECTION OF THE STOMACH  
ON SEROTONIN AND ENTEROCHROMAFFIN CELLS  
OF THE SMALL INTESTINE IN DOGS

R. P. Lebedeva and N. N. Lebedev

UDC 616.33-089.87-092.9-07:616.  
341-008.937.5

Resection of the stomach is followed by changes in the distribution of serotonin and in the state of the enterochromaffin cells along the length of the small intestine.

Many facts have been obtained to indicate the important role of serotonin in the onset of the dumping syndrome and of the successful use of antiserotonin preparations for its prevention and treatment [3, 7, 10-12].

In view of the substantial changes in the deposition of endogenous serotonin when the integrity of the intramural apparatus of the intestine is disturbed [1], it was decided to investigate the distribution of serotonin in the small intestine and to compare it with histochemical changes in the enterochromaffin cells in dogs under normal conditions and after resection of the stomach.

EXPERIMENTAL METHOD

Experiments were carried out on 12 adult dogs weighing 12-16 kg: four intact control animals and eight animals undergoing resection of two-thirds of the stomach by the Hofmeister-Finsterer modification of the Billroth II technique. Pieces of tissue were excised from six areas of the small intestine of each animal, and in them the serotonin concentration was determined by a biological method and the enterochromaffin system was investigated histochemically.

The number of enterochromaffin cells was counted in 5-mm sections stained by the Masson-Hamperl method; the granulation index and saturation index were calculated [8].

EXPERIMENTAL RESULTS AND DISCUSSION

In the control dogs the highest serotonin concentration was observed in the duodenum and proximal part of the jejunum (Table 1). The serotonin concentration in the tissues of the middle part of the small intestine was on the average 71-72% of its level in the duodenum. In the ileum and its terminal portion the serotonin concentration was much closer to that in the duodenum. The distribution of serotonin along the small intestine of healthy dogs in a state of physiological starvation is thus described by a curve with maxima in the proximal and distal portions and a minimum in the middle portion. The cytometric indices showed a similar distribution. A positive correlation was found between the serotonin concentration in the various parts of the small intestine and the histochemical reactions of cells of the enterochromaffin system in the same areas (+0.95;  $P < 0.01$ ).

---

Laboratory of Physiology and Pathology of Digestion, Institute of Normal and Pathological Physiology, Academy of Medical Sciences of the USSR, Moscow. (Presented by Academician V. V. Parin [deceased].) Translated from *Byulleten' Éksperimental'noi Biologii i Meditsiny*, Vol. 73, No. 2, pp. 30-32, February, 1972. Original article submitted May 3, 1971.

© 1972 Consultants Bureau, a division of Plenum Publishing Corporation, 227 West 17th Street, New York, N. Y. 10011. All rights reserved. This article cannot be reproduced for any purpose whatsoever without permission of the publisher. A copy of this article is available from the publisher for \$15.00.

TABLE 1. Changes in Serotonin Concentration and State of Cells of Enterochromaffin System in Small Intestine after Partial Resection of the Stomach

Tissues	Serotonin concentration in tissues				Granulation index			
	control	after resection of stomach		after 12 months	control	after resection of stomach		after 12 months
		after 3 months	after 6 months			after 3 months	after 6 months	
Duodenum	5,80±0,31	8,96±0,36	8,35±0,38	7,40±0,35	379±43,8	519±36,8	416±14,6	655±72
Proximal part of jejunum	4,85±0,31	8,15±0,41	7,26±0,40	6,30±0,42	213±17,3	411±45,6	332±15,7	358±24
Middle part of small intestine:								
proximal	4,20±0,33	7,50±0,43	6,35±0,45	5,80±0,30	140±8,6	391±39,7	250±23,3	266±23
distal	4,15±0,31	7,20±0,41	5,29±0,29	5,10±0,18	121±10,2	398±61,0	177±15,6	310±46
Ileum	4,82±0,41	7,42±0,38	5,45±0,35	5,70±0,30	243±27,0	396±84,0	349±30,8	476±35
Terminal ileum	5,48±0,44	7,50±0,41	6,37±0,32	6,00±0,28	263±29,6	530±54,0	530±43,0	590±53
(continued)								
Tissues	Saturation index				Number of enterochromaffin cells			
	control	after resection of stomach		after 12 months	control	after resection of stomach		after 12 months
		after 3 months	after 6 months			after 3 months	after 6 months	
Duodenum	3,35±0,098	3,23±0,04	3,33±0,145	3,21±0,046	119±10,0	150±9,8	126±9,8	204±24,5
Proximal part of jejunum	2,91±0,145	3,33±0,057	3,20±0,07	2,84±0,065	76±7,8	114±12,8	118±7,6	126±9,0
Middle part of small intestine:								
proximal	2,79±0,122	3,42±0,075	2,99±0,06	2,69±0,071	51±3,2	116±13,8	83±6,6	98,1±7,6
distal	2,72±0,111	3,32±0,03	2,97±0,04	2,93±0,100	45±3,7	121±15,8	64±4,4	104±14,0
Ileum	2,99±0,107	3,36±0,09	3,09±0,12	3,24±0,070	82±9,4	131±25,5	112±6,1	150±9,0
Terminal ileum	3,21±0,116	3,42±0,06	3,57±0,103	3,42±0,042	84±6,7	153±17,0	150±12,8	158±12,7

The serotonin concentration in the tissues of the small intestine throughout its length was increased on the average by 50-70% three months after the operation. A particularly marked increase was observed in the middle portion. As a result the serotonin distribution along the length of the small intestine was more uniform in character. Six months after resection of the stomach the serotonin concentration in the small intestine still remained increased, although rather less so than at the preceding investigation. After 12 months the serotonin concentration was further reduced but was still above the control level. At this time the curve of serotonin distribution along the intestine was closer to the control pattern.

Three months after resection of the stomach there was a marked increase in histochemical activity of the cells in all parts of the small intestine, and this persisted at subsequent periods. After 12 months the granulation index in the duodenum and terminal ileum was much higher than in the earlier periods of the investigation, probably due to hypertrophy of the mucous membrane in the intestine which had developed at this period.

A gradient of deposition of endogenous serotonin thus exists in the small intestine. This gradient bears a definite relationship to the gradients of distribution of other biologically active substances (secretin, acetylcholine) and with the gradients of reception and reactivity of the intestine [1, 5, 6, 9]. The character of the serotonin distribution curve suggests that it is connected in some way with the structural pattern of the intramural nervous system of the small intestine and, in particular, with the distribution of Dogiel's type I and II cells along its length [2, 4]. It can accordingly be postulated that the cells of the enterochromaffin system (the endocrine apparatus of the intestine) are under the constant control of the parasympathetic nervous system, mediated through the intramural nervous apparatus. This hypothesis also explains the mechanism of the considerable and prolonged changes in serotonin level and, simultaneously, in the functional state of the enterochromaffin system after resection of the stomach accompanied by disturbances of the integrity of the intestinal nervous apparatus. The dynamics of the serotonin concentration after resection of the stomach (a tendency for restoration of the normal levels in the later stages) would, in fact, appear to suggest that the changes discovered are the direct consequence of operative trauma. However, in this case the greatest changes in the serotonin level would be expected in those parts of the intestine which were most severely traumatized: the duodenum and the jejunum (in the region of the gastroenterostomy), but this was not observed. Consequently, the only possibility which remains is that the changes in the serotonin concentration after operation were due to postoperative changes in the functional state of the intestinal intramural nervous system. The results thus demonstrate the close connection and interaction between the regulatory and trophic mechanisms of functional reorganization of the digestive system after resection of the stomach.

#### LITERATURE CITED

1. G. M. Isakhanov and N. N. Lebedev, in: *Proceedings of the 16th Scientific Conference of Physiologists of the South of the RSFSR with the Participation of Biochemists and Pharmacologists* [in Russian], Ordzhonikidze (1967), p. 152.
2. N. G. Kolosov, *Innervation of the Human Digestive Tract* [in Russian], Moscow-Leningrad (1962).
3. M. I. Kuzin, *Khirurgiya*, No. 6, 120 (1969).
4. B. I. Lavrent'ev, in: *Morphology of the Autonomic Nervous System* [in Russian], Moscow (1946), p. 13.
5. V. A. Lebedeva, *Byull. Éksperim. Biol. i Med.*, 27, No. 4, 274 (1949).
6. V. A. Muzykantov, *Byull. Éksperim. Biol. i Med.*, 15, No. 3, 48 (1943).
7. L. V. Povar, *The Pathogenesis of the Dumping Syndrome: Clinical and Experimental Study of the Role of Serotonin*, Author's Abstract of Candidate's Dissertation, Perm' (1967).
8. V. I. Talapin, *Tsitologiya*, No. 1, 86 (1964).
9. W. C. Alvarez, *An Introduction to Gastro-Enterology*, New York (1949).
10. T. Drapanas and J. C. McDonald, *Surg., Gynec. Obstet.*, 116, 481 (1963).
11. L. P. Johnson, R. D. Sloop and J. E. Jesseph, *Ann. Surg.*, 156, 537 (1962).
12. G. W. Peskin and L. D. Miller, *Arch. Surg.*, 85, 701 (1962).