DIFFERENCES IN THE CHEMICAL COMPOSITION OF THE MUCOUS MEMBRANES OF THE BODY AND PYLORUS OF THE STOMACH

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Acute experiments performed on 24 fasting dogs anesthetized with morphine and hexobarbital showed that the concentrations of glycogen, nonesterified fatty acids, and inorganic phosphorus differ in the mucous membranes of the body and pyloric portion of the stomach. In the mucous membrane of the body of the stomach there is a higher content of total lipids (by 56.5%), phospholipids (by 69.6%), ATP (50.0%), ADP (by 20.7%), and AMP (by 36.8%) than in the mucous membrane of the pylorus. Lipids perhaps play an important role as sources of energy for hydrochloric acid formation.

The secretory zones of the stomach differ in their structure and function. In the mucous membrane of the pyloric portion of the stomach there are very few oxyntic cells and no peptic cells, the juice of the pyloric glands is alkaline in reaction, and its pepsinogen concentration is 4 times less than in juice from the fundal portion or body of the stomach [2, 11]. Differences in the secretory function of the pyloric glands are based on differences in their chemical composition and metabolism.

This paper describes the results of a determination of the concentration of glycogen, total lipids, phospholipids, nonesterified free fatty acids (NEFA), adenine nucleotides (ATP, ADP, AMP), creatine phosphate, and inorganic phosphorus in the mucous membrane of the body and pyloric portion of the stomach.

EXPERIMENTAL METHOD

Experiments were carried out on 24 dogs anesthetized with morphine (3 mg/kg, subcutaneously) and hexobarbital (35 mg/kg, intraperitoneally). The animals were deprived of food for 20 h before the experiments. After laparotomy the anterior wall of the body and pyloric part of the stomach was resected, the mucous membrane was quickly stripped, and the concentrations of the following substances in it were determined: glycogen by the anthrone method [7], total lipids by the turbidimetric method [9], phospholipids by Bloor's method [8], NEFA by the method of Shaternikov and Savchuk [10], adenine nucleotides by the method of Sato et al. [18], creatine phosphate as creatine [1], and inorganic phosphorus by Delory's method in Grigor'eva's modification [3].

In view of reports that the area of spread of the pyloric glands is variable [15], the precise structure of the mucous membrane was determined by histological methods (staining with hematoxylin-eosin and by Van Gieson's method).

The numerical results were subjected to statistical analysis and differences were evaluated by the use of Wilcoxon's nonparametric criterion [4].

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TABLE 1. Concentration of Total Lipids (in percent), Phospholipids (in mg% P), and NEFA (in mg%) in Mucous Membrane of Body and Pyloric Division of Stomach (M ± m)

Part of stomach	Total lipids	Phospholipids	NEFA
Mucous membrane of body	3,37±0,38 (9)	69,2±6,5 (7)	4,36±0,43 (9)
Mucous membrane of pyloric division	2,15±0,47 (9)	40,8±6,5 (7)	4,75±0,59 (9)

Note. Here and in Table 2 number of animals shown in parentheses.

TABLE 2. Concentration of Adenine Nucleotides (in μmoles/g moist tissue), Creatine Phosphate (in mg%), and Inorganic Phosphorus (in mg%) in Mucous Membrane of Body and Pyloric Division of Stomach (M ± m)

Part of stomach	ATP	ADP	AMP	Total adenine nucleotides	Creatine phosphate	Inorganic phosphorus
Mucous membrane of body	1,35±0,17 (8)	0,64±0,12 (8)	0,26±0,03 (8)	2,25±0,21 (8)	14,9±1,4 (8)	3,14±0,61 (7)
Mucous membrane of pyloric division	0,90±0,13 (8)	0,53±0,10 (8)	0,19±0,03 (8)	1,65±0,22 (8)	14,1±1,4 (7)	3,50±0,97 (6)

The glycogen concentration in the mucous membrane of the body and pyloric division of the stomach was almost identical (198.5 ±31.6 and 193.5 ±32.4 mg%).

EXPERIMENTAL RESULTS

The concentration of total lipids in the mucous membrane of the body of the stomach was 56.5% higher ($P < 0.05$), and that of phospholipids 69.6% higher ($P < 0.05$) than in the mucous membrane of the pyloric division (Table 1). The NEFA concentration in the mucous membrane of these parts of the stomach was the same.

The concentration of ATP was 50% higher, ADP 20.7% higher, and AMP 36.8% higher in the mucous membrane of the body of the stomach than in the pyloric division (Table 2). The total concentration of adenine nucleotides in the mucous membrane of the body was 39% higher than their total concentration in the mucous membrane of the pyloric division (differences statistically significant).

The relative proportion of the individual components of the adenine nucleotides in the body of the stomach were ATP 60%, ADP 28.4%, and AMP 11.6%, and in the pyloric division ATP 55.6%, ADP 32.7%, and AMP 11.7%. The ATP/ADP ratio in the mucous membrane was 2.1 (body of the stomach) and 1.7 (pyloric division).

The results of these experiments thus show that the glycogen concentration is the same in the mucous membranes of the body and pyloric part of the stomach. The sugar composition of these portions of the stomach is also identical [19]. An anaerobic type of metabolism is predominant [17] in the mucous membrane of the pyloric division, but an aerobic type in the mucous membrane of the body of the stomach [17]. The concentrations of lipids, adenine nucleotides, and creatine phosphate are higher in the mucous membrane of the body of the stomach than in that of its pyloric division. During histamine-induced secretion the concentration of lipids in the mucous membrane of the body of the stomach falls [5].

Hydrochloric acid formation is known to require considerable expenditure of energy, and the oxyntic cells belong to the group of body cells with the highest intensity of metabolism [13]. In tissues requiring a considerable quantity of energy (myocardium, kidneys, skeletal muscles during prolonged and sustained work) the role of lipids increases in importance, for on oxidation they liberate far more energy than carbohydrates [12, 14].

The study of the distribution of lipids in different structures of the mucous membrane of the body of the stomach has shown that lipids are concentrated chiefly in the oxyntic cells [6], and it is in these cells that the highest activity of many dehydrogenases, ATPase, and DPN and TPN-diaphorases is observed [16, 20].

The higher concentration of lipids in the mucous membrane of the body of the stomach (than in the pylorus, where there are hardly any oxyntic cells), the decrease in the lipid concentration in the mucous membrane of the body of the stomach during histamine-induced secretion, and the localization of lipids predominantly in the cytoplasm of the oxyntic cells all suggest that they play an essential role in the production of energy required for hydrochloric acid formation.

LITERATURE CITED

1. A. M. Alekseeva, Biokhimiya, No. 2, 243 (1956).
2. B. P. Babkin, The Secretory Mechanism of the Digestive Glands [in Russian], Moscow (1960).
3. V. A. Grigor'eva, Ukr. Biokhim. Zh., 23, 203 (1951).
4. G. F. Lakin, Biometrics [in Russian], Moscow (1968).
5. D. G. Nalivaiko, Abstracts of Sectional Proceedings of the 2nd All-Union Biochemical Congress. Section 10 [in Russian], Tashkent (1969), p. 88.
6. D. G. Nalivaiko and E. M. Tantsyura, Fiziol. Zh. (Ukr.), 17, 472 (1971).
7. M. I. Prokhorova and Z. N. Tupikova, Large Textbook of Practical Carbohydrate and Lipid Metabolism [in Russian], Leningrad (1965), p. 56.
8. O. V. Travina, Textbooks of Biochemical Investigations [in Russian], Moscow (1955), p. 236.
9. V. A. Shaternikov and I. L. Odintsov, Sov. Med., No. 8, 117 (1964).
10. A. I. Shaternikov and L. A. Savchuk, Lab. Delo, No. 10, 598 (1964).
11. A. I. Shemyakin, The Physiology of the Pyloric Part of the Dog's Stomach, Dissertation, St. Petersburg (1901).
12. M. Barac-Nieto and J. Cohen, Am. J. Physiol., 215, 98 (1968).
13. E. E. Crane and R. E. Davies, Biochem. J., 49, 169 (1951).
14. M. Gold and J. J. Spitzer, Am. J. Physiol., 206, 154 (1964).
15. P. J. Kenny, Med. J. Aust., 2, 45 (1968).
16. H. T. Planteydt and R. G. Willighagen, J. Path., 80, 317 (1960).
17. B. Prochaza et al., Gastroenterology, 54, 60 (1968).
18. T. R. Sato, J. F. Thomson, and W. T. Danforth, Analytic Biochem., 5, 542 (1963).
19. J. Schrager and M. D. Oates, Biochem. J., 106, 523 (1969).
20. G. L. Stoffels, W. Gepts, and J. J. Desneux, Gut, 7, 624 (1966).