ON THE EXCRETORY FUNCTION OF THE STOMACH

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The excretory function of the stomach is the least studied of all its many different physiological functions.

Researchers from the I. P. Razenkov Laboratory [2, 3, 6, 7, 10] and the M. P. Konchalovsky [4, 8] and R. A. Luriya [1, 5, 9] Clinics have shown the importance and role of the gastrointestinal tract in the excretion processes.

The excretory function of the stomach is most evident and most intense during kidney diseases and other diseases where the body is threatened by the accumulation in the blood and organs of waste substances which are sometimes extremely toxic.

It has also been experimentally shown that artificial increase of these or other substances in the blood is attended by an intensified excretion of them in the stomach.

The purpose of our work was to find whether the excretory function is separate and independent of gastric secretion or if secretion and excretion is a single and united function of the gastric glands.

EXPERIMENTAL METHODS

The experiments were conducted on healthy dogs of about the same age and weight (12-15 kg) with a permanent Basov fistula (10 dogs) or with a Pavlov pouch (2 dogs).

The excretory function was studied on an empty stomach during the action of a food stimulus (meat bouillon) and histamine. To evaluate the excretory function, the dynamics of gastric gland excretion of urea, ammonia and neutral red dye (chromoscopy method) was studied.

Ammonia was determined by Conway's method, urea by the urease method. The animals were kept on a fixed food ration during the whole observation period. The gastric contents were examined for five hours after each hour.

After a "background" excretion of the above products had been established, the animals were intravenously injected with 5-10 ml of 50% urea, prepared in a physiological solution (0.2-0.4 g of urea per 1 kg of animal weight). Neutral red was injected intramuscularly. The threshold concentration of neutral red in the blood, with which the dye, regardless of gastric gland secretion, begins to be excreted by the mucous membrane, can be attained with a 4 ml injection of a 1% (40 mg), freshly prepared, solution of neutral red. The rate of neutral red dye excretion was determined by the time from the moment of parenteral injection to its appearance in the stomach contents.

Neutral red dye concentration in the gastric contents was determined colorimetrically.

The gastric contents were collected through a fistula tube for 4-6 hours, and the amount calculated every 15 minutes. If the contents of the duodenum were observed to reflux into the stomach, examination ceased.

EXPERIMENTAL RESULTS

The stomach began to excrete neutral red dye 5-10 minutes after the dye had been intramuscularly injected. The concentration of the dye in the stomach increased rapidly, reaching maximum concentration (3-4 mg%) after 30-45 minutes. The duration of the excretory period varied in different dogs from 3 hours, 30 minutes to 5 hours. In individual experiments, fluctuations in the excretory process were observed in some dogs, but they were weakly expressed (Table 1). As the amount of dye injected increased, its concentration in the blood increased, and the period of excretion became longer. One such curve for gastric dye excretion is shown in Fig. 1. The maximal concentration of dye in this experiment (3 mg%) was observed $^3/_4$ of an hour after the beginning of excretion. Then the amount of dye excreted began to decrease, and, after 5 hours, only traces of dye could be found in the gastric contents. The total amount of dye excreted was 691γ.

TABLE 1

Neutral Red Dye Excretion by the Gastric Glands on an Empty Stomach

Name of animal	Time in minutes of dye appearance	Time in minutes of maximal dye concentration appearance	Maximal concentration in mg%	Total amount of dye excreted in γ	Total amount of gastric contents in ml	Duration of dye excretion
Ryzhukha	5	30	4.0	334	22.5	4 Hrs. 15 Min.
	8	15	3.0	360	18.0	4 "
Alma	10	45	2.0	322	25.0	3 " 30 "
	10	30	2.0	316	24.5	3 " 45 "
Pushok	5	45	2.0	611	44.5	4 " 30 "
	10	45	3.0	691	49.5	5 "
Bobik	10	30	2.0	408	35.5	3 " 30 "
	10	30	2.0	511	36.0	3 " 45 "
Ryzhik	5	30	2.0	540	<1.0	4 "
	5	15	2.0	508	36.5	4 "
Verny	5	30	3.0	367	26.5	4 " 30 "
	10	45	2.0	324	27.0	4 " 15 "

In the experiments studying the effect of the food stimulus and histamine on the excretory function, our purpose was to determine the changes in neutral red excretion during the intensified gastric secretion caused by a single feeding of the dog with meat bouillon (150-200 ml). The results of the experiment showed that the course of dye excretion did not change much during intensified gastric gland secretion. The latent period was unchanged. In separate experiments, excretion was prolonged 30-40 minutes. The dye concentration in the gastric contents hardly changed at all with the increased rate of secretion (almost double) (Table 2).

The dye concentration did not always depend on the amount of gastric juice secreted. A high concentration of the dye was observed both with a large and with a small amount of juice. This, of course, does not negate the fact that the total amount of the substance excreted depends on the amount of juice secreted.

With the parenteral injection of histamine (0.5-1 ml of a 0.1% solution), the excretion of dye with the gastric contents began 3-5 minutes after the injection, but its concentration in each batch did not increase. Under these conditions, the duration of the excretion period was lengthened an average of 15-30 minutes. The total amount of dye excreted increased 2-$2^1/_2$ times in comparison with the total amount of dye excreted on an empty stomach.

In the given case, the amount of dye increased due to the increase in the amount of gastric juice.

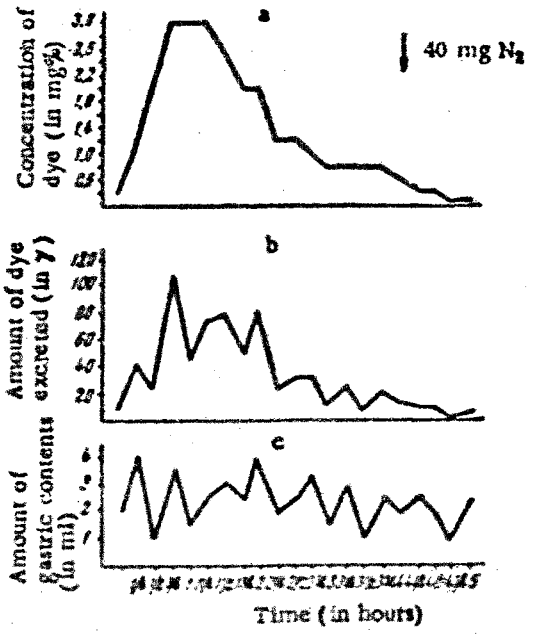

Fig. 1. Excretion of neutral red dye on an empty stomach in the dog Pushok.
a) Concentration of dye; b) amount of dye excreted; c) amount of gastric contents.

In the dogs with Pavlov pouches, the dye was not excreted from the Pavlov pouch on an empty stomach. Dye excretion occurred only after the food stimulus had been given. As in the preceding case, the dye appeared after 5 minutes; its maximal concentration did not exceed 1.8 mg%. The concentration of the dye decreased considerably more rapidly. One must note that dye excretion from the Pavlov pouch was less intensive than from the entire stomach. In this case, the Pavlov pouch evidently does not reflect the excretory function of the stomach as a whole.

According to the data in the literature, dye excretion is known to be mainly carried out by the glands of the pyloric region, and only when they cannot cope with the load do the glands of the fundal region of the stomach participate.

A series of typical patterns also appeared in the excretion of urea and ammonia by the gastric glands.

From 2.7-3.2 mg% of urea and from 6.8 to 7.5% of ammonia were found in the dog's gastric contents. Figure 2 shows the curve characterizing gastric gland excretion of urea and ammonia in a normal animal.

TABLE 2

Effect of Food Stimulus on Neutral Red Dye Excretion

Name of animal	Time in min. of dye appearance	Time in minutes of maximal dye concentration appearance	Maximal concentration in mg%	Total amount of dye excreted in γ	Total amount of gastric contents in ml	Duration of dye excretion
Alma	10	45	3	491	38.5	3 hrs. 30 min.
Bobik	7	15	1.8	608	62	4 hrs. 45 min.
	10	30	3	660	62.5	3 hrs. 45 min.
Pushok	5	30	3	2525	144.5	5 hrs.
	10	45	3	1100	99.5	4 hrs. 30 min.
Ryzhik	5	45	4	1115	75	5 hrs.
	5	30	3	1045	62.5	4 hrs. 45 min.
Sultan	5	45	1.6	692	87	4 hrs.
	5	30	1.6	645	70	4 hrs. 15 min.
Tarzan	5	15	1.6	1003	94	5 hrs.
	5	15	1.6	802	112.5	5 hrs.

Note: In the dogs Sultan and Tarzan – Pavlov pouch; in the other animals – Basov gastric fistula.

While in normal conditions, a small quantity of nitrogenous breakdown products is found in the gastric contents, with urea injected into the blood (0.2-0.4 g per 1 kg of animal weight), a considerable increase in the amount of urea and ammonia in the gastric contents is observed, and there is no doubt that they came from the blood. For example, with an intravenous injection of 5 ml of a 50% urea solution (0.2 g per 1 kg of weight), only a small increase in the concentration and quantity of urea and ammonia was observed. In a majority of cases (experiments on the dog Ryzhik), the maximal concentration of urea appeared during the 5th hour of

observation and consisted of 6.6-12.8mg%. Its concentration did not depend on the amount of gastric juice. A different concentration of urea was observed with the same amount of gastric contents. For example, during the 3rd hour of observation, 6 ml of contents was excreted, and the concentration of urea in the excretion was 6.6 mg%; during the 5th hour, the same amount was excreted, but the urea concentration was 4.3 mg%. Analogous data were obtained in the other experiments also. An average of 4.1 mg% of urea was found in the gastric contents.

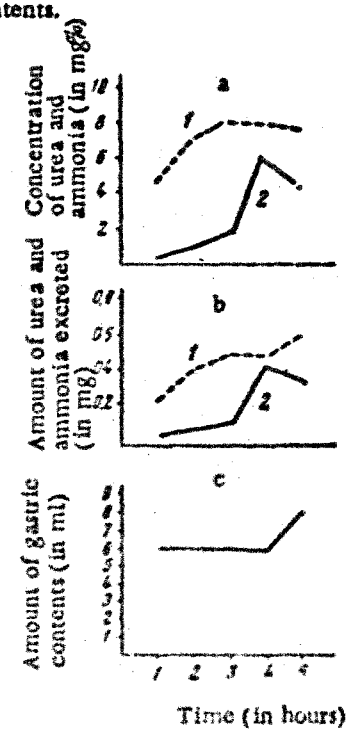

Fig. 2. Gastric excretion of urea and ammonia in the dog Ryzhik. a) Concentration of urea and ammonia; b) amount of urea and ammonia excreted; c) amount of gastric contents: 1) ammonia, 2) urea.

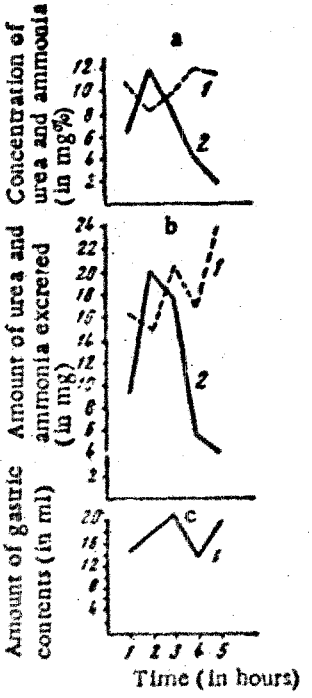

Fig. 3. Gastric excretion of urea and ammonia with supplementary urea injection in the dog Ryzhik, (0.4 g per 1 kg animal weight). Symbols are the same as in Fig. 2.

When 10 ml of a 50% solution of urea was injected into the body (0.4 g per kg of weight), a still greater increase in the concentration of urea was observed; in connection with this, the amount of urea excreted was $2^1/_2$ times the amount excreted in the experiments conducted without the additional urea injection.

The highest concentration was usually observed during the 2nd-3rd hour of observation.

A slightly different picture was observed when ammonia was excreted by the gastric glands. The experimental conditions were the same. When 5 ml of a 50% solution of urea was injected, the concentration of ammonia increased somewhat. The maximal ammonia concentration was from 8 to 15 mg% and appeared, as a rule, near the 5th hour of observation.

The concentration of the substance does not always depend on the amount of gastric juice. For example, in one experiment, 6 ml of juice was excreted with a 6.6 mg% concentration of ammonia during the first hour; during the fifth hour, the same amount of juice was excreted, but with a concentration of 8.0 mg%. Analogous results were obtained in the other experiments. With such a dose, the gastric juice contained 6.5-6.8 mg% of ammonia. When the dose was doubled, the amount of ammonia increased to several times that in the experiments done without the additional injection. The maximal concentration, in most cases, also appeared during the 3rd-4th hour of observation (see Fig. 3). When the injection was increased in the dog Ryzhik, there was about 10.5 mg% of ammonia in the gastric juice (without the additional injection, 6 mg%).

Therefore, with an injected dose of 0.2 g of urea per 1 kg of weight, the amount of urea (3.4-4.1 mg%) and of ammonia (6.5-8.3 mg%) increased. With double the injected quantity (0.4 per 1 kg of weight), a still greater increase in the substances was observed: the urea contained in the gastric juice was 4.5-6.8 mg%, and the ammonia – 10.5-11 mg%.

From our studies, we suggest that the excretory function of the stomach does not depend directly on the secretory function.

Both these functions are closely related, as are all of the gastric functions, but they are independent processes which can proceed simultaneously, or, on the other hand, can change to a known degree independently of each other.

We could not establish any definite dependency of urea, ammonia and neutral red dye excretion on the intensity of gastric secretion. High and low concentrations of these substances can be observed during both increased and decreased gastric juice secretion.

When secretion is intensified, which occurred due to the meat bouillon or the histamine, the amount of gastric juice increases, but the concentration of the substances, as a rule, does not increase. This, of course, does not exclude the dependency of the amount of substance excreted on the amount of gastric juice secreted.

The main general pattern we observed in all of our experiments was that the amount of different substances excreted by the mucous membrane of the stomach principally depends on the concentration of the given substance in the blood.

The rules we observed for urea, ammonia and neutral red dye excretion should not, however, be applied to the excretion of all foreign substances from the blood, as others may be toxic to the stomach wall and may act specifically on its glandular elements.

SUMMARY

The effect of food and histamine on the dynamics of gastric excretion of urea, ammonia and neutral red dye was studied in ten dogs with permanent Basov fistulae, and two dogs with Pavlov pouches. No correlation between the excretion of urea, ammonia, neutral red dye and the intensification of gastric secretion was noted. The amount of substances excreted by the stomach depended mainly on their concentration in the blood.

LITERATURE CITED

[1] Ya. I. Daikhovsky and M. G. Solovei, Terap. Arkh., 1934, Vol. 12, No. 1, pp. 40-51.

[2] K. S. Zamychkina and E. I. Andreeva, Byull. Eksptl. Biol. i Med., 1938, Vol. 6, No. 4, pp. 466-471.

[3] K. S. Zamychkina, and E. I. Andreeva, Fiziol. USSR, 1939, Vol. 26, No. 1, pp. 33-37.

[4] M. P. Konchalovsky, in the book: Works of the 12th All-Union Conference of Therapeutists,* Moscow-Leningrad, 1940, pp. 154-166.

[5] R. A. Luriya, Klin. Med., 1939, Vol. 17, No. 4, pp. 6-14.

[6] I. P. Razenkov, New Data on the Physiology and Pathology of Digestion,* Lecture Moscow, 1948, pp. 240-317.

[7] V. M. Rubel, Material on the Nitrogenous Substances of Gastric and Intestinal Juices in Normal and Pathological Conditions,* Dissertation, Moscow, 1947.

[8] V. N. Smotrov, A. Ya. Zelmanovich, and others, Terap. Arkh., 1936, Vol. 14, No. 4, pp. 527-541.

[9] M. G. Solovei, The Stomach and Kidneys,* Clinical experimental study of the excretory function of the Stomach,* Moscow-Leningrad, 1940.

[10] L. M. Khazen, Byull. Eksptl. Biol. i Med., 1940, Vol. 9, No. 5, pp. 365-367.

* In Russian.