THE CONTRIBUTION OF DIFFERENT RECEPTOR AREAS OF THE GASTROINTESTINAL TRACT TO REFLEX CONTROL OF RENAL FUNCTION

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Previously [8], we have demonstrated the extent to which the renal nerves are concerned in the continuous and direct control of filtration, resorption, and secretion. It is important to follow up this work by finding what determines the excitability of the renal nerves at any given moment.

In many recent works [3, 7, 9, 10, 11, 12] dealing with the physiology of the kidney, it has been found that a change in diuresis occurs on stimulating receptor areas of the gastrointestinal tract.

In the present work, we have set out to determine as precisely as possible the contribution of the different receptor fields of the gastrointestinal tract to reflex control of renal function.

METHOD

Usually, two methods are used to determine the nature and the extent of the reflex control of one organ by another: one is to increase or to reduce the control, and the other is to eliminate it.

In order to increase the influence on the kidneys exerted by receptors of the gastrointestinal tract, we produced a moderate, almost natural stimulation of these receptors by irrigating the mucous membrane with water, physiological saline, weak sodium carbonate solution, or with hydrochloric acid.

To reduce the effects of gastrointestinal tract receptors, we applied novocain to the mucous membrane, and in experiments with a water load, we introduced the water directly into one section or another of the tract by passing the higher sections. In this way we made the experimental conditions as close as possible to normal.

The experiments were carried out on 6 dogs, and of these 3 had ureteric fistulas and fistulas of various parts of the digestive tract, while the remaining 3 had isolated intestinal loops in various parts, made by the methods of Thiry-Vella, Pavlov, Shepoval'nikov, as well as fistulas of the ureters and various sections of the intestine.

RESULTS

Gastric interoceptor control of the kidneys was studied in animals with gastric, duodenal, and ureteric fistulas. Stimulation of the mucous membrane of the stomach was produced by gradually introducing 300-400 ml of water from the taps, heated to body temperature. The duodenal fistula was opened, and the amount of fluid passing out from it was measured at 10-minute intervals. The water from the stomach was voided in 20-30 minutes. In all these experiments, a considerably increased diuresis was observed (Fig. 1).

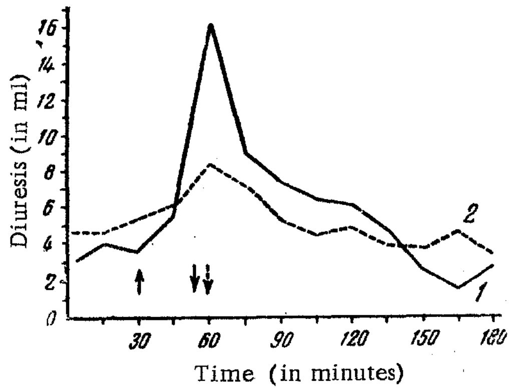

Fig. 1. Diuresis in the dog Pal'ma on irrigating the stomach with water (1) and physiological saline (2); onset (↑) and end (↓,↓) of irrigation.

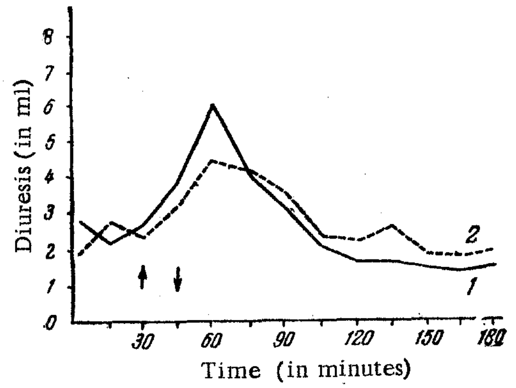

Fig. 2. Diuresis in the dog Volchitsy after irrigating an isolated Thiry-Vella loop of small intestine with water (1) and 0.2% solution of hydrochloric acid (2); onset (↑) and end (↓) of irrigation.

In order to determine what receptors are concerned in this reflex, experiments were carried out in which the mucous membrane of the stomach was irrigated with physiological saline, or with a solution of 1-0.5% sodium bicarbonate in physiological saline. Here, we aimed to act on certain receptors: water was intended to stimulate chiefly the osmo- and mechanoreceptors, while the physiological saline should stimulate mechanoreceptors, and the sodium bicarbonate solution the chemoceptors.

The experiments produced the intended results. Irrigating the stomach with physiological saline brought about an increased diuresis, though this was much less than when irrigating with water (see Fig. 1). In most cases, irrigating with sodium bicarbonate solution caused a greater diuresis than was elicited by physiological saline.

Further confirmation was obtained by experiments where, after measuring the spontaneous diuresis, the gastric mucous membrane was treated with a 2% solution of novocain, and 10 minutes later, the stomach was again irrigated with the fluid under test.

It was found that when the receptors were put out of action by novocain, gastric control of the kidney was eliminated, and the diuresis remained at the natural level.

Experiments in which intestinal interoceptor control of renal function was studied were carried out on animals with isolated loops of various sections of the intestine, and with ureteric fistulas.

To stimulate the mucous membrane of the isolated Thiry-Vella intestinal loop, or that of the gastric mucous membrane, water was introduced slowly through the length of intestine for 10-20 minutes. It passed out through the fistula at the caudal end to the outside.

In another set of experiments, a burette with a rubber tube was used to introduce water into the intestine, where it was kept under a constant pressure for 10-15 minutes. Irrigation of the mucous membrane of an isolated loop of small intestine always led to an increased diuresis.

The increase in the diuresis was more marked when irrigating isolated loops of jejunum than when equal lengths of ileum were used. No appreciable diuretic changes were observed in any experiment in which the large intestine was irrigated.

Irrigation of the mucous membrane of an isolated loop of the small intestine with physiological saline had no diuretic effect. Application of a 0.1-2% solution of hydrochloric acid in physiological saline caused a considerable increase of diuresis.

During the irrigation, 10-16 ml of fluid were absorbed. This amount, by itself, could not increase diuresis: if 10-16 ml of water, as a control, were introduced into the intestine through a fistula, no diuretic change resulted.

Application of a 2% solution of novocain to an isolated intestinal loop eliminated any reflex influence on the kidneys, and no diuretic changes were found. The amount of liquid absorbed in this case was the same as before (Fig. 2).

TABLE

Diuresis in the Dog Pal'ma after a Water Load of 300 ml

Conditions of experiment	Diuresis as a percentage of the amount of water introduced	
	during 1 hour	during 3 hours
Drinking water	42	86
Water introduced into stomach	38	83
" " " duodenum	35	78
" " " jejunum	27	66
" " " ileum	21	55
" " " large intestine	12	32

It is important to note that after treating the gastric or intestinal mucosa with novocain, there is a marked change, usually an increase, in the diuresis.

Quite possibly, the interoceptors of the gastrointestinal tract exert a constant influence on a renal control center and maintain its tone at a certain level.

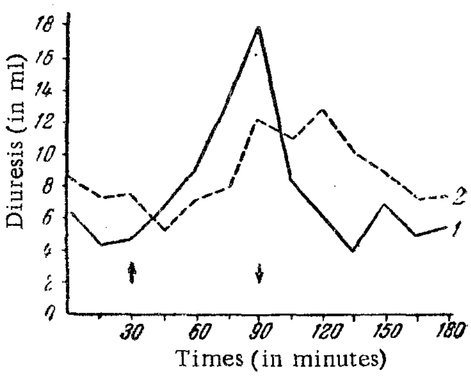

Fig. 3. Diuresis in the dog Chernushka on introducing water for 1 hour into an isolated Shepoval'nikov loop of small intestine (1-102 ml taken in); in curve (2) 250 ml of water are introduced into the large intestine; onset (↑) and end (↓) of irrigation.

Control by the interoceptors of various sections of the gastrointestinal tract was particularly well shown in experiments with a water load, where a comparison could be made of the type and the extent of the diuresis during drinking, and when introducing water through a fistula directly into the stomach, duodenum, jejunum, ileum, and large intestine.

In all cases, for a given initial level, the diuresis was less when the water was introduced into the lower section of the tract than when it entered the gut higher up. The more caudally the liquid was introduced, the less was the diuresis (see table).

It must be supposed that the more intense diuresis occurring when water is introduced into the upper section of the gut depends to a considerable extent on the summation of impulses passing to the nervous center from the superior and inferior sections, and conversely, the weak diuresis following the introduction of water into the hind-end of the gut is due to the cessation of impulses from the upper section.

Under these conditions, the extent of the diuresis is due to the different rates of absorption of fluid in the different sections of the tract.

To find whether this were so, a comparison was made of the diuresis following the introduction of water into an isolated 40 cm loop of small intestine with that caused by introducing the fluid into the large intestine.

Water was introduced into a loop of small intestine through a fistula for 1-1½ hours using a burette with a piece of rubber tubing attached. The liquid in the burette was maintained at a constant level. Under these conditions, after one hour, 100-120 ml of fluid was absorbed.

It was found that this water caused a more intense diuresis than when 200-250 ml were introduced through a fistula into the colon (Fig. 3). The increased diuresis in the first experiment occurred usually after 20 minutes, while in the second experiment it occurred 50 minutes after giving the water. Simultaneous introduction of physiological saline into the loop of small intestine caused no diuretic change.

After treating the mucosa of the isolated loop of small intestine with a novocain solution, when other conditions were kept constant, no increase in diuresis was obtained. Also, there was no change in the absorption of water.

From these results we may suppose that interoceptor control from the intestine plays an important part in stimulating diuresis, and that the small intestine plays a greater part than does the large.

No clear description has been published of the nature or importance of intestinal interoceptor control of diuresis. For example, K.M. Bykov [2], and later E.B. Berkhin [1], found that no appreciable diuretic change followed irrigation of the gastric mucosa with water. K.A. Chukin [12] found a reduced diuresis to follow application of water to the gastric mucosa, and this was later confirmed by N.N. Pronina and Ya.A. Al'tman [11], who, however, found that an increased diuresis occurred when water was introduced into the stomach through a fistula and then removed 1 minute later. A.A. Lebedev [7] irrigated the stomach with water and found a heightened diuresis, and that when the stomach was distended, the diuresis was reduced. N.A. Myasoedova [9, 10] showed that distension of the stomach and large intestine might cause a reduction of diuresis.

According to E.P. Kuchinskii [3], irrigating the stomach with a solution of peptone and sodium bicarbonate increases diuresis, while irrigating with hydrochloric acid solution reduces it.

Distending a loop of large intestine, in most cases causes a reduction in diuresis, while distension of the small intestine brings about an increase. In most cases, irrigation of the mucosa of the small intestine with a peptone solution increases diuresis during the stimulation, while a similar irrigation of the large intestine slightly reduces it.

These contradictory results are evidently due to the fact that the authors used methods of irrigation which failed entirely to reproduce natural conditions.

In our experiments, in which we stimulated the osmo-, chemo-, and mechanoreceptors of the gastric mucosa and the osmo- and chemoceptors of the small intestine with stimuli which were close in type and in form to normal, a marked diuresis was always obtained. In irrigating the mucosa of the large intestine with water, and a loop of small intestine with physiological saline, so as to stimulate preferentially the mechanoceptors, no appreciable change in diuresis was observed.

These results agree to some extent with those obtained in V.N. Chernigovskii and V.A. Lebedeva's laboratory [5, 6] concerning the receptor gradient of the digestive tract.

To conclude, we may suppose that the gastrointestinal tract constitutes a powerful reflexogenous zone for the stimulation of diuresis; the stomach, and especially the small intestine, are more concerned in this action than are the colon, cecum, and rectum. It is clear that, given an appropriate type and intensity of stimulus, these reflexogenous zones may exert the opposite effect.

SUMMARY

In assessing the role of different receptive fields of the gastrointestinal tract in the reflex regulation of the renal activity, the author studied the diuresis in polyfistular dogs by stimulating the mucous membrane of the stomach and different portions of the intestine before and after its treatment with a novocain solution. Changes of diuresis were also investigated by introducing water directly into various sections of the gastrointestinal tract and into an isolated intestinal loop (before and after the novocain solution treatment of the mucous membrane). The results demonstrated that the gastrointestinal tract is a powerful reflexogenous zone for the stimulation of diuresis. The stomach and the small intestine, especially its cranial portions, play a greater role in this respect than the large intestine.

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