RECEPTOR GRADIENT IN THE ALIMENTARY TRACT

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(Received June 6, 1955. Presented by V. N. Chernigovskii, Member of the Academy of Medical Sciences, USSR)

It has been shown by V. A. Lebedeva [3], in acute experiments on cats, that a receptor gradient exists in the alimentary tract. In this work the sensitivity of the receptors was derived from the rise in arterial blood pressure and from respiratory changes following stimulation of the stomach and gut.

The present paper describes chronic experiments on dogs, in which study of reflexes from the gastrointestinal tract was based on measurement of urine flow, instead of blood pressure as in Lebedeva's work.

The experiments were conducted on 6 dogs with ureteral fistulae. Various levels of the alimentary tract were studied in 105 experiments by measuring urine flow before, during, and after stimulation of baro- and chemo-receptors of the stomach and intestines.

Our experiments showed that stimulation of a particular receptor field of the alimentary tract of the same animal, applying qualitatively and quantitatively identical stimuli of equal duration, can give rise to quantitatively different or even opposite effects on different days.

Thus we found that the dog Zaika gave opposite responses to identical stimuli of the same strength and duration on different days. On June 26, 1950 stimulation of the gastric mucosa with a stream of air for 30 seconds raised urine flow to 300% of the initial value, whereas on June 29, 1950 the flow was reduced to 40% of the initial value.

It appears from our experiments that reversal of response also occurs with more prolonged stimulation. Stimulation of the gastric mucosa of the dog Nyaka with a stream of air on September 2, 1950, lasting for 15 minutes, resulted in profound (down to 25% of initial) and prolonged (60 minutes) lowering of urine flow, whereas identical stimulation of the dog Zaika on July 13,1950 lowered urine flow to only 83% of initial, with rapid recovery after cessation of stimulation; the same dog had responded to the same stimulation of July 11, 1950 with rapid and considerable increase in urine flow. The initial level of flow was almost the same in these experiments, viz., 0.5 ml on July 13, and 0.5-0.9 ml on July 11.

It is evident from these examples that under identical conditions of stimulation reflex responses may vary, evidently because of differences in the physiological state of the animals at the inception of the experiments. We found that gastric reflexes gave the most variable results; whether this variability is due to the unusual nature of the stimulus (a stream of air) or to the closer proximity of the stomach to the exterior, or to any other factors, is hard to say.

Chronic experiments involving mechanical and chemical stimulation of the jejunum and colon showed that here, too, deviations from the usual (most often encountered) type of response also occurred, although much less frequently than with the stomach. It is possible that this greater uniformity was due to the greater adequacy of the stimulus applied, viz., distension of the intestine by means of an inserted balloon.

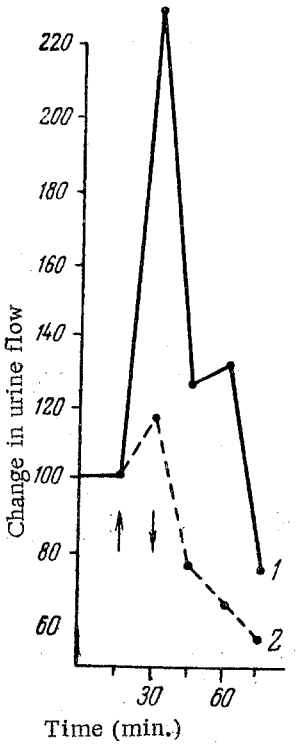

Fig. 1. Urine flow of the dog Damka, with a Thiry-Vella jejunal fistula and a Pavlov-Orbeli ureteral fistula, after distension of the gut at a pressure of 20 mm Hg. Curve 1: experiment of September 26, 1949, applying a pressure of 60 mm Hg. Curve 2: experiment of October 4, 1949.
↑↓ beginning and end of distension.

V. A. Lebedeva [3] took the rise in blood pressure only as a measure of the sensitivity of the receptors of various levels of the alimentary tract. With monophasic changes in function, such as were observed by her, such reasoning is justifiable. Our study of reflex secretory activity revealed a regularly diphasic response; one phase of change in urine flow was regularly succeeded by a second phase, in the reverse direction. Depending on a number of factors, the intensity of the phase of suppression or enhancement of flow varied. Different responses were given by one and the same dog to stimulation of the same receptor area, depending on the strength of the stimulus. More intense stimulation of the jejunum either caused a lowering of the response (Damka, Fig. 1), or a reversal of its direction as compared with weaker stimulation (shown by the dog Chernushka). It might be assumed that similar effects should be expected when stimuli of the same strength are applied to receptors of different sensitivity. One cannot therefore draw conclusions regarding the sensitivity of receptors from different parts of the alimentary tract solely on the basis of the rise in blood pressure following their stimulation. V. A. Lebedeva herself made the following observation: "a definite depressor reflex was noted in some of our experiments on distension of the duodenum. In others we were unable to register responses from the respiratory and vasomotor centers to even very intense stimulation" (1952).

We consider that these facts cannot be disregarded in analyzing mechanoceptor gradients in the alimentary tract. In any case, this type of response of blood pressure to mechanical stimulation of the duodenum does not allow one to conclude that the receptors of this organ are relatively insensitive to such stimulation, as is claimed by V. A. Lebedeva. It should be added that, according to N. A. Lapshin's observations, mechanical stimulation of the stomach, duodenum, and rectum of cats more frequently causes fall in blood pressure than does such stimulation of other sectors of the alimentary tract.

A. I. Ivanov [2] found, in acute experiments, that mechanical stimulation of the esophagus leads to depression, and of the stomach to increase, in blood pressure.

It thus appears that different workers arrive at different conclusions for the same problem. These differences are, in our opinion, due not only to differences in sensitivity of the stimulated receptors but also to differences in the initial condition of the animals. Thus the unphysiological state of animals used in acute experiments may interfere with the full development of the reflex reaction in all its complexity, and only a part of it may become manifest.

V. A. Lebedeva [3] demonstrated the different sensitivity of jejunal and colonic receptors of cats, in acute experiments, to mechanical stimulation. Her data relate to reflex action on blood pressure and respiration.

In most of our experiments distension of a colonic loop caused lowering of urine flow, whereas distension of the jejunum had the opposite effect.

Thus, in the dog Zhuchka (June 11, 1951) distension of a colonic loop at a pressure of 20 mm Hg for 15 minutes lowered urine flow to a value of 40% of the initial; identical stimulation of a jejunal loop (dog Damka) raised urine flow to 230% of the initial value (September 26, 1949).

We cannot from the results of these experiments draw any conclusions regarding the sensitivity of jejunal and colonic receptors, since stimulation of identical intensity evoked diametrically opposite responses.

We shall now proceed to the question of chemoceptor gradients.

According to our findings, irrigation of the gastric mucosa of dogs with solutions of peptone and sodium bicarbonate through an open gastric fistula in chronic experiments, leads to increased, and with hydrochloric acid solution to diminished, flow of urine. Irrigation of the jejunal mucous membrane with peptone solution in most cases leads to increased flow during the actual application of the stimulus, while the response to identical stimulation of colonic mucous membrane is a small fall in urine flow during irrigation. Irrigation of the colonic mucosa with peptone is usually followed by a profound fall in flow of urine; this effect is not observed following irrigation of the jejunum (Fig. 2). Hence, if we consider only the changes in urine flow taking place during application of the stimulus, we can draw the conclusion that jejunal receptors are relatively more sensitive to chemical stimulants, but if we base our conclusions on the changes in flow taking place after removal of the stimulus we would draw the opposite conclusion, that colonic receptors are relatively more sensitive. We think that both conclusions are justified, inasmuch as the changes in urine flow observed during the application of the stimulus and after its cessation are both results of the same stimulation. However, neither the one nor the other conclusion can be considered to apply to the process as a whole, since they are each based on a consideration of only one stage of the process.

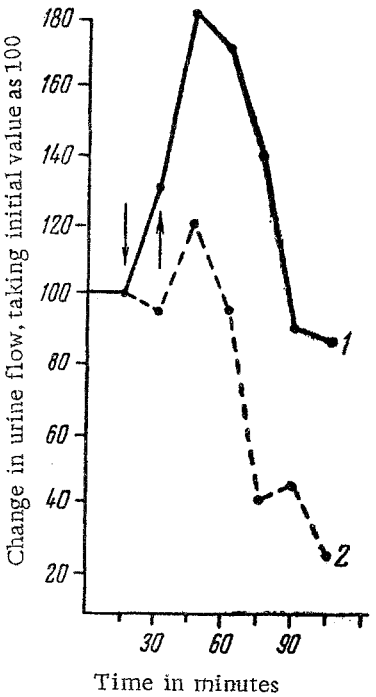

Fig. 2. Urine flow of the dog Sylvia during and after irrigation of a Thiry-Vella jejunal loop (Curve 1) and of the dog Palma during and after irrigation of the colon with 5% peptone (Curve 2).

↓ ↑ Beginning and end of irrigation.

It appears to us that V. A. Lebedeva, in her work on the gradient of the reflex action of alimentary receptors on blood pressure, took into account in drawing her conclusions only one phase of the reflex, viz., the pressor effect, but disregarded the second, depressor, stage. For this reason, while we do not dispute V. A. Lebedeva's conclusion that a gradient of reflex activity exixts along the alimentary tract, as expressed by blood pressure changes, we nevertheless consider that this conclusion is a one-sided one.

In general, we think that trustworthy conclusions as to the sensitivity of receptors to a given stimulus cannot be drawn with certainty from the presence or absence of reflex responses to this particular form of stimulus. A reflex may be absent even though the receptors are sufficiently sensitive, and it may not be realized even if afferent impulses originate from these receptors, owing to inhibition of its transmission in the central nervous system.

N. E. Vasilevskaya's experiments [1] have shown that the chemoceptors of those parts of the jejunum which are, according to V. A. Lebedeva, relatively insensitive to chemical stimuli, must in reality be fairly sensitive to them, producing afferent impulses when stimulated; were this not to be the case they could not serve as a source of conditioned reflex signalization, which took place in N. E. Vasilevskaya's experiments.

It may be concluded that the problem of the existence of receptor gradients in the alimentary tract requires further experimental study.

LITERATURE CITED

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