THE INFLUENCE OF THE ADRENAL MEDULLA ON THE RESPONSE OF THE GASTRIC GLANDS TO PAINFUL STIMULATION

A. S. Yampol'skii

Department of Normal Physiology (Head, Professor S. S. Serebrenikov)
Ivanovskii Medical Institute (Director, Docent Ya. M. Romanov)
(Presented by Active Member AMN SSSR V. V. Parin)
Translated from Byulleten' Éksperimental'noi Biologii i Meditsiny,
Vol. 53, No. 3, pp. 30-34, March, 1962
Original article submitted March 1, 1961

By now it has been shown [4, 5, 7, 8, 9] that painful stimulation or emotional excitation causes a marked reflex increase in the liberation of epinephrine into the blood.

Previously [9] we have studied the changes in the composition of gastric juice under the influence of painful stimulation, and it therefore seemed interesting to determine the involvement of the adrenals in the response of the gastric glands to painful stimulation. We also decided to study the action of epinephrine on the activity of the gastric glands, because of the widespread clinical use of epinephrine.

Many authors have studied the influence of epinephrine on digestion in the stomach, but the results they have obtained have been extremely contradictory. Some [1-3, 13, 14] attribute to epinephrine an inhibitory action on gastric secretion, while others [4, 15] maintain that it stimulates such secretion.

Most workers have paid chief attention to the amount of gastric juice, and only some have observed changes of acidity or of digestive power. Because changes of composition may be of considerable importance in the pathology of digestion, we decided to pay particular attention to qualitative changes induced by epinephrine.

METHOD

Experiments were carried out on four dogs. Three of them (Ava, Raketa, and Jack) had Heidenhain pouches, and one (Pirate) had a Pavlov pouch as modified by G. M. Shpug. The experiments were always carried out in the same room, and the dogs were maintained on an invariable food ration.

Excitation of the gastric glands was induced by allowing 200 g of raw meat to be consumed in five minutes. Observations on the secretion of the juice were made for three hours. In each hourly portion the amount of free, bound, and total hydrochloric acid was determined, as well as total acidity, protease and lipase activities, specific gravity, amount of dry residue, and amount of organic and inorganic substances.

Before analyzing the gastric juice, to free it from mucus it was twice filtered through normal filter papers. The free, bound, total hydrochloric acid and total acid were determined in a single test by the usual method. Protease activity was determined by Mett's method, and lipase activity as follows. A mixture of 1 ml of the juice and 1 ml of fresh cow's milk was neutralized by NaOH, with phenolphthalein as an indicator, until a weak color appeared, after which it was placed in a water bath at 37°. After 30 min a mixture was extracted, and the fatty acids formed in the milk under the action of lipase were titrated from a microburette with 0.1 N NaOH until a weak color appeared. From the amount of alkali required to neutralize the fatty acids the lipase activity of the gastric juice could be determined.

We carried out six sets of experiments.

In the first set, painful stimulation was applied immediately after meat had been given. The painful stimulation was derived from the secondary winding of an induction coil, which was closely wound on the primary to which a potential of 6 v was connected. The stimulation was applied to the lower leg for 30 sec.

In the second set of experiments, the painful stimulation was applied one hour after feeding, i.e., at the height of the secretion.

In the third set, immediately after consuming meat the animals received an intravenous injection of 0.1 ml per kg of 0.1% epinephrine solution (produced by the Ivanovskii Meat Plant).

In the fourth set of experiments, the same dose was injected one hour after food had been given.

In order to prevent epinephrine entering the blood stream on account of the painful stimulation, from two dogs (Pirate and Jack) the right adrenal was removed, and all branches of the greater and lesser splanchnic nerves supplying the left adrenal were divided. After the operation, the amount of regular secretion was observed, and then fifth and sixth sets of experiments were carried out, in which the painful stimulation was applied either immediately after or one hour after food had been given.

Altogether 184 experiments were carried out on four dogs.

RESULTS

Previously [9] it has been shown that painful stimulation prolongs the latent period of secretion, reduces the amount of gastric juice, and the amount of free hydrochloric acid, but leads to an increase in the amount of bound hydrochloric acid; protease activity is decreased, and lipase activity, specific gravity, and the amount of dry (organic) residue increased; there is no change in total hydrochloric acid or in total acid.

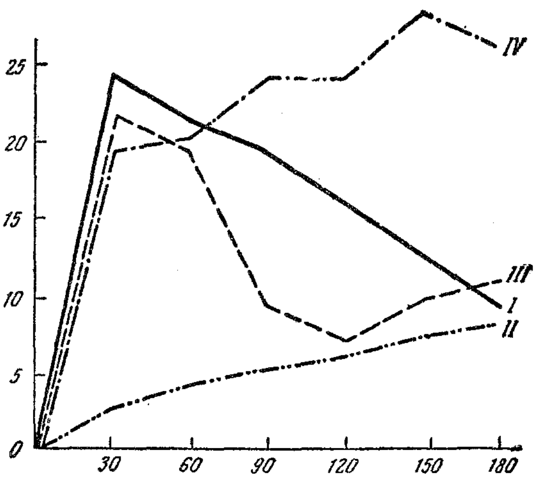

Fig. 1. Change in the amount of gastric juice under different conditions (different sets of experiments). Ordinate – amount of juice (in ml). I) Control; II) first set of experiments; III) third set of experiments; IV) fifth set of experiments.

The results obtained in the first two sets of experiments conform completely to these results.

In all experiments with epinephrine, the latent period of secretion was prolonged. In the third set of experiments, on the day on which epinephrine was injected the latent period of secretion was prolonged 1.5-3 times. Thus, in Pirate it was increased from 8-13 to 30-35 min, and in Jack from 23-28 to 50-55 min. For 1-3 days after the epinephrine injection the latent period of secretion was somewhat prolonged, as compared with the mean values in the control experiments. In the fourth set of experiments, on the day after epinephrine had been injected, the latent period was increased on average 1.5-2.5 times. It returned to the control value on the 3-4th day. The increase of the latent period evidently indicates that epinephrine has an inhibitory effect on the excitability of the gastric glands.

It was only in some of the experiments of the third set that we observed a marked reduction in the amount of juice as early as the first hour of the experiment, whereas in the other experiments, there was either no or very little change in the first hour. As a rule there was a great reduction of between 2 and 2.5 times in the amount of juice secreted in the second hour; the amount was also less than normal in the third hour (Fig. 1). In the fourth set of experiments the reduction in the amount of gastric juice secreted began immediately after the epinephrine injection. On the 1-3 days after the injection, there was almost always a more or less well shown increase of secretion. The effect has also been observed by other authors [4, 6]. By the 4-5th day secretion was once more normal.

In studying the influence of epinephrine on gastric acidity, we encountered the following facts. In some experiments, irrespective of the time of injection of epinephrine there was a 12-15% reduction in the amount of free, bound, and total hydrochloric acid, as well as of total acids; however, in other experiments there was a reduction in the amount of free hydrochloric acid, though the amount of bound hydrochloric acid was increased, while the amounts of total hydrochloric and total acid lay within the limits set by the control experiments. On the 2-3rd day, acidity was once more normal.

The enzymes of the gastric juice were affected differently by the epinephrine injection. Irrespective of the time of injection, in all the experiments protease activity was greatly reduced, and amounted only to 25-35% of the mean values established in the control experiments. In the next 3-4 days, protease activity was also greatly below normal. On the other hand, in response to the action of epinephrine, lipase activity was increased by 70-80% in both sets of experiments, but returned to the mean values of the control experiments by the 3-4th day.

In all experiments, it was found that epinephrine caused an increase in the specific gravity of the gastric juice. Whereas the value was normally 1.009-1.012, in response to epinephrine it rose to 1.016-1.024. On the following two days, the value was also somewhat raised.

Because of the increase of the specific gravity, we studied the action of epinephrine on the amount of dry residue. We found that the latter was increased 1.5-1.8 times, independently of the time of injection of the epinephrine, and that normal values were restored by the 3-4th day.

In measuring the amount of organic and inorganic substances in the dry residue it was found that the increase was mainly in the organic fraction, and there was very little change in the amount of inorganic matter.

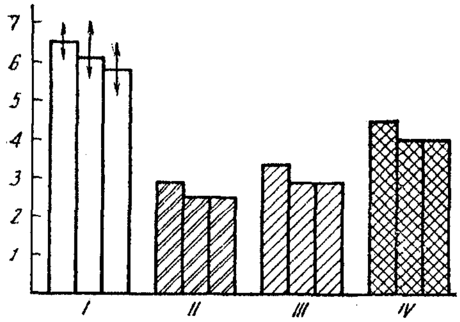

Fig. 2. Change of protease activity under different conditions (different sets of experiments). I) Control; II) first set of experiments; III) third set of experiments; IV) fifth set of experiments.

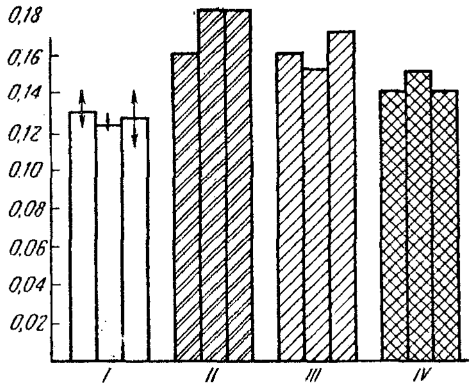

Fig. 3. Change in the activity of lipase under different conditions (different sets of experiments). Ordinate – amount of 0.1 N NaOH solution (in ml) required to neutralize the gastric acids. I) Control; II) first set of experiments; III) third set of experiments; IV) fifth set of experiments.

The operation of removal of the right adrenal and division of all the visible branches of the greater and lesser splanchnic nerves proceeding to the left adrenal had but little effect on secretion. After the operation, in both dogs there was a constant but not marked increased secretion. There was no change in the composition of the juice.

In the fifth set of experiments on the day on which the painful stimulation was applied there was a 20-30% increase of the latent period and in the sixth set the same increase occurred on the day after; in both sets the effect was present for the next one or two days.

On the day on which the painful stimulation was applied, and on the next 1-2 days, the amount of gastric juice secretion fell somewhat below the steady state established after the operation.

Painful stimulation had either no effect on acidity, or else caused a small reduction in the amount of free hydrochloric acid and an increase in the bound hydrochloric acid, while total hydrochloric acid and total acid remained unchanged.

The change of enzymatic activity induced by pain was the same as was observed in the first two sets of experiments, but the reduction in the activity of protease (Fig. 2), and the increase in that of lipase (Fig. 3) were not at all well shown, and occurred only for 1-2 days. In some of the experiments of the fifth and sixth set, the enzymatic activity remained within the limits of the control experiments.

In neither set of experiments were any special changes of specific gravity, or of the amount of dry residue or of organic and inorganic fractions observed to follow painful stimulation. Only in some of the experiments was there a very small increase in the specific gravity and in the amount of dry residue (organic fraction).

From the results reported it can be seen that intravenous injection of epinephrine not only causes considerable and prolonged alterations in gastric juice secretion, but also leads to profound changes in its composition.

This fact must be taken into account when epinephrine is used clinically.

When a comparison is made of the results of the first two experiments with those of the third and fourth sets, it is easy to see that the changes in the amounts and in the composition of the gastric juice induced by epinephrine in many ways resemble those observed to occur in response to painful stimulation.

After the possible reflex secretion into the blood stream of epinephrine induced by painful stimulation had been excluded, the effect of pain was not eliminated, but all the qualitative and quantitative alterations of the gastric juice observed in the operated animals in response to pain were very much less well shown and shorter lasting.

All the evidence indicates that the adrenal medulla plays a definite part in the response of the gastric glands to painful stimulation.

However, apparently other humoral and nervous mechanisms are also concerned in this complex reaction.

SUMMARY

The part played by the adrenals in the response of the gastric glands to painful stimulation was studied in dogs with Pavlov and Heidenhain pouches. Both painful stimulation and intravenous injection of epinephrine induced similar quantitative and qualitative changes of the gastric juice. Reflex secretion of epinephrine into the blood was prevented by removal of the right and denervation of the left adrenal gland, and it was then found that painful stimulation caused only insignificant and transitory changes of the gastric secretion. We therefore think that the adrenals participate in the response of the gastric glands to painful stimulation.

LITERATURE CITED

1. D. E. Al'pern, Vrach. delo, No. 10-12 (1922), p. 180.
2. S. M. Dionesov, Fiziol. zhurn. SSSR, Vol. 20, No. 4 (1936), p. 636.
3. L. G. Merkulov and E. N. Speranskaya, Fiziol. zhurn. SSSR, Vol. 31, No. 1-2 (1945), p. 74.
4. V. V. Savich and A. V. Tonkikh, Bulletin of the Lesgaft Petrograd Scientific Institute, Vol. 5 (1922), p. 37.
5. V. V. Savich and A. V. Tonkikh, Russk. fiziol. zhurn., Vol. 19, No. 2 (1926), p. 315.
6. A. V. Solov'ev, New Contributions to the Secretory Function of the Stomach and Pancreas [in Russian], Moscow-Leningrad (1959).
7. S. A. Shcherbakov, V. S. Zimnitskii, and V. R. Dmitriev, Research Reports of Kazan' University, books 3-4 (1929), p. 462.
8. S. A. Shcherbakov, V. S. Zimnitskii, and V. R. Dmitriev, Kazansk. med. zhurn., Vol. 25, No. 9 (1929), p. 888.
9. A. S. Yampol'skii, Pat. fiziol. i eksper. ter., No. 6 (1958), p. 51.
10. W. B. Cannon and R. G. Hoskins, Am. J. Physiol., Vol. 29 (1911), p. 274.
11. W. R. Hess and R. Gundlach, Pflüg. Arch. ges. Physiol., Bd. 185, S. 122 (1920).
12. R. K.-S. Lim, Quoted by S. M. Dionesov.
13. J. Rogers, J. M. Rahe, and E. Ablahadian, Quoted by S. M. Dionesov.
14. G. Suda, Arch. path. Anat., Bd. 251, S. 56 (1924).
15. G. Yukawa, Arch. Verdau Kr., Bd. 14, S. 166 (1908).

All abbreviations of periodicals in the above bibliography are letter-by-letter transliterations of the abbreviations as given in the original Russian journal. ***Some or all of this periodical literature may well be available in English translation.*** **A complete list of the cover-to-cover English translations appears at the back of this issue.**