ROLE OF THE VAGUS NERVE IN THE SECOND PHASE OF GASTRIC SECRETION

N. V. Asmayan

Department of Normal Physiology (Head—P. K. Anokhin, Active Member of the Academy of Medical Sciences USSR), I. M. Sechenov 1st Moscow Order of Lenin Medical Institute, Moscow

(Presented by Active Member of the Academy of Medical Sciences USSR, P. K. Anokhin)

Translated from Byulleten' Éksperimental'noi Biologii i Meditsiny, Vol. 49, No. 6, pp. 16-20, June, 1960

Original article submitted May 25, 1959

Pavlov and Shumova-Simanovskaya, in 1890 [3], were the first to demonstrate that section of the vagus nerves causes reduction of tonus of the stomach wall and cessation of secretion initiated by sham feeding. Stimulation of the peripheral parts of the sectioned nerves, however, causes some secretion of gastric juice only under certain conditions. Other investigators [4, 5, 6] have also made such observations. Almost all reports have concerned the role of the vagus nerve in the first phase of gastric secretion. As far as its importance for the second phase is concerned, this has up to the present remained insufficiently studied. The reason for this is probably that the method used in these studies, section of the vagus nerve, does not always provide conclusive information. Thus, for example, complete exclusion of the vagi by means of cervical section may cause localized irreversible changes, and these changes may be responsible for general organic dysfunction. Nevertheless, when the nerve is sectioned below the diaphragm, on the wall of the same stomach attached to a Heidenhain pouch, complete exclusion of vagal influence is also not assured. The problem is not resolved by methods involving a subcutaneous isolated pouch (Ivy [8]), since in this case not only is the vagus nerve sectioned, but there is complete denervation and considerable reconstruction of the blood supply.

A method which has slowly gained importance in studies of the vagus nerve in the second phase of gastric secretion is that of transient conduction block of the vagus by means of various pharmacological substances: cocaine, novacaine, nupercaine. Using this technique, investigators have introduced these substances either into the region of the neck where the vagus is situated [2], or into a cutaneous flap into which the truck of the vagus is previously sewn [1]. However, this method does not exclude accessory effects of the applied substance and, consequently, does not provide a solution to the problem. Transient conduction block of the vagus in dogs was accomplished by Anichkov and Kartashevskii [7] after sewing one vagus trunk into a cutaneous sleeve on the neck and cutting the other. Conduction block was produced by either introduction into the sleeve of 0.5 ml cocaine (1%), or by a piece of ice which produced hypothermia.

After studying the literature related to the problem, we evaluated this method as being the most acceptable, and decided to conduct observations under analogous conditions, excluding as far as possible any supplementary effects on other organs or on the organism as a whole. We decided to use mechanical constriction of the cuff, as it was found that during moderate constriction nerve block was completely adequate and stable, and that after constriction was discontinued, conduction was rapidly restored.

METHODS

Experiments were conducted on 4 dogs. One vagus trunk was cut and the other was enclosed in a cutaneous cuff on the neck. Besides this, dog No. 1 had an esophagotomy and stomach fistula, dog No. 2—stomach fistula and isolated fundic Pavlovian pouch, dog No. 3—stomach fistula and isolated fundic Heidenhain pouch and, finally, dog No. 4—stomach fistula, gastroenterostomy and isolated and exposed subcutaneous pouch, formed from the pyloric part of the stomach and the initial part of the duodenal intestine.

Constriction was produced with the aid of a rubber balloon inserted in a metal ring surrounding the cuff. Nerve block resulted when pressure in the cuff was slightly greater than systolic blood pressure, i.e., somewhat greater than 120 mm Hg. It was found that nerve block was maintained even after subsequent pressure reduction from 120-130 mm to 30 mm Hg or less. In connection with this, it can be assumed that when block is produced by pressure it is most probably a stable phenomenon.

RESULTS

During compression of the cuff the Horner syndrome was most prominent, i.e., miosis and ptosis of the nictatating membrane was observed, but also an ipsilateral increase in cephalic skin temperature. This syndrome, associated with conduction failure in sympathetic nerves, served to indicate the onset of block. Concurrently, an abrupt increase in pulse rate to 180-200 per min and changes in respiration (increased depth with same rate) were observed. These changes were apparently a consequence of conduction disorder of the vagus nerve. Both

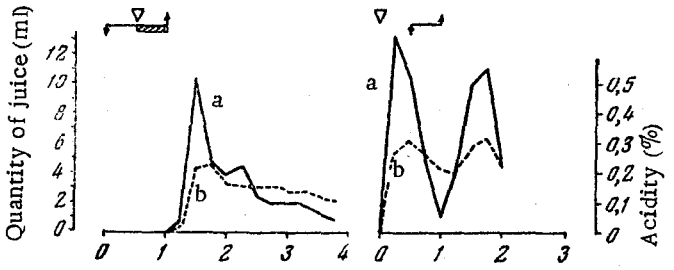

Fig. 1. Changes in stomach secretion in dog No. 1 (fistula) with sham feeding. A) Quantity of juice, in ml; B) Acidity of juice in per cent (free HCl). Small arrows indicate beginning and end of cuff compression; triangles indicate beginning of sham feeding.

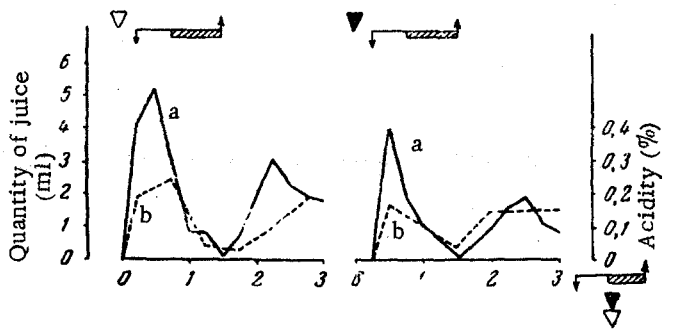

Fig. 2. Changes in secretion of Pavlov pouch in dog No. 2. Triangles indicate introduction into pouch of 100 g meat (solid triangle) and 200 g bread (open triangle). Remaining marks same as in Fig. 1.

phenomena (Horner syndrome and pulse and respiration changes) did not occur immediately after the beginning of compression, but only after 25-30 min. Besides this, with some dogs, particularly when frequent repetitive compression of the cuff was involved, salivation, deglutition, sometimes nausea and emesis were observed. In these cases, following the end of compression and restoration of nerve conduction, it was sometimes possible to observe the appearance of transient (30 min) gastric secretion.

This could be avoided by introducing 1-2 ml novacaine (2%) into the subcutaneous sleeve before the onset of compression. Control studies showed that this dose did not disturb conduction in the vagus trunk, and consequently, did not have any effect on stomach function.

Nerve conduction was restored 3-5 min after the end of compression; the Horner syndrome disappeared and cardiac and respiratory activity returned to the initial level.

The major analysis concerned the relation between the state of the vagus nucleus and alimentary neural stimulation. Experiments were carried out on esophagotomized dogs and others which were fed sham food (broth with added pieces of meat) which freely fell out from the open fistula.

The experiments confirmed the work of Zemskaya [2], who observed in esophagotomized dogs (with one vagus sectioned and the other included in a cutaneous flap on the neck) absence of gastric secretion during sham feeding following the administration into the flap of 1-2 ml nupercaine (0.1%). In our experiments it was found that gastric secretion was absent during 5 min of sham feeding with vagus nerve block, and that secretion might appear only after the end of compression, even if this had occurred for 30 min or more after feeding. Cuff compression halted secretion already initiated, but decompression restored it (Fig. 1).

A similar picture was also observed in dogs with resection of the pyloric region of the stomach and the initial part of the duodenal intestine.

Further experiments were devoted to the problem of the role of the vagus in the second phase of gastric secretion.

Experiments showed that disorder of physiological conduction of the trunk of the vagus resulted in abrupt reduction or complete cessation of secretion (Pavlov or Heidenhain pouch; stomach fistula) which ordinarily appeared following the introduction of food into the stomach cavity (100g meat or 200 g bread, or 1000 ml broth) or mechical stimulation (rubber chain). Nerve conduction disorder also completely prevented and halted secretion which ordinarily was obtained from a fistula of the greater stomach

as a result of stimulation of isolated pyloric pouch mucous membrane. The stimulation in this case was the introduction of a rubber balloon or, for more intense stimulation, a canoe-shaped rye biscuit into the pouch cavity (Fig. 2 and 3).

Absence of fundic gland secretion was observed during the introduction of 500 ml alcohol (5%) into the stomach; considerable depression of secretion was noted during the introduction of 200 ml of the same alcohol into the rectum.

Finally, during transient conduction disorder of the trunk of the vagus (with the other sectioned), we observed not only suppression of secretion but also of stomach motor activity. In these cases, introduction of a balloon into the stomach cavity caused only insignificant contractions of the stomach wall. This was noted even with a highly inflated balloon.

On the basis of these results it was possible to assume that suppression of secretion and motor activity of the stomach in connection with conduction disorder of the trunk of the vagus nerve in the neck is related not only to exclusion of secretory, motoric and tonic effects of this nerve, but also to an intensification of the influence of the sympathetic nervous system both on the tonus of stomach vessels and, possibly, on its function.

Special experiments, however, showed that an increase in general sympathetic tonus and concomitant augmentation of blood adrenalin apparently does not occur. The evidence concerning this was the absence of any change in the quantity of blood sugar (Hagedorn-Jensen method) both at the onset of nerve block and after its release (Table).

According to our experiments, secretory impulses appear in the vagus nucleus throughout the duration of protected sham feeding (apparently, for the total period of secretion), and are not limited to only the onset of feeding. Disorder of physiological conduction in the vagus nerve excludes not only the first, but also the second phase of gastric secretion, and secretion which normally appears in connection with stimulation of the mucous membrane of an isolated pyloric gland. In addition, secretion of the

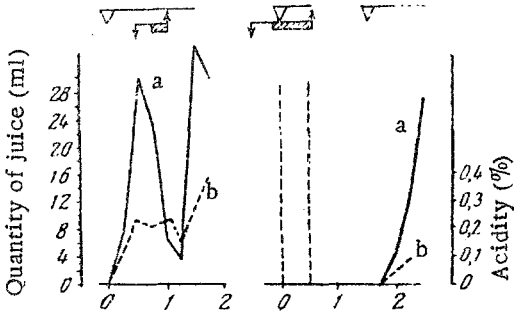

Fig. 3. Changes in stomach secretion in dog No. 4 (fistula). The triangle and the line show the moment and the duration of stimulation of pyloric pouch mucous membrane by introduction of a rye biscuit. Remaining marks same as in Fig. 1.

TABLE. Quantity of Blood Sugar (in milligrams-percent) (Dog No.3)

Experiment No.	Before exclusion of vagus nerve	At onset of exclusion	After restoration
4	0,075	0,072	0,075
6	0,082	0,082	0,084

fundic gland, produced by introducing 500 ml alcohol (5%) into the stomach or 200 ml of the same solution into the rectum is also inhibited. Throughout all these conditions the quantity of blood sugar remains constant, indicating the absence of any change in general sympathetic tonus or quantity of blood adrenalin.

SUMMARY

This work was conducted on 4 dogs esophagotomy and gastric fistula, isolated Pavlov's pouch, gastric fistula and Heidenhain's pouch, fistula of the stomach and isolated gastric pouch made of pylorus), in which one of the vagus nerves was enclosed into a cuff on the neck, and the other divided. As shown by experiments, the compression of the cuff by a force a little over 120 mm Hg provokes a block of the vagus conductivity, which may be estimated by the acceleration of the pulse and the appearance of Horner's syndrome. This excludes the first and the second phases of the gastric secretion, as well as secretion provoked by stimulating the mucous membrane of the isolated pyloric pouch.

LITERATURE CITED

1. N. Anitschkof and E. Kartaschewski, Pflugers arch. gesmante Physiol. 203, 443 (1924).
2. E. I. Zemskaya, Mechanism of the First Phase of Gastric Secretion. Thesis report. Scientific Congress on Problems of Physiology and Pathology of Digestion, Commemorating the 40th Anniversary of the VOSR [in Russian]. Tartu, 1957).
3. V. F. Lysov, Neural Mechanism of Stimulation and Regulation of Secretory Activity of the Gastric Gland. Scientific Notes of the Kazan Vet. Inst. 64, 1, 169 (1956).
4. I. P. Pavlov and E. O. Shumova-Simanovskaya, Vrasch. 41, 929 (1890).
5. V. G. Ushakov, Influence of the Vagus Nerve on Gastric Secretion in Dogs [in Russian] Diss. (St. Petersburg, 1896).
6. A. M. Cheshkov, Nineteen Months After Bilateral Cervical Vagotomy in the Dog [in Russian] Diss. (St. Petersburg, 1902).
7. N. P. Yurgens, Condition of the Digestive Tract during Chronic Paralysis of the Vagus Nerve [in Russian] Diss. (St. Petersburg, 1892).
8. A. Ivy and G. Farrell, Am. J. Physiol. 74, 639 (1925).