THE EFFECT OF STIMULATION OF THE VAGI ON THE PYLORIC REGION OF THE STOMACH.

By E. D. McCREA[1] and B. A. McSWINEY.

(*From the Department of Physiology, University of Manchester.*)

THE course taken by the vagus fibres which supply the pyloric region has not been very definitely ascertained. Anatomically the main branches of the anterior and posterior vagal trunks from the œsophageal plexus are traceable to the region of the incisura angularis and their terminal fibres supply the pyloric antrum. In no instance does the anterior or posterior vagal trunk send fibres as far as the pylorus canal or sphincter. Many observers state, however, that all the pyloric region receives its nerve supply from these branches. The anterior vagal trunk has been shown to give off a branch, and sometimes two or three branches, to the liver, which communicate with sympathetic fibres and have been called the hepatic branch of the vagus. From these, nerve strands descend to supply the pylorus and first part of the duodenum. Latarjet(1) states that the pylorus receives its entire nerve supply, in man and the dog, from above and considers these strands to consist wholly of sympathetic fibres. One of us, McCrea(2), has dissected the hepatic branch in man, dog, cat and rabbit and shown that the strands given off to the pylorus contain vagus fibres. It seemed then desirable to ascertain the effects which this pyloric branch is capable of producing upon the musculature of the pyloric region.

In a recent paper, McCrea, McSwiney and Stopford(3), working on the intact stomach, have shown that stimulation of the vagi influences both the motor activity and "postural tonus," the type of reaction depending on the condition of the peripheral mechanism. The entogastric pressure was used as an indication of the state of activity of the peripheral mechanism, as this was found to vary with the degree of contraction of the viscus on its contents. In the passive organ (obtained by starving an animal for at least 12 hours) which did not normally maintain an entogastric pressure, stimulation of the nerve caused an augmentor response. In the active stomach (obtained by feeding a starved animal

[1] Working for the Medical Research Council.

three hours before the experiment) a preliminary inhibitory response followed stimulation.

Method. The experiments were made on cats and dogs. The animals were anæsthetised with ether. The abdomen was opened by a mid-line incision extending downwards from the xyphoid process. The abdominal walls were retracted and the abdomen filled with warm saline. The pyloric region was severed from the rest of the stomach between two purse string sutures; just distal to the incisura angularis. A short vulcanite tube, in some instances with a balloon attached, was inserted into the pyloric antrum. The duodenum was ligated and care was taken to ascertain that all the nerves of the anterior vagal trunk running in the region of the lesser curvature had been severed. In some experiments a record of the movements of the body of the stomach was also taken by means of a tube passed into the stomach through the cervical œsophagus. The tube in the pyloric antrum was connected with a system filled with warm saline. A water float was used to record contractions and pressure variations. The vagi nerves were cut in the neck and stimulated with a faradic current of different strengths.

Investigations were also carried out on the movements as seen by X-ray, and photographs were taken when required. The animals having been anæsthetised, the stomach was divided into two parts and the vagi prepared as described above. By means of a syringe, the barium sulphate was introduced into the pyloric region.

For observation on the inactive body of the stomach, food was withheld from the animals for a period of not less than 12 hours before examination; those animals, however, in which an active body of the stomach was required, received a small meal of meat extract and milk three hours before the experiment. We have not been able to control the activity of the pyloric region in the same manner as the body. The operative technique described effects the complete separation of the pars pylorica from the body of the stomach, while the nerve supply to the pyloric canal through the hepatic branch of the vagus remains intact.

Stimulation of the peripheral end of the vagus in the neck.

The effect of stimulation varied according to the condition of the pyloric antrum. If inactive, the pyloric region was quiescent in the cat and slow spontaneous contractions were present in the dog. In the active condition, rapid rhythmic movements were observed in the pylorus of the cat and dog.

Stimulation of the nerve when the region was inactive initiated rhythmic movements in the pars pylorica of the cat and increased the rate of contractions in the dog (Fig. 2). On the other hand, in the active pylorus, rhythmic movements were always inhibited (Fig. 4). The movements were decreased in rate but the height of the contractions was not affected. The diastolic intra-pyloric pressure remained constant.

In the cat stimulation of the vagus with moderate strength of current (just felt on the tongue) initiated peristaltic waves in the pyloric region which spread to the duodenum. The frequency of these movements was approximately nine to ten a minute. The contractions were of equal height and returned to the base, *i.e.* there was no variation in tone. On increasing the strength of the current the character of the movements altered (Fig. 1).

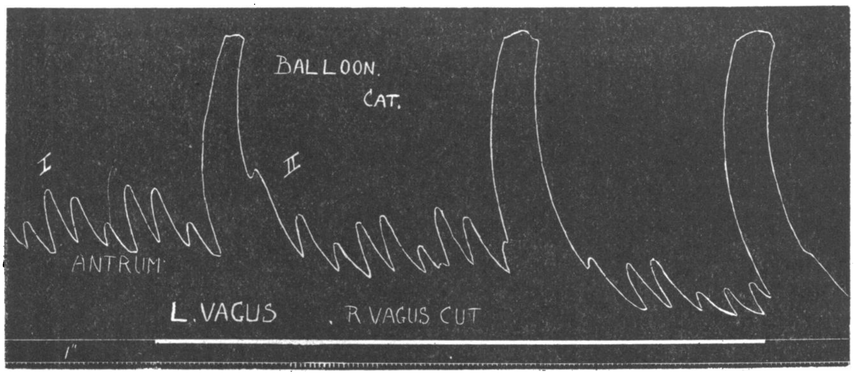

Fig. 1. (1) Rhythmic peristaltic movements, and (2) initiation of total contractions on stimulation of peripheral end of left vagus.

Large rhythmic contraction now occurred at intervals of 20 to 30 seconds. On direct observation they were seen to represent a simultaneous contraction of the whole pyloric region. In the intervals of these contractions, shallow peristaltic waves were seen, passing along the pyloric canal, the average frequency being about eight to twelve a minute. This two-phase type of contraction, if established, persists throughout the experiment, and we have failed to re-establish the original one-phase type. Similar movements have been described by McCrea, McSwiney, Morison and Stopford(4) in their X-ray investigations of the normal movement of the cat's stomach, and by Alvarez(5) in his investigations of the rabbit and cat.

In the dog, the total contraction of the pyloric region was most frequently obtained, the whole pyloric region, rhythmically contracting and relaxing at intervals of 20 to 30 seconds. The movements are remarkably regular, the amplitude, duration and frequency remaining

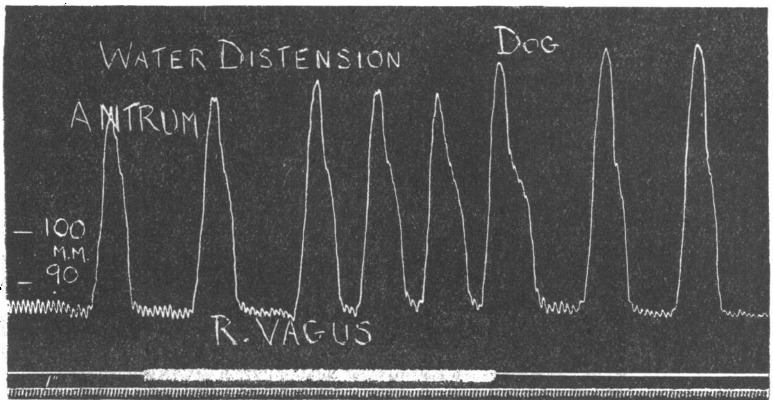

Fig. 2. Inactive pyloric region. Acceleration of rhythmic movements on stimulation of peripheral end of vagus nerve.

unaltered as long as the pressure is kept constant. A strong stimulus may cause a sustained contraction, the rhythmic movements increasing in rate and starting above the base line, indicating summation. Escape may occur, the rhythmic movements become slower and the lever returns to the base line (Fig. 3). Occasionally shallow peristaltic waves, similar to those observed in the cat, occurred in the intervals of the total contractions.

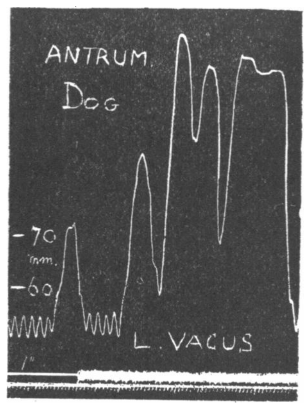

Fig. 3. Rise of lever from base line with rhythmic movements superimposed (spasm) on stimulation of peripheral end of left vagus nerve.

Distension of the pyloric region of the cat ordinarily fails to initiate movements, whereas in the dog, increase of content is usually an adequate stimulus. We have found an optimum tension exists, but if the walls of the pyloric region are over distended by allowing excess of fluid to flow into the viscus, the amplitude of the contractions become diminished. These results agree with those of Ducceschi(6) on the stomach of the dog *in situ.*

In some experiments simultaneous tracings were taken from the body and pyloric region isolated from one another. The inactive body of the starved animal shows a motor response on stimulation of the nerve, rhythmic movements were initiated and a rise of pressure occurred;

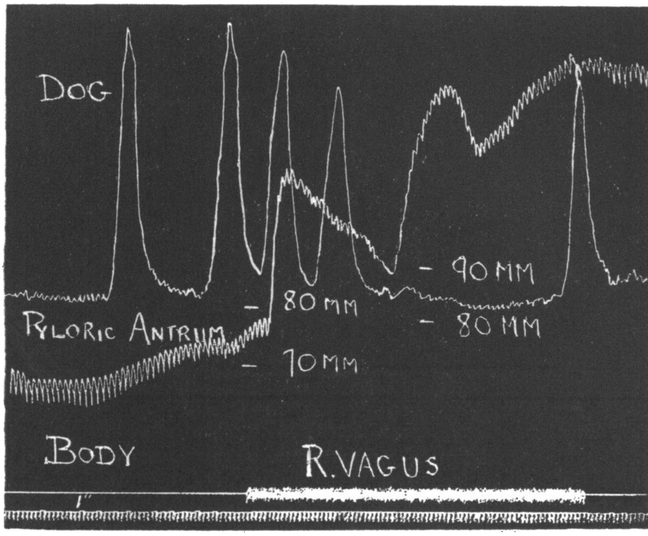

Fig. 4. (1) Rise of pressure in body, and (2) inhibition of movements of pyloric antrum on stimulation of peripheral end of right vagus nerve.

movements, if present, were augmented and sometimes accelerated (Fig. 4). In the fed animal, vagal stimulation of the active body caused a fall of pressure and cessation of movements (Fig. 5). In the pyloric region the effects were similar to those previously described.

In these experiments we have been able to show a complete dissociation in the response of the two regions. In some instances vagus stimulation caused inhibition of the cardiac end of the stomach and increased the rate of contractions in the pyloric region. We have also obtained the reverse effect, viz. a motor effect in the body and inhibition of the pyloric region. The experiments of McCrea, McSwiney and Stopford on the intact stomach agree with these results.

X-ray observations. The movements observed under X-ray and the response to vagal stimulation were in both the cat and dog the same as those previously described.

The *results described above* show that the nerve strands which descend from the hepatic branch of the vagus and run in the lesser omentum to the pylorus contain fibres for the pyloric canal and sphincter. These fibres control the augmentor and inhibitory response of this region, and the nature of the response to vagal stimulation depends on the condition of activity of the pars pylorica. The recent work of McCrea, McSwiney

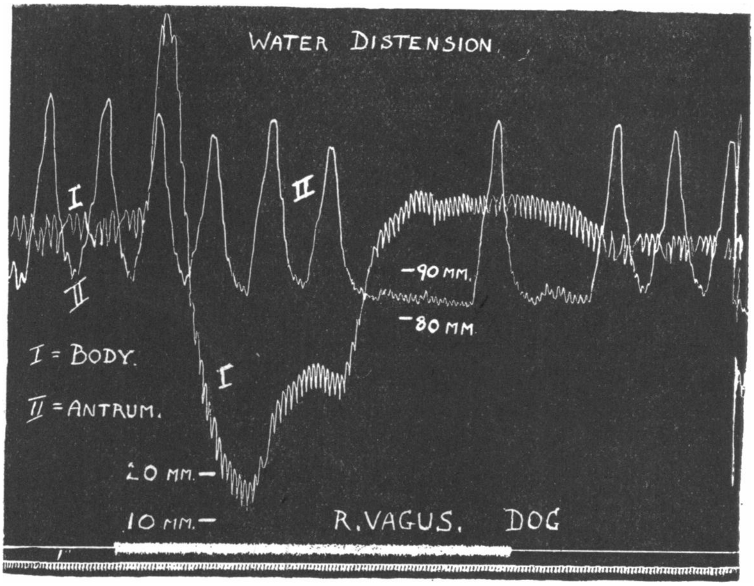

Fig. 5. (1) Fall of pressure in body, and (2) inhibition of movements of pyloric antrum on stimulation of peripheral end of right vagus nerve.

and Stopford affords evidence that the augmentor or inhibitor response of the stomach to nerve stimulation is controlled by the condition of the peripheral mechanism.

It has been shown by a number of observers that in digestion the movements of the greater part of the cardiac end of the stomach differ essentially from those of the pyloric region. In the cardiac end, the contractions may be either rhythmic or tonic or both, while in the pyloric region the contractions are rhythmic only—peristaltic or total. The results we have obtained give additional evidence of this essential difference and it is particularly to be noted that in the pyloric region, stimulation of the vagi, whether it causes augmentation or inhibition of rhythmic movements, causes little or no variation in tone.

CONCLUSIONS.

1. The hepatic branch of the vagus supplies and regulates the pyloric region.

2. Movements of the isolated pyloric region are similar to those observed in the pars pylorica of the intact stomach.

3. The pyloric region does not exhibit the property of "postural adaptation."

The expenses of this investigation have been borne by a grant from the Government Grants Committee of the Royal Society.

REFERENCES.

1. Latarjet. C.R. Soc. de Biol. 84. p. 985. 1921.
2. McCrea. Journ. Anat. 59. p. 18. 1924.
3. McCrea, McSwiney and Stopford. Quart. Journ. Exp. Physiol. 15. p. 201. 1925.
4. McCrea, McSwiney, Morison and Stopford. Ibid. 14. p. 379. 1924.
5. Alvarez. Journ. Amer. Med. Assoc. 79. p. 1281. 1922.
6. Ducceschi. Quoted by Luciani. Text Book of Human Physiol. 2. p. 188. 1913.