PLASTIC TONE OF THE FUNDAL AND PYLORIC DIVISIONS OF THE STOMACH

S. D. Groisman

Department of the Physiology of Digestion and Blood Circulation (Head, Doctor of Biological Sciences P. G. Bogach), Institute of Physiology, Kiev Order-of-Lening State University
(Presented by Active Member AMN SSSR V. V. Parin)
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Kelling [7] first noted the ability of the stomach to increase its volume considerably when a ballon was inflated within it without there being any associated increase of intragastric pressure. Subsequently the phenomenon of plastic gastric tone was confirmed in an extensive study [4, 5, 9, 10]. Then Sick and Tedesko [10], and then Dianturco [4] found that plastic tone occurs only in the fundal part of the stomach and does not extend to the pyloric region. This view has not been contested until now.

In studying the motor response of the pyloric region during gradual inflation of a balloon in it we observed a rapid increase of the pressure inside the balloon and of the amplitude of the contractions of the pyloric region when the first portion of air was introduced. As further air was pumped in the amplitude of the pyloric contractions and the rate of increase of the pressure within the balloon decreased asymptotically. Subsequently the pressure became stable although the volume was increased (Fig. 1). Constancy of pressure within the balloon despite an increase in its volume indicated the existence of plastic tone in the pyloric region. Because this observation runs counter to the opinion that there is no such thing as plastic tone in the pyloric region we decided to make a comparative study of the plastic tone in the pyloric and fundal regions.

EXPERIMENTAL METHOD

The experiments were carried out on 3 dogs with fistulae in the fundal and pyloric regions. Into each region we introduced a balloon connected to nipples on tubes measuring 3-4 cm corresponding to the length of the fistula tube. The capacity of the fundal balloon when it was not blown up was 80-100 ml, and that of the pyloric balloon 25-30 ml. The balloons were made from condome rubber, and were double. The pressure inside the balloon was recorded on millimeter graph paper by means of a U-type mercury manometer with a float carrying a pen. Air was introduced in 10-ml portions into the fundal region and in 5-ml portions into the pyloric portion. The moment of introducing the air was marked on the curve. Because in the device which we used for inflation [1] the air pressure within the balloon the error made by measuring the volumes of air introduced was minimal.

The balloons were inflated in the fundal and pyloric regions of dogs which had fasted, or of dogs fed with 200 g of bread. The fundal balloon was inflated on 15 occasions to 150 ml, and the pyloric on 10 occasions to 50 ml. Because mechanical stimulation excites gastric contractions, whether the dogs were fed or fasted the pressure curve took the form of a wavy line which reflected the tonic and peristaltic gastric activity. We were of course chiefly interested in the lower part of the curve from which we inferred the tonic contraction of the walls of both parts of the stomach. Immediately after the end of the experiment the balloon which had been removed was inflated with the same volumes of air which they had contained in the experiment. The record of pressure within the balloon obtained in this way enabled us to subtract that component of the pressure which was counteracted by the elasticity of the balloon. The difference between the pressure in the balloon while present in the stomach and while outside the stomach and inflated with the same volume of air represented the true pressure exerted on the inner wall of the stomach. Altogether we carried out 30 experiments including 600 pressure measurements.

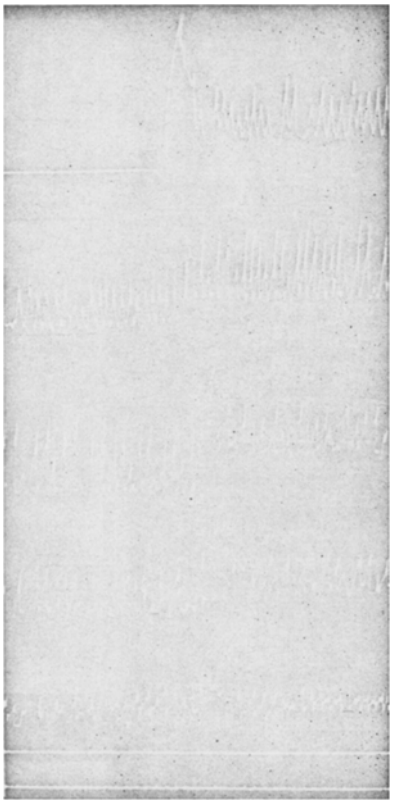

Fig. 1. Change of motility of the pyloric portion of the stomach when inflated by a balloon. In each successive section of the curve (from above downwards) the volume of the balloon is increased by 5 ml. Time marker 15 sec.

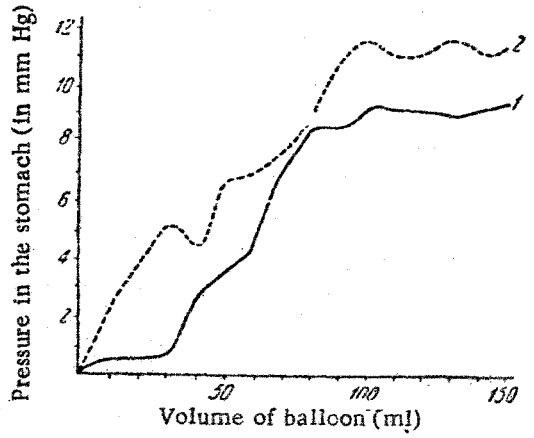

Fig. 2. Change of the pressure within the lumen of the fundal portion of the stomach when the volume of the balloon was increased from 0 to 150 ml (averaged values) in a fasted dog (continuous line) and in one which had been fed (dotted line).

EXPERIMENTAL RESULTS

If during the period when the stomach was at rest 30-40 ml of air were introduced into a balloon placed in the fundal region very little change in pressure occurred. If subsequent amounts of air were introduced the pressure began to rise and continued to do so until the volume of the air reached 80-100 ml. The pressure was then 8-9.5 ml Hg, and varied from one experiment to another from 7 to 11 mm. With successive additions of air to a volume of 150 ml no increase of pressure occurred. Inflation during a period of gastric motility gave the same results except that the pressure began to increase from the start. In animals which had been fed the pressure underwent the same changes as in the hungry animals except that in the former the pressure was 1-2 mm higher, reaching a value of 9-13 mm.

The introduction of 5 ml of air into a balloon in the pyloric region, occasionally had no influence on the pressure. With the addition of successive amounts it rose rapidly, reaching a maximum value of 6.5-7 mm Hg (variation from 6 to 10 mm) at a volume of 25-30 ml; with the introduction of additional amounts up to 20-25 ml there was very little further pressure increase. In animals which had been fed the pressure attained was 0.5-1 mm higher than in the unfed group.

The introduction of air into the fundal and pyloric balloons induced gastric contractions. As a rule the amplitude was far greater in the pyloric region.

From Figs. 2 and 3 it can be seen that plastic tone is characteristic not only of the fundal but also of the pyloric region. It develops in the pyloric region at an even lower pressure than in the fundal portion. At first this result seems odd, because the thickness of the walls of the pyloric division is much greater than that of the fundal wall. However, it must be remembered that according to Grützner's theory, which has been supported by the experiments of Müller [8] the increase of gastric volume is determined chiefly not by changes in the length of the muscle fibers but by displacement of the muscular layers of the gastric wall with respect to each other. Thus, whereas the wall of the empty stomach of the frog or salamander consist of 15-20 layers of muscle fibers, the wall of the stretched stomach comprises no more than 2-3 layers [8]. Possibly in the circular muscles which are the most strongly developed in the pyloric region [3] the displacement occurs at a lower luminal pressure than it does in the longitudinal layer of muscles.

We must now inquire into the reason for the differences between our results and those of Sick and Tedesko and Gianturco [4, 10] who failed to observe plastic tone in the pyloric region. The conditions of their experiment of (stomach in vitro) differed greatly from those we have described in this article. As far as the Gianturcos' experiments are concerned, it is known that he inflated a balloon introduced into the feline stomach through the mouth and found that in a stomach outlined with lead shot sewn in along the greater and lesser curvatures only the fundal portion expanded. However, it must be remembered that on account of the

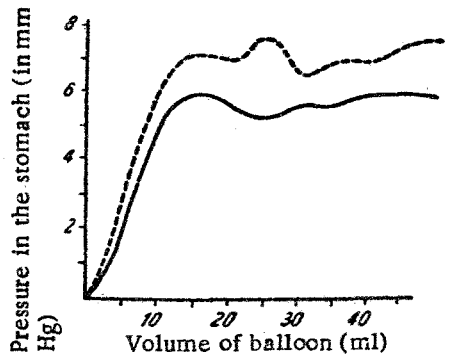

Fig. 3. Change of pressure in the pyloric region of the stomach during inflation of the balloon from 0 to 50 ml (mean values). Indications as in Fig. 2.

conical form of the stomach the balloon inflated in it becomes displaced towards the fundal portion which under these conditions undergoes the main expansion. In our experiments the balloons were introduced into the stomach through special fistulae in the fundal and pyloric portions. The short tubes bearing nipples to which the balloons were fixed were firmly held in corks which tightly closed the fistula tubes and which greatly reduced the mobility of the balloons in the stomach.

From what has been said we may conclude that within the limits set by the volumes of air which we used to inflate the balloons plastic tone is present in both the fundal and pyloric regions.

SUMMARY

Plastic tone of the stomach was studied in three dogs with fistulae in the fundal and pyloric regions. It was found that when the balloon was inflated with air to 150 ml, in the fundal portion the pressure continued to rise only until the volume reached 80-90 ml. Further increase in volume occurred at a constant pressure of 8.5-9.5 mm Hg (the pressure was measured at intervals between gastric contractions). The maximum pressure of 6.5-7.5 mm in the pyloric portion occurred at a balloon volume of 20-25 ml. Further increase of volume to 50 ml did not affect gastric pressure. This result indicated that plastic tone was inherent not only in the fundal but also in the pyloric portion of the stomach.

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