Continuous Recording of Pyloric Sphincter Pressure in Dogs
Relationship to Migratory Motor Complex

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Antral, pyloric, and small bowel intraluminal pressures were continuously recorded in dogs with gastric and duodenal cannulae. A cyclic phasic activity related to fasting motility in the antrum and small bowel was observed at the level of the pylorus. During phase I of the interdigestive motility complex, manometry was characterized by pressure variations of 31 ± 2 cm H2O. During phase II, two type of waves were observed: small waves similar to those seen during phase I, with superimposed waves of higher amplitude (89 ± 1.9 cm H2O). Pyloric pressure during phase III, showed a predominance of waves of even greater amplitude: 103 ± 3.9 cm H2O. A basal tone of 65.6 ± 3.2 cm H2O above the duodenal pressure was recorded throughout the period of study; but during phase III, frequent decreases in basal pressure were also observed. This relaxation of the pylorus during phase III of the IDMC may be related to the mechanism for size discrimination of particles leaving the stomach at the gastroduodenal junction.

Manometric studies at the gastroduodenal junction have yielded conflicting results depending upon the species studied (1-5). Studies using infused catheters in dogs have constantly revealed a high pressure zone at the gastroduodenal junction (6, 7). In contrast, such a high-pressure zone has been observed in some studies of humans (8-10), but not in others (11, 12). Differences in the recording systems and the positions of the experimental subjects are usually mentioned as possible causes of these conflicting observations (13). It is of interest that in all these experiments, the “pull-through” technique has been used and that only a few studies have been done with recording of the pressure over a long period of time (14, 15). The interdigestive motor complex (IDMC), characterized by variable cyclic motor activity, has cyclic effects on the stomach and the intestine. It is conceivable that the different phases of the IDMC could also modify the manometric pattern of the pylorus.

The aim of this work was to study the pyloric sphincter pressure continuously over a prolonged period of time and to establish a possible relationship with the fasting motor activity of the neighboring antrum and small intestine.

MATERIALS AND METHODS

Six male, mongrel dogs with a mean weight of 18.3 kg (range 14-22 kg), were prepared with a Thomas gastric cannula, 10 cm proximal to the gastroduodenal junction. A second stainless-steel cannula (9.5 mm in diameter) was placed in the duodenum, 12 cm distal to the pylorus. Studies were begun at least four weeks after the operation. A surgical thread passed from the gastric to the duodenal fistula was used to position the catheters at the beginning of each experiment and remained in place between experiments. The animals were trained to stand on a Pavlov table and were fasted 24 hr before each test, although water was allowed ad libitum.
Pyloric and Antral Pressure. A single polyvinyl tube, 220 cm long (0.9 mm ID) was used as a sensor. It was sealed in its middle portion and two lateral holes (1 mm diameter) were made at 1.5 cm on either side of the seal. One end of the catheter was passed through both cannulae from the duodenum to the stomach, leaving orifices positioned externally on the duodenal side. The ends of the catheters were then connected to pressure transducers (Statham P 23 Db), continuously infused with distilled bubble-free water at a rate of 0.4 ml/min, with a pneumohydraulic capillary infusion system (Arndorfer Medical Specialties), and the pressure changes recorded on a Grass-7D polygraph (Grass Instrument Co., Quincy, Massachusetts). Once the recording started, the catheter was slowly pulled from the gastric side, allowing the recording orifices to pass through the pylorus. At the duodenal level, a low basal pressure was recorded. When the first hole reached the pylorus, a sharp increase in pressure was consistently observed. Pull on the catheter from the gastric side continued until the second orifice reached the pylorus, noting again a rise in the pressure. At this time, one orifice was at the pylorus and the other in the antrum, 3 cm proximal to the pylorus. Then both sides of the catheter were firmly tied to the outlet of both cannulae.

In order to establish the relationship between the high-pressure zone and the gastroduodenal junction, this maneuver was repeated in 10 additional experiments (on five dogs) measuring simultaneously motility and potential difference (PD) by means of a Ringer-perfused manometric catheter (16). The end of the catheter, designed to record pyloric pressure, was connected to the respective transducer and perfused with a lactated Ringer solution by means of a syringe pump (Unita I.B. Braun, Melsungen, West Germany). The plastic cap of this transducer was modified to allow insertion of a 3-mm (ID) polyvinyl tube filled with 4% agar–lactated Ringer solution. A similar agar–lactated Ringer bridge was connected to a peripheral vein, and served as the reference PD bridge. Both bridges were immersed in two beakers containing a 3 M KCl solution and two Ag–AgCl electrodes. The PD was measured on a digital electrometer (Sabtronics 2000 DMM, Dallas, Texas). The mean duodenal PD was −9.4 ± 0.7 mV; a sudden change of these values to −37 ± 4 mV was observed during withdrawal of the catheter in all these experiments and was coincident with the second rise in pressure corresponding to the pylorus.

Intestinal Motility. Three polyvinyl catheters (0.9 ID), 55 cm in length, were glued together. A small latex balloon was attached at the end of one of them, while the other two had lateral holes (1 mm diameter) spaced 20 cm from each other. The assembly was passed distally through the duodenal cannula, and the balloon was inflated with 4 ml of water and allowed to advance spontaneously to its full length. When in place, the proximal and distal holes were located at 15 and 35 cm from the duodenal cannula, respectively. The balloon was emptied, and the recording catheters were infused with the same pneumohydraulic system and attached to a similar pressure transducer and recording system.

All four transducers were positioned at the level of the entrance of the cannulae into the abdominal wall. The amplifier for the pyloric pressure was connected to an integrator channel, Model 7P-10B (Grass Instrument Co.), in order to estimate the area under the curve.

Analysis of Pressure Records. The pyloric basal tone and the amplitude of the waves were directly read on the chart paper, by means of the integrator and expressed as centimeters of water. The duodenal pressure was considered as zero reference, and the basal tone was measured at the lowest part of the curve of the phasic oscillations. The different phases of the IDMC in the small bowel were identified using the following criteria: phase I was characterized by a complete absence of pressure waves. During phase II, pressure waves occurred in irregular sequence; phase III was characterized by a cyclic burst of regular contractions, with a frequency of about 18 per minute and an amplitude greater than 30 cm of H2O at the level of the duodenum and followed by a period of complete quiescence.

Student's t test for paired samples was used in the statistical analysis to compare pyloric motility patterns during the different phases of the IDMC.

### RESULTS

Eleven experiments were performed (three on two dogs, two on one dog, and one on three dogs) with a mean duration of 326 ± 25 min each, ranging from 162 to 419 min.

Intestinal Motility. In all the experiments the intestinal motility showed a regular cyclic sequence of the different phases as previously described. A total of 20 IDMCs were recorded. The mean duration between phase III cycles was 132 ± 1 min, similar to that reported by several authors. The frequency of contractions during the activity front was 18.7 ± 0.3/min. The duration of the phases at the different levels is shown in Table 1.

| TABLE 1. DURATION OF DIFFERENT PHASES OF RECURRING PHASIC ACTIVITY | Minutes (mean ± SEM) |
| --- | --- | --- | --- |
| **Phase I** | **Phase II** | **Phase III** |
| Small bowel | 35 ± 3.8 | 87 ± 12.7 | 11.5 ± 0.6 |
| Pylorus | 28 ± 3.8 | 70.5 ± 14 | 35 ± 4 |

Pyloric Motility. The continuous recording at the pyloric level was characterized by phasic oscillations of pressure, superimposed on an almost invariable basal tone. The phasic oscillations showed a changing pattern similar to cyclic variations described in the small bowel. Thus it was also possible to distinguish three phases at the pyloric level: phase I characterized by uniform waves with an amplitude of 31 ± 2 cm H2O and a frequency of 12.6