EFFECT OF VAGOTOMY AND GASTRIC SURGERY ON GASTRIC EMPTYING

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INTRODUCTION

The past decade has witnessed an exponential growth of knowledge in the field of gastric motility. The elucidation of the clinical problems of gastric emptying is based on remarkable morphophysiologic, clinical , diagnostic, and pharmacotherapeutic advances. The concept of different anatomic areas of the stomach handling different physical phases of gastric contents has allowed new pathophysiologic insight into gastric dysmotility. New diagnostic techniques are clarifying many clinical and postsurgical emptying disorders.

Before the clinical problems of gastric motility after vagotomy and gastric surgery are considered, the physiologic aspects of emptying of the stomach must be reviewed. *[Minami, 1984]*.

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THE PHYSIOLOGY OF GASTRIC EMPTYING

Any Hypothesis regarding gastric emtying must deal with the fact that when a liquid, a digestible solid and an indigestible solid are simultaneously ingested, the pattern of emptying of each component is different. This was clearly shown in experiments by ***Hinder and Kelly [1977]*** in which dogs were given a meal of 400ml 1% dextrose, 50g, cubed liver and 40 plastic spheres[diam. 7mm; sp. gr, 1.6] and the rate of discharge of each component from the stomach into the duodenum was quantitated. The liquid was emptied rapidly; by 1hr. only about 10% of the initial volume of 400 ml dextrose was left in the stomach. The digestible solids emptied more slowly, nearly 4hrs were required for 90% of the liver to empty. In contrast , the indigestible solids were hardly emptied at all during the same interval. The 40 plastic spheres were nearly completely retained, whereas the liquid and the digestible solid were emptied. How does the stomach accomplish this remarkable feat?

An attractive hypothesis is that the gastric emptying of liquid is controlled mainly by promixal gastric contractions, whereas gastric emptying of solids is regulated mainly by distal gastric contractions. To expand on this, the rate of gastric emtying of any component of a

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meal is a fucntion of the difference in pressure between the stomach [Ps] and the duodenum [Pd] and varies with the resistance to flow across the pylcurs [Rp] as ***Nelson and kohatsu [1971]*** pointed out several years ago.

$$= \frac{Ps - Pd}{Rp}$$

The resistance to the flow of liquid across the pylorus is small, so that they empty readily from the stomach, and their rate of emptying is determind mainly by the gradient in pressure between the stomach and duodenum. Because proximal gastric contractions have a major role in regulating intragastric pressure and, therefore the gradient, they have a major role in determining the rate of emptying of liquid. In contrast, the resistance to the passage of solids across the gastric outlet is large, so large, that solids are usually not allowed to leave the stomach. Because contractions of the distal antrum and pylours determine the resistance, they have a major role in controlling emptying of solids. What evidence exists to support the hypothesis ?

TWO GASTRIC REGIONS :

The stomach can be separated in two distinct motor regions, each with a unique physiological function, as *Cannon [1898]* pointed out years ago. Cannon gave mixtures of bismuth subnitrate and food to cats and observed their

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gastric movements fluoroscopically. He identified the proximal stomach as the gastric reservoir. It relaxed to receive boluses of food from the oesophagus and temporarily stored the ingesta. Slow sustained contractions then appeared in the proximal stomach that gradually pressed the gastric content toward the more distal stomach and duodenum. As the gastric content moved into the distal stomach, peristaltic contractions appeared in the gastric region. The peristaltic contractions of the distal stomach thoroughly triturated the content and mixed it with gastric juice. Cannon drew the line of division between the two gastric regions transversely from the greater to the lesser curve at a point midway between the gastroesophageal junction and the pylorus

Recent studies have confirmed and expanded Cannon's concepts. A more modern division of the stomach in its two parts is based on a mapping of the electrical cycles underlying the peristaltic waves of the distal stomach *[Sarana et al., 1972]*. The modern division beigins more proximally on the greater curve and sweeps more obliquely across the stomach to the lesser curve, but the similarity to Cannon is striking. The proximal stomach consists of the true or anatomic fundus and about the orad one-third of the corpus. The distal stomach comprises the remaining corpus, the antrum, and the pylorus.

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Proximal Stomach :

A good deal of evidence exists to support a major role for the proximal stomach in gastric emptying of liquids, but a minor role in emptying of solids.

Emptying of Liquid :

Myoelectrical patterns : The slow, sustained contraction of the proximal stomach are well designed to regulate intragastric pressure and thereby to control gastric emptying of liquids.

The contractile pattern of the proximal stomach can be nicely studied with an innervated but completely separated pouch of the gastric fundus and proximal corpus ***[Okike et al., 1977]***. Changes in pressure within the lumen of such a pouch are due to contractile events in the wall of the pouch itself and are not caused by motor events in the adjacent main stomach.

Two types of phasic contractions are present in the pouch. A slow phasic contraction with a duration of about 3 min and an amplitude of about 30 cm H20 and a faster phasic contraction with a duration of about 10 - 12 seconds and an amplitude of about 10cm H20. Both types of phasic

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contractions are superimposed on a steady-state or "tonic" contraction of about 10cm H2O.

The electrical events underlying the contractions of the proximal stomach is poorly understood. Bursts of rapid spikes occur just before or during the samll rapid phasic changes in pressure in the proximal stomach *[Okik et al., 1977]*. Pacesetter potentials which are found throughout the distal stomach are not present in the proximal stomach *[Kelly et al., 1969 and Sarana et al., 1972]*.

Regulation of Intragastric Pressure :

The proximal stomach has two remarkable motor properties that allow it to carefully regulate intragastric pressure during gastric filling, namely, receptive relaxation and accommodation. Receptive relaxation is a term coined by *Cannon and Lieb [1911]* who noted that the pressure in the proximal stomach declined with the onset of and during swallowing. The proximal stomach relaxes to receive the bolus of ingesta from the esophagus, hence the term receptive relaxation. *Cannon and lieb* further showed that receptive relaxation was mediated by vagal inhibitory fibers activated by swallowing. Accommodation to distention is the process whereby the stomach accepts increasing volumes without greatly increasing intragastric pressure.

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Effect of Resection :

The role of proximal gastric contractions in regulating intragastric pressure and gastric emptying of liquids is illustrated by the operation fundectomy *[Wilbur, 1977]*. In these experiments, just the anatomic gastric fundus was removed in dogs, leaving the gastric corpus and antrum intact. The dogs were carefully studied before fundectomy and again after fundectomy. before fundectomy, the proximal stomach accomadated to distention easily, Keeping intragastric pressure low as the stomach filled to 600-800 ml. In contrast, after fundectomy larger increases in pressure occured during gastric distention, so much so, that with a volume of 400-500 ml in the stomach, the experiment usually had to be stopped because the dogs became uncomfortable and began retching. Removing the fundus impaired accommodation and led to greater increase in intragastric pressure with gastric filling. Moreover, the greater increase in pressure after fundectomy led to more rapid gastric emptying of liquids in each of the dogs studied.

Effect of Vagotomy :

The operation, proximal gastric vagotomy, sheds further light on the regulation of gastric emptying of liquids by proximal stomach *[Wilbur et al., 1973]*. This

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operation vagally denervates the fundus and corpus of the stomach , ' but leaves the antral vagal innervation intact. Gastric accommodation is impaired by proximal gastric vagotomy, just as with fundectomy. Intragastric pressure increases more with gastric distention after the vagotomy than before the vagotomy. The increased intragastric pressure leads to more rapid gastric emptying of liquids both isotonic Nacl and hypertonic glucose empty more rapidly after vagotomy than before.

Effect of Hormones :

The action of the hormone gastrin on the proximal stomach also illustrates the role of the proximal stomach in regulating the intragastric pressure and controlling gastric emptying of liquids.Gastrin profoundly inhibits contractions of the proximal stomach *[Wilbur 1974; Okike et al., 1977]*. The onset of inhibition is prompt, and intraluminal pressure remains low as long as pentagastrin is being given. After stopping pentagastrin, the pressure gradually returns to the control.

The inhibition of proximal gastric contractions and the decrease in intragastric pressure caused by gastrin slows gastric emptying of liquids, as *Hunt and Ramsbottom [1967]* found in human being and was confirmed in dogs *[Dozois, 1971]*. That pentagastrin slows gastric emptying by acting

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on proximal stomach and not on the distal stomach is supported by the fact that the hormone also slowed gastric emptying in dogs with antrectomy. Thus, gastrin inhibits proximal gastric contractions, decreases intragastric pressure and slows gastric emptying of liquids

Cholecystokinin also inhibits proximal gastric contractions, decreases intragastric pressure *[Valenzula, 1976]* and slows gastric emptying of liquids *[Debas, 1975]*. In fact, the effects of cholecystokinin on the proximal stomach are thought to be physiological, whereas those of gastrin many not be. The doses of cholecystokinin required to bring about the effects are less than maximum dose required to stimulate pancreatic secretion *[Debas, 1975]*, whereas the doses of gastrin required to inhibit proximal gastric contractions are larger than those required to maximally stimulate Hcl secretion from the stomach *[Strunz et al., 1980]*.

In contrast to the inhibitory effect of gastrin and cholecystokinin on the contractions of the proximal stomach, motilin stimulates contractions in this gastric region *[Brown, 1971]*. The motilin-induced augmentation of proximal gastric contractions speeds gastric emptying of liquids *[Debas et al., 1977]*.

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Emptying of Solids :

In contrast to its major role in gastric emptying of liquids, the proximal stomach has a minor role in gastric emptying of solids. Although gastric emptying of liquids is speeded by proximal gastric vagotomy, gastric emptying of solid spheres is not altered by the operation ***[Wilbur et al., 1973]***. The antrum and its innervation are not disturbed in proximal gastric vagotomy, and so solids empty normally, whereas complete gastric vagotomy and total abdominal vagotomy, vagally denervate the astrum, weaken antral contractions and slow emptying of solids ***[Wilbur, 1973]***.

In conclusion, the proximal stomach acts as the gastric reservoir. Its slow sustained contractions regulate intragastric pressure, which in turn alters the gastroduodenal gradient in pressure that controls gastric emptying of liquids .

Distal Stomach :

The evidence favors a major role for the distal stomach in gastric emptying of solids, but a minor role in gastric emptying of liquids.

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