Selective Vagotomy of the Parietal Cell Mass:

Part II: With Suprapyloric Mucosal Antrectomy and Suprapyloric Antral Resection

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SELECTIVE vagotomy of the parietal cell mass with preservation of the innervated antrum was evaluated in Part I of this study as an operation for duodenal ulcer designed to prevent the dumping syndrome. The results were successful in preserving normal gastric motility and rhythmic emptying. However, Heidenhain pouch secretion increased significantly because of an increased release of gastrin from the innervated and non-acidified antrum. The additive effects of suprapyloric antrectomy were therefore evaluated in this part of the study to determine the possibility of decreasing the production of gastrin without causing significant alteration in gastric emptying.

Preliminary Studies

Evaluation of suprapyloric antrectomy was stimulated by the studies of Maki *et al.*[8] who reported that simple transection and anastomosis of the stomach 2 cm. proximal to the pylorus, and also proximal antral resection with preservation of the distal 2 cm. of antrum, resulted in no gastric stasis and minimal disturbance of pyloric function. To confirm these results, and also to obtain a control study without vagotomy, the stomach was transected and anastomosed 2 cm. proximal to the pylorus in three dogs. In two other dogs with Heidenhain pouches, suprapyloric antral resection was performed with preservation of the distal 2 cm. of antrum. Postoperative gastric emptying of barium meals (mean, 3.2 hours) was faster than preoperative emptying (mean, 4.6 hours), but cineradiographic studies showed partial preservation of rhythmic gastric emptying in all dogs. The 24-hour Heidenhain pouch secretion in the dogs with suprapyloric antrectomy decreased from a preoperative mean of 22.1 mEq. to a postoperative mean of 4.6 mEq.

These preliminary results suggested the feasibility of combining suprapyloric antrectomy with selective vagotomy of the parietal cell mass. The main concern was that the addition of vagotomy of the proximal stomach would result in gastric stasis, which, in turn, would result in an increased release of gastrin from the residual non-acidified antral remnant.

Material and Methods

Five adult mongrel dogs were provided with Heidenhain pouches. Selective vagotomy of the parietal cell mass was combined with suprapyloric antral resection in two dogs (MS14 and MS15). The proximal line of resection was at the proximal border of the antrum (delineated by an intragastric spray of Congo red as in Part I), and the distal line of resection was 2 cm. proximal to the pylorus. The serosa along the lesser curve of the resected antrum was preserved

Submitted for publication December 12, 1968.

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This study was aided by funds accruing from National Institutes of Health Grant #AMO8094.

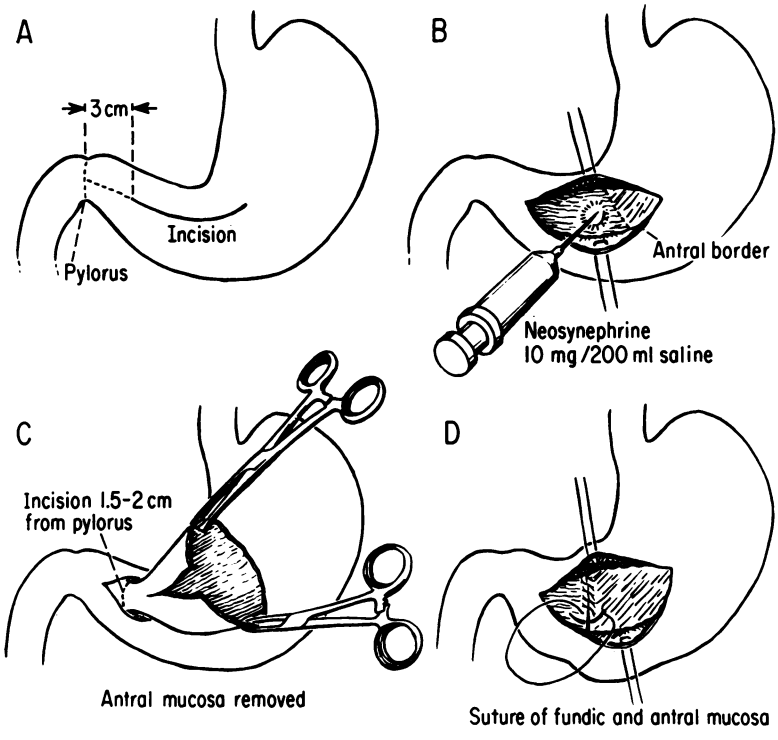

FIG. 1. *Suprapyloric Mucosal Antrectomy:* (A) An 8 to 10 cm. longitudinal gastrotomy is made adjacent to the greater curve. (B) The proximal antral border has been delineated by an intragastric Congo spray of Congo red as described in Part I. A solution of 10 mg. of neosynephrine in 200 ml. of saline is injected into the submucosal layer of the antrum for hemostasis. (C) The proximal antral mucosa is excised leaving intact the distal 1.5 to 2 cm. of antral mucosa. (D) The cut edge of the parietal mucosa is approximated to the cut edge of the antral mucosa with interrupted catgut sutures. This end-to-end anastomosis of the larger proximal lumen to the smaller distal lumen is made possible by the elasticity of the mucosa. The gastrotomy is closed longitudinally with interrupted silk sutures through the seromuscular layer.

in order to avoid injury of the gastric vagi to the distal antrum and pylorus. The proximal parietal and the distal antral remnants were anastomosed end-to-end in two layers. In the other three dogs (MS2, MS9 and MS13) selective vagotomy of the parietal cell mass was combined with suprapyloric mucosal antrectomy which, in contrast to antral resection, preserves all of the innervated antral muscle (Fig. 1). The amount of residual antral mucosa was 1 cm. in dog MS2, 2 cm. in dog MS9, and 3 cm. in dog MS13.

Before and after each procedure the dogs were studied by the same methods described in Part I. Gastric motility and emptying were tested by cineradiographic observations and barium meals. Gastric secretion was evaluated by insulin tests and 24-hour Heidenhain pouch collections. Lastly, completeness of vagotomy was determined by electric vagal stimulation in the presence of circulating neutral red.

Results

Tests for Completeness of Vagotomy

The postoperative insulin response of the main stomach and Heidenhain pouch are presented in Table 1. The responses of the main stomach are positive by both Hollander's criteria [5] and Stempien's criteria [9] in Dogs MS9 and MS15, negative by these criteria in Dog MS14, and positive by Hollander's criteria but negative by Stempien's criteria in Dog MS2. As in Part I, the positive responses are of the small and delayed type indicative of only small areas of residually innervated parietal mucosa. Small areas (less than 1 cm. in greatest dimension) of residual innervation were confirmed by the secretion of neutral red from the most distal parietal mucosa abutting the antrum in Dog MS2 but not in Dogs MS9, MS14 and MS15. Dog MS13 was not tested.

TABLE 1. *Insulin Responses of Main Stomach and Heidenhain Pouch*

	Half-hourly Secretions After Insulin Injected at 0 Hour									Blood Sugar (mg./100 ml.)		
											After Insulin	
	Basal ½–0	0–½	½–1	1–1½	1½–2	2–2½	2½–3	3–3½	3½–4	Before Insulin	½ Hr.	2 Hrs.
Dog MS2												
Stomach												
ml.	3.1	0.6	4.5	3.4	2.5	0.3	0.2	0.2	0.0	61	38	54
pH	7.5	7.9	7.2	4.3	3.9	4.7	4.7	5.0	—			
mEq./l.	0.0	0.0	0.0	19.	25.	30.	4.2	3.0	0			
mEq.	0.0	0.0	0.0	0.06	0.06	0.0	0.0	0.0	0.0			
Pouch												
ml.	0	0	0	0	0	0	0	0	0			
pH	—	—	—	—	—	—	—	—	—			
Dog MS9												
Stomach												
ml.	0.	3.0	14.6	18.2	4.2	0.6	0.5	0.3	0.0	66	45	62
pH	—	7.5	6.4	3.5	3.6	4.3	4.4	4.8	—			
mEq./l.	—	0.0	6.	19.	23.	10.	—	12.	—			
mEq.	—	0.	0.08	0.34	0.09	0.	—	0.	—			
Pouch												
ml.	0.	0.3	0.2	1.4	0.8	0.2	0.4	0.4	0.1			
pH	—	3.6	3.9	3.2	3.2	3.3	3.7	4.1	4.5			
Dog MS14												
Stomach												
ml.	4.1	5.3	4.2	4.4	1.9	2.0	4.7	6.8	5.3	59	28	64
pH	4.8	4.4	4.1	3.7	3.8	4.4	7.0	7.7	8.0			
mEq./l.	9.	22.	22.	25.	22.	15.	0.	0.	0.			
mEq.	0.04	0.11	0.09	0.11	0.04	0.03	0.	0.	0.			
Pouch												
ml.	0	0	0	0	0	0	0	0	0			
pH	—	—	—	—	—	—	—	—	—			
Dog MS15												
Stomach												
ml.	3.3	0.8	11.7	7.7	1.4	0.2	6.2	0.6	1.0	66	30	56
pH	4.1	3.8	2.9	2.9	3.4	4.3	4.0	4.1	4.1			
mEq./l.	15.	38.	59.	63.	59.	—	27.	—	20.			
mEq.	0.05	0.03	0.68	0.48	0.08	—	0.16	—	0.0			
Pouch												
ml.	0	0	0	0	0	0	0	0	0			
pH	—	—	—	—	—	—	—	—	—			

TABLE 2. *Rates of Gastric and Intestinal Emptying of Barium Meal*

Dog No. and Time of Study	Stomach Empty	Barium First in Colon	All Barium in Colon
MS2			
Preoperative	3 h.p.c.	2 h.p.c.	3 h.p.c.
Postoperative			
5 weeks	4 h.p.c.	2 h.p.c.	4 h.p.c.
8 weeks	3 h.p.c.	2 h.p.c.	3 h.p.c.
MS9			
Preoperative	3 h.p.c.	3 h.p.c.	4 h.p.c.
Postoperative			
4 weeks	4 h.p.c.	3 h.p.c.	4 h.p.c.
8 weeks	3 h.p.c.	2 h.p.c.	3 h.p.c.
MS13			
Preoperative	6 h.p.c.	5 h.p.c.	7 h.p.c.
Postoperative			
4 weeks	3 h.p.c.	2 h.p.c.	3 h.p.c.
MS15			
Preoperative	5 h.p.c.	3 h.p.c.	5 h.p.c.
Postoperative			
4 weeks	4 h.p.c.	2 h.p.c.	4 h.p.c.
8 weeks	4 h.p.c.	2 h.p.c.	4 h.p.c.

Gastric Emptying and Motility

The pre- and postoperative rates of gastric emptying with barium meals are shown in Table 2. In the dogs with suprapyloric mucosal antrectomy, the rates were the same in Dogs MS2 and MS9 but in Dog MS13 the stomach emptied faster postoperatively than preoperatively. In the dogs with suprapyloric antral resection, gastric stasis was observed in Dog MS14; stenosis at the anastomosis was found at autopsy, and this dog is therefore excluded from further consideration. In the other dog (MS15) postoperative gastric emptying was slightly faster than preoperative emptying.

The cineradiographic observations showed preservation of some rhythmic emptying of the stomach in all dogs. However, antral peristalsis was less propulsive after all operations; the barium left the stomach in a more continuous stream and the duodenal bulb did not fill or empty as completely as before operation. This partial loss of rhythmic gastric emptying was least pronounced in the dogs with suprapyloric mucosal antrectomy and most pronounced in the dogs with suprapyloric antral resection.

Heidenhain Pouch Secretions

The means and standard deviations of each dog before and after operation are presented in Table 3. Dogs MS2, MS9, and MS15 with 1 and 2 cm. of residual antral mucosa secreted less acid after operation than before. Dog MS13 with 3 cm. of residual antral mucosa secreted more acid. The differences in pre- and postoperative secretion were statistically significant in all dogs.

Discussion

Maki *et al.*[8] performed suprapyloric antral resection in patients with gastric but not duodenal ulcers. Their postoperative cineradiographic films, shown to us by Shiratori of Maki's group, demonstrated an adequate gastric reservoir that emptied rhythmically; neither dumping nor stasis occurred. They have not performed this operation for duodenal ulcer because of an inadequate decrease in gastric secretion by suprapyloric antrectomy alone. However, our results with suprapyloric antrectomy plus selective vagotomy of the parietal cell suggest that this combination may be applicable to duodenal ulcer which is uncomplicated by hemorrhage or perforation or obstruction.

The level of 2 cm. proximal to the pylorus for suprapyloric antrectomy appears to be of critical importance from the standpoints of both gastric secretion and emptying. In regard to the 2-cm. level and secretion, the dogs with 1 to 2 cm. of residual antral mucosa showed a significant reduction in acid output from their Heidenhain pouches but the dog with 3 cm. of residual antral mucosa did not. The results with 2 cm. or less of residual antral mucosa indicate that reduction of secretion by removing the source of gastrin does not require excision of *all* of the antral mucosa, as was done by

Flynn and Longmire [3] and Killen and Symbas [6] by means of stripping the mucosa away from the distal antral muscle and out of the pyloric ring. In regard to the 2 cm. level and gastric emptying, Maki *et al.*[8] demonstrated in dogs that transections and resections less than 2 cm. from the pylorus eliminated pyloric sphincteric function, whereas transections and resections greater than 2 cm. from the pylorus resulted in gastric stasis. Wangensteen also reported gastric stasis in his early clinical experience with segmental gastric resection, and later reported the need for pyloroplasty.[11] In contrast, with suprapyloric antrectomy at the 2-cm. level in the present study, sphincteric function was partially preserved and no gastric stasis occurred except in the dog with the technical failure due to stenosis at the anastomosis. That the addition of vagotomy of the proximal stomach did not produce gastric stasis seems noteworthy, particularly in the dog with suprapyloric antral resection. (In another dog with suprapyloric mucosal antrectomy, anterior truncal vagotomy was performed and severe gastric stasis resulted; this dog was excluded from this report.)

These experimental results of selective vagotomy of the parietal cell mass plus suprapyloric antrectomy are superior to the clinical results of an approximately two-thirds segmental resection with preservation of the antrum and its vagal innervation plus preservation of vagal innervation to the proximal parietal remnant described by Ferguson *et al.*[2] Despite preservation of the innervated antrum and pylorus with this two-thirds segmental resection, the dumping syndrome occurred because of a significant reduction in the size of the stomach as demonstrated by Symbas et al.[10] The amount of stomach resected by suprapyloric antrectomy is considerably less, and does not significantly reduce the function of the stomach as a reservoir to the point of rapid gastric emptying and dumping. In addition, Ferguson [1] later reported a rate of recurrent ulcer comparable to the Billroth II resection; recurrent ulcers were presumably due to a high secretory potential of the innervated antrum, as in Part I of this study, and also due to a high secretory potential of the innervated parietal remnant. In contrast, the secretory potential of the distal 2 cm. of antral mucosa and the denervated parietal cell mass is quite low after suprapyloric antrectomy and selective vagotomy of the parietal mucosa.

TABLE 3. *Twenty-four Hour Heidenhain Pouch Secretions*

Dog	Mean mEq./24 hrs.		Comparison by Student t Test
	Preop.	Postop.	
MS2	20.66 ± 7.63	7.32 ± 3.10	t 8.79 $p < 0.005$
MS9	58.42 ±5.11	21.60 ± 3.12	t 10.71 $p < 0.005$
MS13	33.58 ±15.36	54.28 ±15.38	t 4.25 $p < 0.005$
MS15	8.12 ± 3.62	4.36 + 2.82	t 4.08 $p < 0.005$

Clinical application of selective vagotomy of the parietal cell mass plus suprapyloric antrectomy may be seriously questioned on the basis of unacceptable technical difficulty. Although Hart [4] demonstrated the technical feasibility of selective vagotomy of the parietal cell mass, and Kirk [7] the feasibility of complete mucosal antrectomy, the combination of these two procedures would be more arduous and tedious than any of the currently conventional operations. Suprapyloric antral resection is more attractive than suprapyloric mucosal antrectomy because of greater technical ease. Furthermore, it is possible that gastric vagal innervation of the distal 2 cm. of antrum may be insignificant after suprapyloric antral resection plus selective vagotomy of the parietal cell mass. This possibility raises the question whether suprapyloric antral resection may be combined with the easier selective or truncal technics of com-

plete vagotomy of the stomach. This question is under current investigation.

Summary and Conclusions

Gastric motility and secretion were studied before and after selective vagotomy of the parietal cell mass plus suprapyloric antrectomy in Heidenhain pouch dogs. When 2 cm. of distal antral mucosa was left intact with suprapyloric mucosal antrectomy, and 2 cm. of distal antrum left intact with suprapyloric antral resection, no gastric stasis occurred and some but not all of the normal rhythmic gastric emptying was preserved. Gastric motility was altered less by suprapyloric mucosal antrectomy than by suprapyloric antral resection. In addition, with only 2 cm. of distal antral mucosa or antrum preserved, Heidenhain pouch secretion decreased.

It was concluded that these procedures show promise of controlling the diathesis of duodenal ulcer and eliminating the dumping syndrome, but further investigation is indicated before recommending their clinical application.

Acknowledgments

The authors wish to thank Mr. Zoltan Zelenak, Mr. John Williams and his staff, and Miss Marion Hunner and her staff for their capable assistance throughout this study.

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