

SECTION OF THE VAGUS NERVES TO THE STOMACH IN THE TREATMENT OF PEPTIC ULCER*†

Complications and End Results After Four Years

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and by invitation

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DURING THE PAST FOUR YEARS, division or resection of the vagus nerves to the stomach as a method of treatment has been employed in the Department of Surgery of the University of Chicago on 212 patients with various types of peptic ulcer. One patient died of aspiration pneumonia, making an operative mortality of something less than one-half per cent. Although a careful watch was made, no gross evidence of any serious disturbance that could be ascribed to a vagus reflex was encountered. The theoretical background for employing this procedure in the treatment of peptic ulcer has been presented in previous publications from this clinic.¹ It is the purpose of the present communication to describe the complications and end results of vagus section for peptic ulcer in 160 patients who were operated on by us during the four years from January 18, 1943, to January 1, 1947. In these 160 patients, the vagus section was complete in 142 cases as evidenced by a reduction in the night secretion of gastric juice, a decrease of over 60 per cent in the total hydrochloric acid output from the stomach, and a negative secretory response to insulin hypoglycemia. Persistence or recurrence of ulcer symptoms has not been seen in any of these patients, and at the present time, all of them are free of ulcer distress without medication or any type of dietary restriction. In most cases, there is also satisfactory objective evidence that the ulcers have healed. In the 18 patients where physiologic tests have indicated that the vagus section was not complete, 13 have remained free of ulcer symptoms without medication or dietary restriction. In the remaining five, persistence or recurrence of ulcer symptoms in varying degree have been observed. In two of the patients, the symptoms were sufficiently severe so that our proposal for a reoperation was accepted. One of these patients had been operated upon by the transthoracic and one by the transabdominal approach. Reoperation in each case was done by the transabdominal method. In both instances, a remaining vagus fiber was found and sectioned. The results are summarized in Tables I and II. In three of the patients where recurrence of symptoms has been observed, these have been so mild that no treatment has been desired. The 13 patients in whom we

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have reason to believe that the vagotomy was incomplete, but who at present are free of ulcer symptoms without medication or dietary restriction, are being watched with great interest. It seems probable on the basis of present information that to be effective, the vagus section must be complete, and that recurrence or persistence of ulcer symptoms may occur if even a small vagus fiber to the stomach has been overlooked. This observation is of interest when correlated with the effect of vagus section on gastric secretion. Section of one of the vagus nerves in dogs has no effect on the volume, acidity, or total output of acid in the gastric secretion. In man, apparently the persistence of a small vagus fiber after section of two of the larger vagal trunks permits the continued excessive night secretion characteristic of the ulcer patient. The remaining vagus fiber appears to be able to activate the entire glandular apparatus, acting presumably through the submucous plexus of Meissner.

TABLE I

Patient J. S.	Male	Age 57			
Five-year history of duodenal ulcer with two massive hemorrhages.					
<i>September 10, 1945</i> TRANSTHORACIC VAGOTOMY					
Night Secretion	Volume	Free Acid	HCl Output	Insulin Test	
Preoperative.....	1,375 cc.	24	34 m.e.	Pos.	
Postoperative.....	1,065 cc.	36	38 m.e.	Neg.	
Patient entirely well in the interim, on full diet and without medication.					
November 23, 1946 Silent massive hemorrhage.					
<i>December 12, 1946</i> TRANSABDOMINAL VAGOTOMY					
Night Secretion	Volume	Free Acid	HCl Output	Insulin Test	
Preoperative.....	1,200 cc.	62	74 m.e.	Pos.	
Postoperative.....	640 cc.	23	15 m.e.	Neg.	

TABLE II

Patient L. H.	Male	Age 42			
Six-year history of duodenal ulcer.					
<i>October 10, 1946</i> TRANSABDOMINAL VAGOTOMY					
Night Secretion	Volume	Free Acid	HCl Output	Insulin Test	
Preoperative.....	970 cc.	13	13 m.e.	Pos.	
Postoperative.....	858 cc.	29	25 m.e.	Pos.	
Relief of symptoms for one month post-operatively. Then recurrence of all previous symptoms.					
<i>January 3, 1947</i> TRANSABDOMINAL VAGOTOMY					
Night Secretion	Volume	Free Acid	HCl Output	Insulin Test	
Preoperative.....	870 cc.	18	16 m.e.	Pos.	
Postoperative.....	410 cc.	0	0	Neg.	

Where the vagotomy has been complete, there is to date no evidence of regeneration of the secretory fibers in the vagus nerves. Re-examination of these patients has been made at intervals by measuring the night secretion of gastric juice, the total hydrochloric acid output, and the secretory response to insulin hypoglycemia and the sham meal. Since an interval of three and four years has elapsed in a number of these patients, it seems quite probable that the nervous phase of gastric secretion has been permanently abolished. The evidence obtained from the experimental laboratory on the pathogenesis of peptic ulcer suggests that the ulcers will not recur unless the previous excessive secretion returns. The outlook is accordingly much more favorable than the present limited period of clinical observation would justify.

POSTOPERATIVE MANAGEMENT

The complications following gastric vagotomy for peptic ulcer have been for the most part transitory and inconsequential. In 61 patients, the vagus section was performed by a transthoracic operation. One of these patients developed an aspiration pneumonia which proved fatal. This was the only death in the series and occurred early in our experience. There have been no deaths in the last 150 vagotomies. A pleural effusion requiring aspiration was encountered in six patients. In no case did this effusion become infected. Inter-costal pain in the region of the incision proved troublesome in ten patients, and in these, persisted for a period of two to four weeks.

Gastric Retention. It is probable that a delay in the emptying of the stomach occurs in all patients following section of the vagus nerves. This delay produced transitory symptoms in 19 of the 61 patients in whom a transthoracic vagotomy was performed. In four the gastric retention was severe enough to necessitate a gastroenterostomy within two or three months following the vagus section. In each of these cases, cicatricial obstruction at the pylorus was found. The necessity for a second operation in these four patients prompted us two years ago to explore the possibility of securing a complete vagus section by a transabdominal approach. The remarkable elasticity of the esophagus, which was appreciated in the transthoracic operation, suggested that it ought to be possible to pull the esophagus downward into the abdomen sufficiently to permit careful exploration of its lower three or four inches. We are now convinced that it is just as possible to secure a complete section of the vagus nerves to the stomach by a transabdominal operation as can be secured by the transthoracic approach. The method that we presently employ is best described in a series of diagrams and drawings (Figs. 1-4). We prefer the transabdominal operation at the present time because it is possible to deal with cicatricial obstruction at the pylorus at the same procedure. Of the patients who were operated upon by the abdominal route to January, 1947, in 64 cases, the abdominal vagotomy was accompanied by a posterior gastroenterostomy, while in 35 patients, a vagus section alone was performed. In the first patients, the gastroenterostomy was added as a routine in all patients with duodenal ulcer, but for the past year, it has been employed only when pyloric obstruction has been indicated either by clinical symptoms or fluoroscopic findings. At the present time, posterior gastroenterostomy is being performed in approximately one-third of the patients for whom a transabdominal vagus section is done for duodenal ulcer. In the 35 patients with duodenal ulcer in whom vagus section alone was performed, 19 patients displayed transitory symptoms of gastric retention. Two subsequently required a gastro-enterostomy because of cicatricial obstruction at the pylorus. Of the 64 patients in whom a gastroenterostomy was performed at the time of the abdominal vagotomy, eight patients showed transitory symptoms of gastric retention but have subsequently remained well.

Stomach Motility and Tonus. It is probable that more difficulty would have been encountered from the decreased tonus and motility of the stomach

produced by vagus section had its possibility not been anticipated and measures taken to prevent it. The stomach like the heart and the amphibian lung possesses a local automatism which is largely due to its relation to Auerbach's plexus. This makes it possible for the stomach to display its normal motility after all extrinsic nerves have been severed, or even after the stomach has been removed from the body. Under normal conditions, however, its activity is under the influence of two sets of extrinsic nerves. In general, the vagus nerves exert an inhibitory influence over the motor activity of the cardia, an

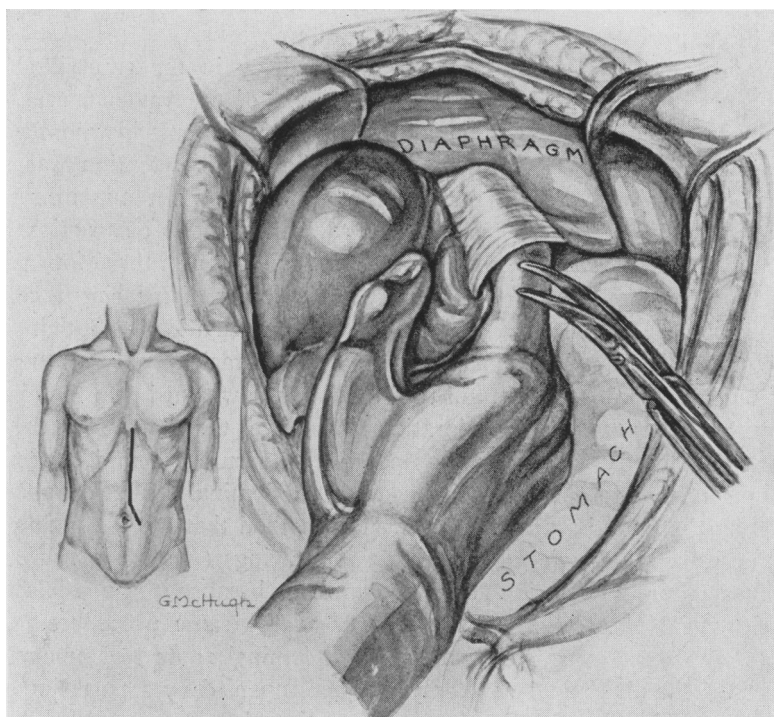


FIG. 1.—The abdomen is opened through a high left paramedian incision. The triangular ligament to the liver is divided.

augmented influence on the body of the stomach, and an inhibitory influence on the pylorus. In general, the effect of the sympathetic is antagonistic to that of the vagus. A sudden removal of the tonic effect of the vagus nerves leaves the inhibitory influence of the sympathetics unopposed, and the end result is to cause a marked inhibition in the tonus and motility of the stomach. This makes the stomach very susceptible to the dilating effect of swallowed air or accumulated secretion, and if care is not taken, an acute dilatation can quite readily be produced. After a period of time which varies in different patients, a readjustment of the peripheral motor mechanism occurs, and the motility of the stomach returns toward its normal state. It is likely that it never regains the hypertonus and hypermotility so commonly found in ulcer patients. It has been

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our practice to guard against distention of the stomach during the immediate postoperative period by maintaining gastric decompression by means of a Levine tube and the Wangensteen suction apparatus for a period of five days following the vagus section. This is perhaps the most important single item in postoperative care. After the five-day period, the patient is given small amounts of water, and at the end of 12 hours, the stomach is aspirated to

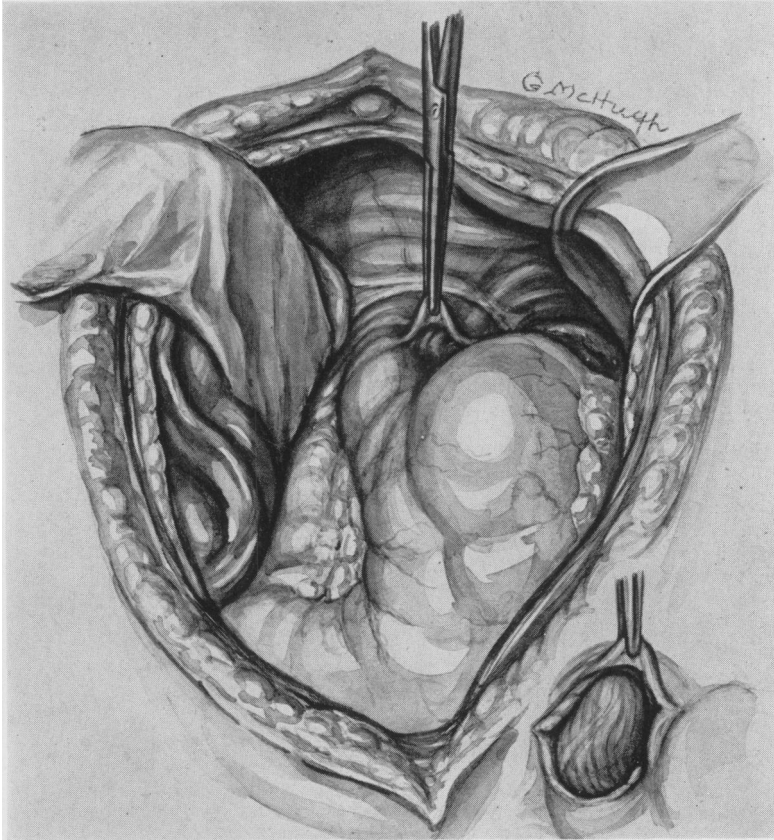


FIG. 2.—The left lobe of the liver is retracted to the right, and the peritoneum over the esophagus at the margin of the diaphragm is divided and the hiatus opened.

determine if retention has occurred. If the stomach is not emptied, decompression is instituted and maintained for another 24 to 48 hours. Only when the stomach empties itself satisfactorily of liquid content is the patient permitted to ingest solid food. The amount ingested at any one feeding is limited, and the patient is cautioned not to overload the stomach during the first two or three months after the operation. In several patients, we have felt that the return of function or readjustment of the peripheral motor mechanism of the stomach was facilitated by giving the patient ten mg. of urecholine from an hour to 30 minutes before the ingestion of food. This drug produces a long

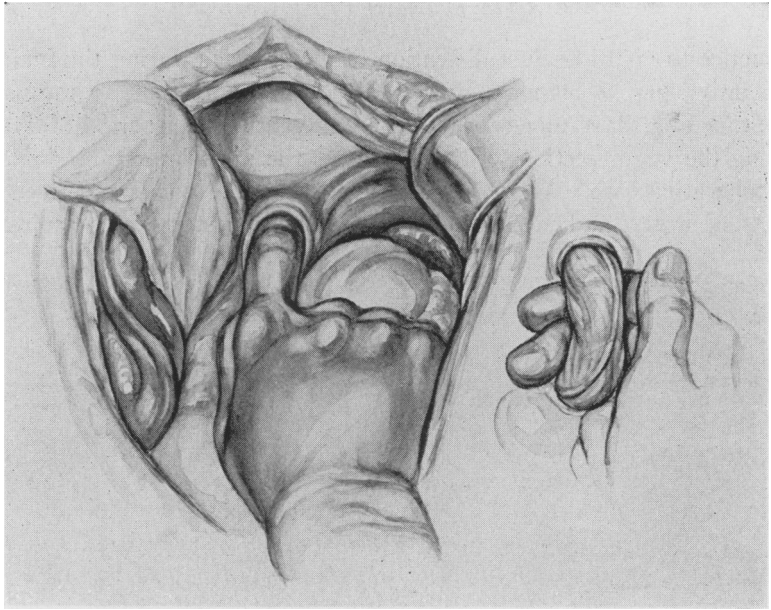


FIG. 3.—The finger is introduced over the esophagus into the mediastinum, the esophagus mobilized by careful finger dissection and pulled downward into the abdomen for a distance of 2 to 3 inches.

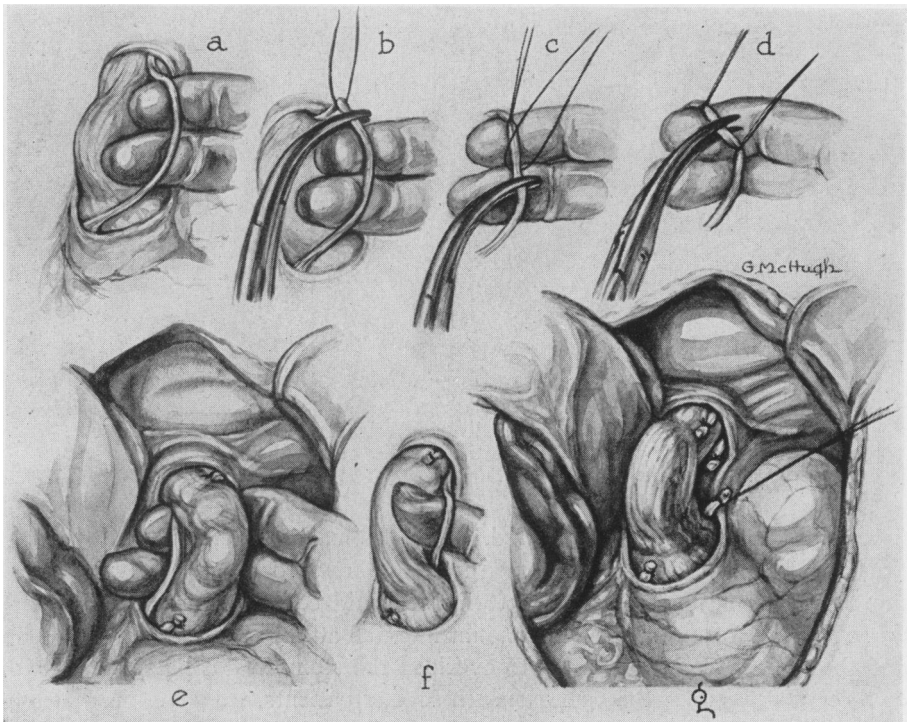


FIG. 4.—The vagus nerves are separated from the esophagus by finger dissection, ligated with nonabsorbable suture material, divided, and a segment 4 to 6 centimeters in length excised.

continued increase in the motility of the stomach probably through stimulation of the peripheral neuromotor mechanism. That this readjustment in gastric motility can be confidently expected is indicated by the fact that none of the patients who were operated upon by us during the first three years are at present experiencing any difficulty on this score.

Alteration in the bowel habit was encountered in 25 of the 61 patients who underwent transthoracic section of the vagus nerves. In 18 of these patients, the effect was slight and transitory and usually elicited only by question. In seven patients, however, there was a moderately severe diarrhea, in some cases lasting from two to five weeks after the operation. This diarrhea was usually episodic in character with frequent long intervals of freedom between attacks. There appeared to be an association between the diarrhea and symptoms of gastric retention. The cause of this diarrhea has not been fully determined. Since division of the vagus nerves removes the augmenting influence of this system from the tonus and motility of the small intestine and the proximal half of the colon, a change in the bowel habit in the direction of stasis or constipation was anticipated. To our surprise, this has not been encountered in a single patient. It is doubtful if the diarrhea can be ascribed to an increased motility of the small intestine and colon due to removal of vagal influences since it is most likely that this occurs in every patient who undergoes a partial or subtotal gastric resection. A consideration of the anatomy of the vagus nerves to the stomach makes it seem very probable that the usual type of gastric resection removes the vagus innervation from all structures below the stump of stomach that remains. The gastric contents following complete vagotomy usually contain no free acid during the digestive period when food is present in the stomach. The removal of the antiseptic action of the free acid of the gastric juice probably makes these patients more susceptible to diarrheas of bacterial origin. The situation here may be similar to that obtaining in patients with anacidity from other causes such as pernicious anemia. Retention in the stomach in combination with this anacidity makes fermentation possible and the consequent elaboration of various irritant organic acids. In the 64 patients with duodenal ulcer in which an abdominal vagotomy plus gastroenterostomy was performed, diarrhea, slight and transitory in character, was encountered in only four patients. Since gastric retention was less evident in these patients than in those with vagotomy alone, it seems likely that this factor is of some significance in the cause of the diarrhea. The diarrhea has usually subsided promptly when gastric decompression has been resumed. Spontaneous recovery from the diarrhea has usually accompanied readjustment of the motor activity of the vagotomized stomach and intestines, and none of the early patients are experiencing any difficulty on this account.

In the dog, section of the vagus nerves high in the chest or in the cervical region almost invariably produces a high grade and long continued spasm of the cardia and of the pylorus. For this reason, it is of great interest that we have not encountered spasm of the cardia in a single patient following vagus section. This is probably due to the fact that the vagi are usually

divided a short distance above the diaphragm. It is quite possible that damage to the vagus nerves higher up might produce spasm of the cardia in man as it does in the lower animals. In two patients, edema of the lower esophagus, probably due to the trauma of the operation, caused temporary dysphagia. The passage of the esophagoscope promptly gave relief without recurrence.

In summarizing our experiences with complete section of the vagus nerves to the stomach in the treatment of peptic ulcer, it appears clear that this operation, as we have described it, abolishes permanently the nervous phase of gastric secretion, and likewise removes the augmenting influence of the vagus nerves on the tonus and motility of the stomach and small intestines. It is probable that both the effect on gastric secretion and on motility exert a favorable effect on the healing of peptic ulcers. It is probable that the depressant effect on the secretion of gastric juice is the more important factor in bringing about the healing of the lesion. The decrease in the tonus and motility of the stomach probably also exerts a beneficial influence in the same direction, and undoubtedly contributes much to the relief of the distress which these patients experience. Both of these effects are likewise mainly responsible for the undesirable sequelae and complications of the operation. We should like to emphasize, however, that these complications in our experience have been self-limited, and for the most part inconsequential as compared to the complications that have been described following subtotal gastrectomy for peptic ulcer.

One of the most conspicuous effects of section of the vagus nerves to the stomach in patients with peptic ulcer is the immediate, complete, and apparently permanent relief of the ulcer distress that is produced. We have frequently called attention to this phenomenon which is so marked that in our early experience led us to speculate on the possibility that the stomach had been rendered anesthetic by the operation. Subsequent experience, however, has convinced us that this is not the case. In the operations that have been performed by the transabdominal route, the anesthetic has been for the most part continuous spinal. Under these conditions, mobilization, pinching, ligating, and dividing the vagus nerves have not produced any sensation. A more crucial experiment, however, has been performed on five patients who had very severe ulcer pain when they came to the hospital. In these patients, it was found that aspiration of the gastric content usually provided immediate relief. The reintroduction in the stomach of 200 cc. of .5 per cent hydrochloric acid solution caused an almost immediate reappearance of typical ulcer pain and distress. Following the operation, all of these patients were immediately and completely relieved. Usually on the third day following the operation, without the knowledge of the patient, the Wangenstein suction apparatus was discontinued, and 200 cc. of .5 per cent hydrochloric acid solution was instilled into the stomach. Within a period of one to nine minutes, the former typical ulcer distress reappeared in all of its former severity. While this experiment does not necessarily prove that the ulcer pain and distress is due directly to the free hydrochloric acid, since the motility of the stomach was not simultaneously

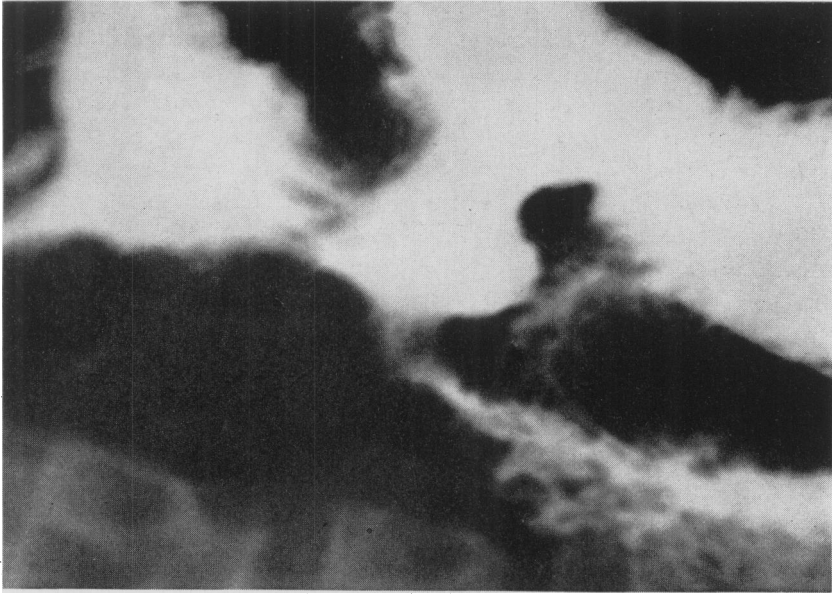


FIG. 6.—X-ray film showing definite decrease in gastrojejunal ulcer crater 25 days after transthoracic vagotomy.

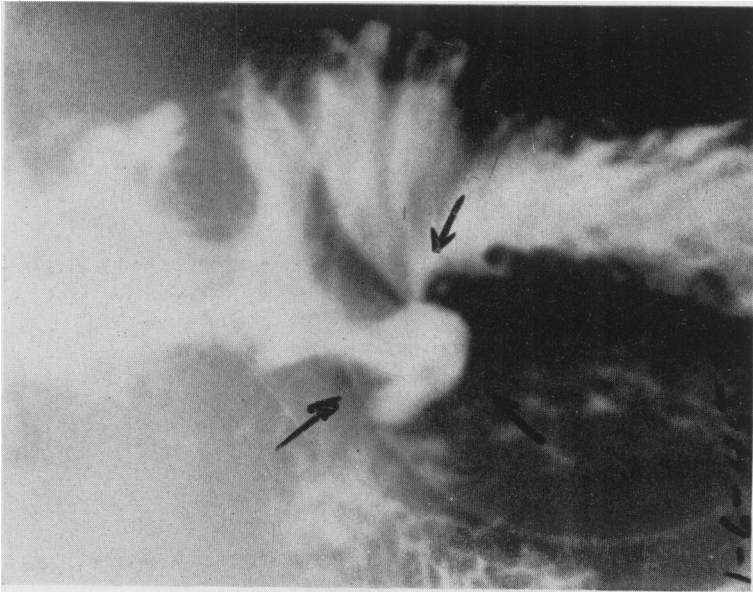


FIG. 5.—X-ray film showing a large gastrojejunal ulcer crater following antral exclusion and subtotal gastric resection.



FIG. 8.—X-ray film showing absence of gastrojejunal ulcer crater 21 months after transthoracic vagotomy and also retrograde filling of the duodenum and antrum of the stomach.

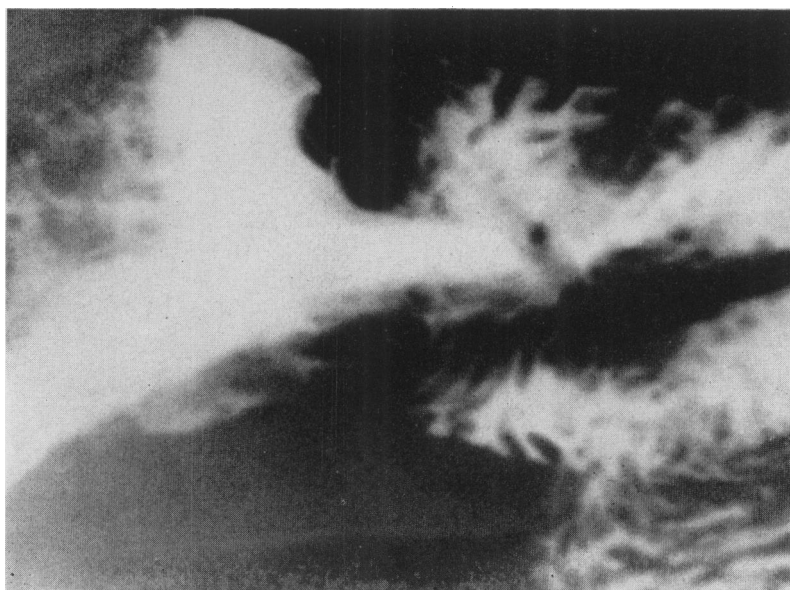


FIG. 7.—X-ray film showing complete disappearance of gastrojejunal ulcer crater 47 days after transthoracic vagotomy.

studied, it does indicate that the stomach has not been rendered anesthetic by the operation.

The beneficial effect of vagus section in the healing of peptic ulcer is especially well illustrated in 14 of our patients in whom this operation was done for recurrent gastrojejunal ulcer following either gastroenterostomy or subtotal gastric resection. A detailed report of these findings has been published elsewhere. We should like to refer here to an additional patient with a gastrojejunal ulcer who presents some features that are of special interest. The patient, a male, age 36, was first seen on August 29, 1938. For the previous two months, he had been complaining of typical ulcer distress, and x-ray examination revealed a duodenal ulcer with a crater. Symptoms were controlled for a time on medical management but recurred in severe form in 1943, and surgery was requested. At operation, a large, chronic, duodenal ulcer penetrating into the pancreas was found. Because of the extensive involvement, a Finsterer-Devine type of exclusion operation was performed with subtotal gastric resection. Six months after the operation, a recurrence of symptoms developed, and a gastrojejunal ulcer was demonstrated at x-ray. X-ray therapy to the stomach was then given with relief of symptoms, and there was apparent disappearance of the ulcer crater. The symptoms recurred in six months, and the pain became more severe. X-ray examination again revealed an ulcer crater (Fig. 5). On March 23, 1945, a transthoracic supra-diaphragmatic section of the vagus nerves was performed. Recovery was uneventful, and the patient was entirely relieved of ulcer distress. X-ray examination on April 16, 1945, revealed definite decrease in the size of the ulcer crater (Fig. 6), and on May 9, 1945, complete disappearance of the crater (Fig. 7). He remained well, resumed his former occupation, and was able to eat an entirely unrestricted diet without any type of medication. Fluoroscopic examination of the stomach was made in December, 1946, and the findings proved to be most interesting (Fig. 8). The film shows no trace of an ulcer crater, and the stomach and jejunum are well outlined with barium. Of great interest is the demonstration of a retrograde passage of the barium through the duodenum, the pylorus, and into the antrum of the stomach, which was left behind at the time of the operation. The increased incidence of gastrojejunal ulcer following gastric resection in which the antral mucosa is left unremoved has been well recognized. The explanation offered for the high incidence of jejunal ulcers in these cases is that this mucosa makes possible the continued excessive secretion of gastric juice, presumably through the elaboration of gastrin as called for in the hypothesis of Edkins. The work of Edkins, however, indicated that gastrin is liberated from the antral mucosa only on contact with food. Here is visual evidence that a retrograde passage of the gastric content through the duodenum, through the pylorus, and into the antrum, can occur, which fulfill the requirements for the liberation of gastrin and its stimulating action on the gastric glands. It is significant, therefore, that in this patient a large jejunal ulcer healed following complete

vagus section, even though that part of the humoral mechanism for gastric secretion controlled by the antral mucosa was still present.

SUMMARY AND CONCLUSIONS

During the period from January 18, 1943, to March 1, 1947, division or resection of the vagus nerves to the stomach as a method of treatment has been employed in the University of Chicago Clinics in 212 patients with various types of peptic ulcer. One patient died of aspiration bronchopneumonia, and there have been no deaths in the last 150 vagotomies performed. Adverse reflex effects that might be ascribed to stimulation of the vagus nerves have not been seen. The clinical results of the operation have been excellent and have led us to the impression that a benign peptic ulcer may be regularly expected to heal if all the vagus fibers to the stomach are divided. This is best accomplished by exposure of these nerves along the lower esophagus by either a transabdominal or a transpleural approach. The transabdominal operation has the significant advantage that it makes possible inspection and palpation of the lesion and the performance of a gastroenterostomy should cicatricial obstruction at the pylorus be present. Gastric vagotomy abolishes the nervous phase of gastrin secretion and decreases very markedly the total amount of gastric juice produced. These effects appear to be permanent. Evidence of regeneration of the secretory fibers in the vagus nerves has not been observed even in the patients operated upon four years ago. These findings suggest that regeneration of the divided vagus fibers will not prove to be a troublesome feature of this type of operation. Complications and undesirable sequelae that have been encountered are intercostal pain or neuralgia, pleural effusion, pulmonary atelectasis, delayed emptying of the stomach, and diarrhea. For the most part, these complications have been mild and self-limited. Careful attention to post-operative care reduces the incidence and severity of most of them. Persistence of ulcer symptoms has been observed in five patients, and in these, physiologic tests have indicated that not all the vagus fibers were divided. In two of these patients, a second operation was performed, and a residual vagus fiber was discovered and divided.

These findings suggest that to be effective in abolishing the nervous phase of gastric secretion and causing the healing of benign peptic ulcers, removal of the vagus innervation of the stomach must be complete. It is probable that the poor results secured by the early workers in this field are due to the fact that attempts were made to section the vagus nerves in operations directed at the stomach instead of the esophagus and thus were in all probability incomplete. The necessity of repeated physiologic tests to determine residual vagal innervation of the gastric glands is clear and should be emphasized.

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DISCUSSION.—DR. KEITH S. GRIMSON, Durham, N. C.: I wish to thank Dr. Walters and Dr. Firor for arranging the privilege of the floor, and to congratulate Dr. Dragstedt, Dr. Moore, Dr. Walters and Dr. Griswold on their excellent studies. There can be little doubt now that Dr. Dragstedt's reintroduction of vagotomy has profoundly influenced surgical management of ulcer. This is best evidenced by the 500 cases reported this afternoon including our 77, and by the continuing use of vagotomy by each author even though few cases have been followed for more than two years.

Since vagotomy is in a stage of evaluation, I should like to express agreement with certain observations presented. First, with very few exceptions healing or quiescence of ulcer occurred. Failure in two of our patients necessitated secondary subtotal gastric resection. Second, changes of acidity and motility have been variable, but usually acidity of fasting gastric content and response to histamine or insulin hypoglycemia have been reduced and emptying of the stomach delayed. There has been some evidence that some but not all of these variations may be caused by incomplete vagotomy. Excellent clinical results have occurred, however, in patients with a positive insulin test. Since changes of secretion and motility usually persisted in patients studied for two or three years, regeneration is not likely to be a limiting factor.

Unfortunately we have had more trouble with complications than most. Greatest has been the necessity for performing seven secondary gastroenterostomies, or one among each seven patients who did not already have enterostomy. Gastric retention six hours after taking barium has been greater than 30 per cent in all patients without gastroenterostomy and often 50 to 90 per cent. It is our belief that physiologic obstruction of the outlet of the stomach occurred and was a more important cause of retention than scarring from ulcer. Resting intragastric pressure or tone, according to our observations, increased slightly after vagotomy. Gastric retention was relieved by gastroenterostomy or occasionally by urecholine or doryl. Diarrhea occurred in some patients. Although complications have been serious at times, most patients are relieved of symptoms of ulcer, satisfied and able to work. Only a few have not gained weight. At the present time we are employing subdiaphragmatic vagotomy with pyloroplasty, exclusion or gastrojejunostomy for duodenal ulcer, and reserving transthoracic vagotomy alone for stomach ulcer.

DR. RALPH COLP, New York: I have had the privilege of previously reading Dr. Walters' interesting communication. From our limited experience I agree that the results following the severance of the vagus nerves to the stomach in the treatment of peptic ulcer are "inconsistent, variable and in most cases unpredictable." I shall not discuss the effects of vagotomy on acid secretion. I shall confine my comments mainly to the post-operative motor difficulties which apparently bear little relationship to the completeness or incompleteness of the division of the vagi as revealed by the insulin test.

I should like to present a series of 20 cases of chronic duodenal ulcer without obstruction. At that time, we performed supradiaphragmatic vagotomy. All cases but one follow-