
Gastric Functions in Patients with the Intrathoracic Stomach after Esophageal Surgery

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Functions of the stomach placed in the posterior mediastinum after esophagectomy were studied in 20 esophageal carcinoma patients. Seven were long-term survivors who lived more than 5 years after operation, and five of them showed normal fasting serum gastrin levels and good or fair gastric acid secretion. Of 13 patients who had their operations within 3 years before the study, 11 showed high fasting serum gastrin levels and poor gastric acid secretion. The hepatobiliary and alimentary scintigrams with double isotopes demonstrated a time lag between the excretion of the food from the stomach and the excretion of bile into the bowels, regardless of the postoperative periods. Absorption of vitamin B₁₂ was normal in patients who lived more than 2 years after operation. The intraluminal pressure and pH studies in long-term survivors showed that our operative technique, the posterior invagination esophagogastrostomy, was effective in preventing a gastroesophageal reflux in the anastomosis.

DURING THE PAST 16 years, we performed the resection and primary reconstruction of the esophagus in 92 patients with esophageal carcinoma by the posterior invagination esophagogastrostomy we devised. The advantages of this operative technique in preventing the anastomotic leakage and reflux esophagitis were already reported.^{1,2} In this paper we report digestive and absorptive functions of the stomach, placed in the posterior mediastinum, in early and late postoperative periods. The antireflux function at the esophagogastric anastomosis was also studied in patients who lived for more than 5 years after operation.

Operative Technique

In the patient placed in the right lateral position, a single thoracoabdominal incision is made through the left fifth or sixth intercostal space, thereby taking the fifth for an

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upper or middle intrathoracic esophageal lesion and the sixth for a lower esophageal lesion. After dividing the esophagogastric junction, the pyloroplasty is performed. The apex of the remaining stomach is bent forward, as illustrated in Fig. 1A. The proximal segment of the esophagus is placed on the posterior wall of the stomach and fixed in position with three lines of mattress sutures. The anastomosis is created by a layer to layer technique. The apex of the stomach is extended up onto the left esophageal wall so as to cover the anastomosis and to be a new fornix (Fig. 1B). The details of the posterior invagination technique have been described in our previous reports.^{1,2}

Clinical Materials

Twenty patients were studied. There were 17 men and 3 women. Their ages at operation ranged from 38 to 74 years (mean: 59.1). The esophagogastrostomy was done in the left cervical region in 13 patients and in the posterior mediastinum in seven patients. All patients had squamous cell carcinoma. Of 20 patients, seven were long-term survivors who lived for more than 5 years after operation (from 5 to 13 years), and 13 had their operations within 3 years before the study (from 1 month to 3 years).

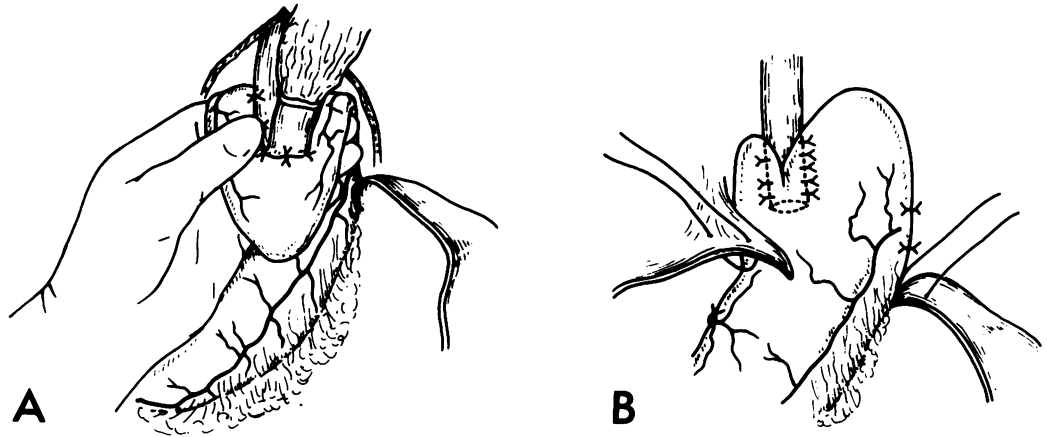
Investigations and Results

Secretion of Gastric Acid and the Fasting Serum Gastrin Level

The gastric acid secretion was investigated by means of the Congo-red method.³ Under endoscopic observation, the gastric mucosa was washed with 5% sodium bicarbonate solution; then a 0.3% Congo-red solution was sprayed over the whole gastric mucosa. A tetragastrin hy-

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FIGS. 1A and B. Schema of the posterior invagination technique. *A*. The proximal segment of the esophagus is placed on the posterior wall of the stomach, and fixed in three lines with three mattress sutures (left lateral view). *B*. The apex of the stomach is extended upon the left esophageal wall and fixed with several stitches to cover the anastomosis (anterior view).



drochloride of 5 $\mu\text{g}/\text{kg}$ was administered intramuscularly. The secreting area of gastric acid was identified by the color development from red to black.

Out of seven long-term survivors, two had good gastric acid secretion (that is, the black areas in the gastric mucosa were seen widely along the greater curvature of stomach and were well distinguished from the pyloric and fundic gland areas) (Fig. 2). Three patients had fair acid secretion (that is, the gastric mucosa was black in several long, narrow zones along the greater curvature). The remaining two patients had poor acid secretion (that is, there was no black area, or the gastric mucosa was black in a few speckled areas).

On the other hand, out of 13 patients who lived less than 3 years after operation, one had good and another

had fair acid secretion. The others had poor acid secretion (Fig. 3). The schema of the results was presented in Figure 4.

The fasting serum gastrin (FSG) level was measured by radioimmunoassay (polyethylene glycol method). Out of five long-term survivors who showed good or fair acid secretion, four had normal FSG levels (below 140 pg/ml) and one a high FSG level (310 pg/ml). In the remaining two long-term survivors who had poor acid secretion, the FSG levels were high (590 and 324 pg/ml).

In 13 patients less than 3 years after operation, two patients who had good or fair acid secretion revealed normal FSG levels. Of the residual 11 patients who had poor acid secretion, nine revealed high FSG levels and two normal ones (Fig. 5).

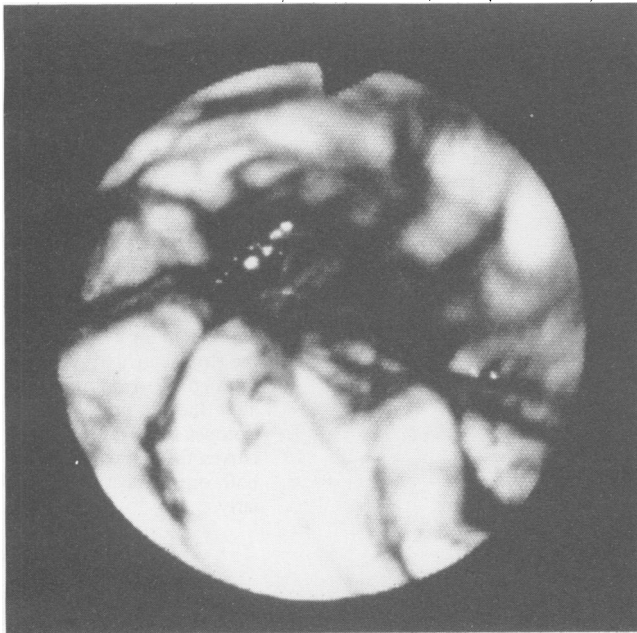


FIG. 2. Endoscopic findings of a good gastric acid secretion by Congo-red method.

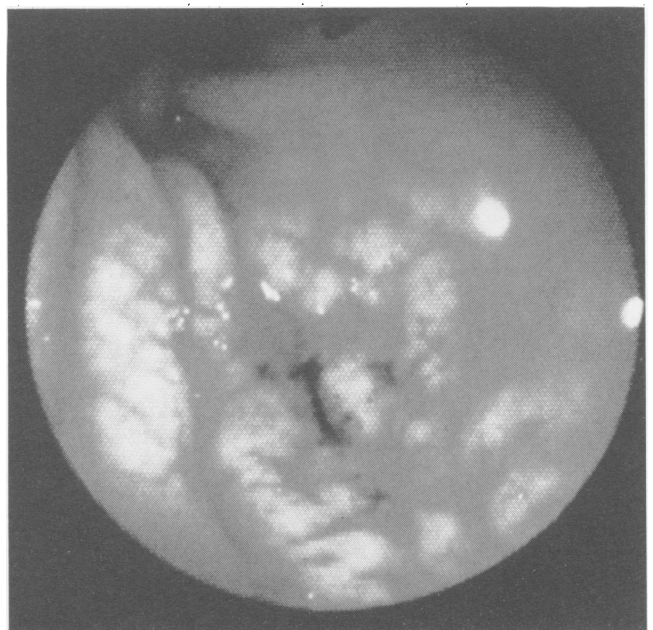


FIG. 3. Endoscopic findings of a poor acid secretion by Congo-red method.

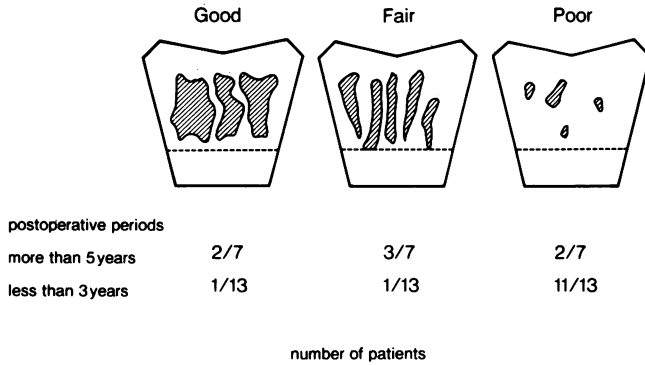


FIG. 4. Schema of the results of gastric acid secretion by Congo-red method. The stomach is opened along the lesser curvature. A dotted line represents a margin of the pyloric gland area.

Hepatobiliary and Alimentary Scintigrams

In order to investigate the passage of the food in the stomach in relation to the excretion of bile, the hepatobiliary and alimentary scintigrams were done simultaneously. According to the Torizumi's method,⁴ two different radioisotopes were administered to the patient. One was technetium-99m-(Sn)-pyridoxylidene-isoleucine (^{99m}Tc-PI) for hepatobiliary scintigram and the other, indium-111-diethyltri-amino-pentacetic acid (¹¹¹In-DTPA) for alimentary scintigram. The diet containing ¹¹¹In-DTPA of 200 μCi was administered orally, followed by an intravenous injection of ^{99m}Tc-PI of 4.0 mCi. The patient was placed in the supine position during measurement. With the aid of a scintillation camera (Searle), the scintigram was recorded. The time-activity curve (the ex-

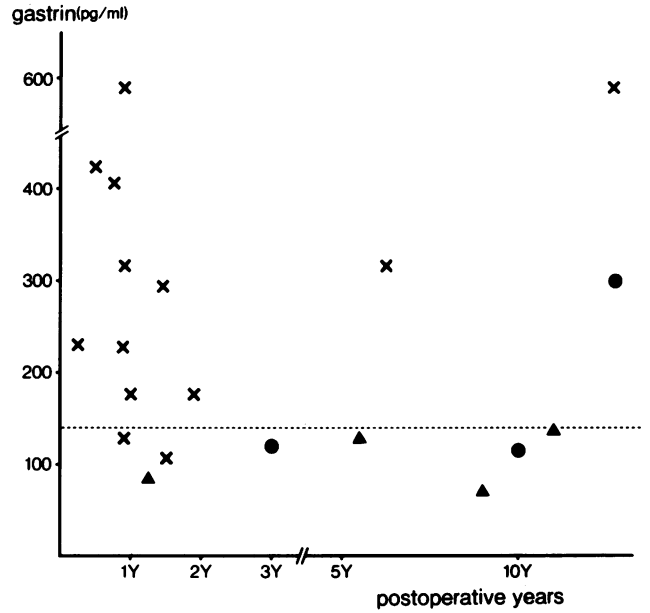


FIG. 5. The gastric acid secretion and the FSG levels with the postoperative periods. Each marker represents as follows, X: a poor acid secretion, ▲: a fair acid secretion, ●: a good acid secretion. A dotted line represents an upper margin of the normal FSG level (140 pg/ml).

cretion and accumulation curve) of each radioisotope was drawn with the aid of a computer (Scitipac 1200, Shimadzu).

Six patients, including two less than 3 years and four more than 5 years after operation, and one healthy subject were studied. In the healthy subject, both the liver and the stomach were delineated clearly at 5 minutes after

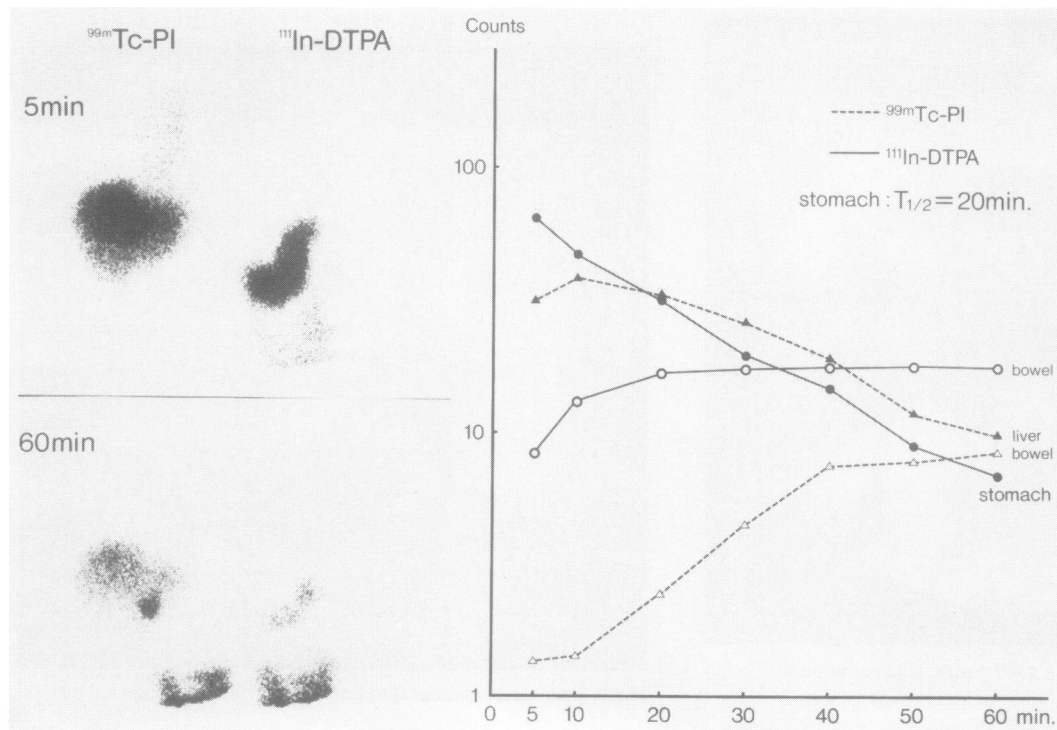


FIG. 6. Hepatobiliary and alimentary scintigrams and time activity curves in a healthy subject. In scintigrams both the liver (left) and the stomach (right) were delineated clearly at 5 minutes after the administration of isotopes. In time activity curves the radioactivities in both organs decreased similarly.

administration of the radioisotopes. The radioactivity of each isotope in the liver and the stomach decreased similarly. The half-life of $^{111}\text{In-DTPA}$ in the stomach was 20 minutes (Fig. 6).

On the other hand, in five of six patients, regardless of the postoperative periods and the site of the esophago-gastrostomy, the food in the stomach went down into the bowels 5 minutes after taking the diet (Fig. 7). In the remaining one patient who had the operation with cervical anastomosis 13 years before the study, the food in the stomach went down into the bowels more slowly than in the healthy subject and the half-life of $^{111}\text{In-DTPA}$ was 30 minutes (Fig. 8).

Absorption of Vitamin B₁₂

By means of the dual radioisotope urinary excretion test (Dicopac, Radiochemical Center, England),⁵ the absorption of vitamin B₁₂ (VB₁₂) was examined. A dose of $^{58}\text{Co-VB}_{12}$ and a dose of $^{57}\text{Co-VB}_{12}$ bound to human gastric juice (intrinsic factor) were simultaneously administered orally, followed immediately by an intramuscular injection of 1000 g of nonradioactive VB₁₂. All urine excreted in 24 hours after giving the doses was collected. The radioactivities of ^{57}Co and ^{58}Co were calculated with the aid of a scintillation counter.

Nine patients, including five less than 3 years and four more than 5 years after operation, were studied. In one female patient, who had the operation 1 month before the study, the urinary excretion rates of $^{57}\text{Co-}$ and $^{58}\text{Co-VB}_{12}$ were found to be 3.9% and 3.1%, respectively. In two patients who lived 11 and 17 months after operation, the excretion rates of $^{58}\text{Co-VB}_{12}$ were lower than the nor-

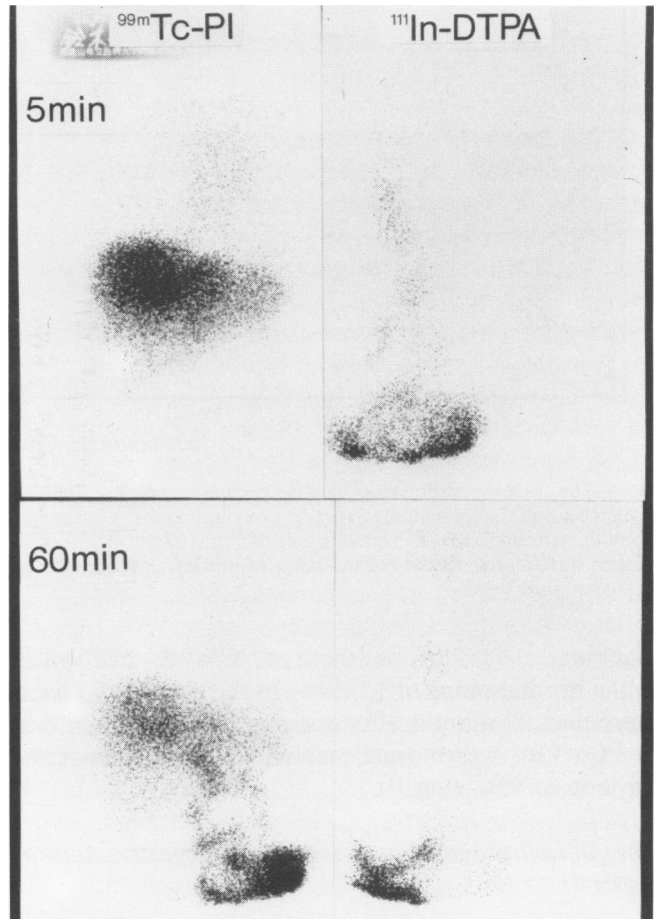


FIG. 7. Hepatobiliary and alimentary scintigrams in the patient who lived 3 years after operation with cervical anastomosis. The radioactive substance in the stomach went down into the bowels already within 5 minutes after the administration.

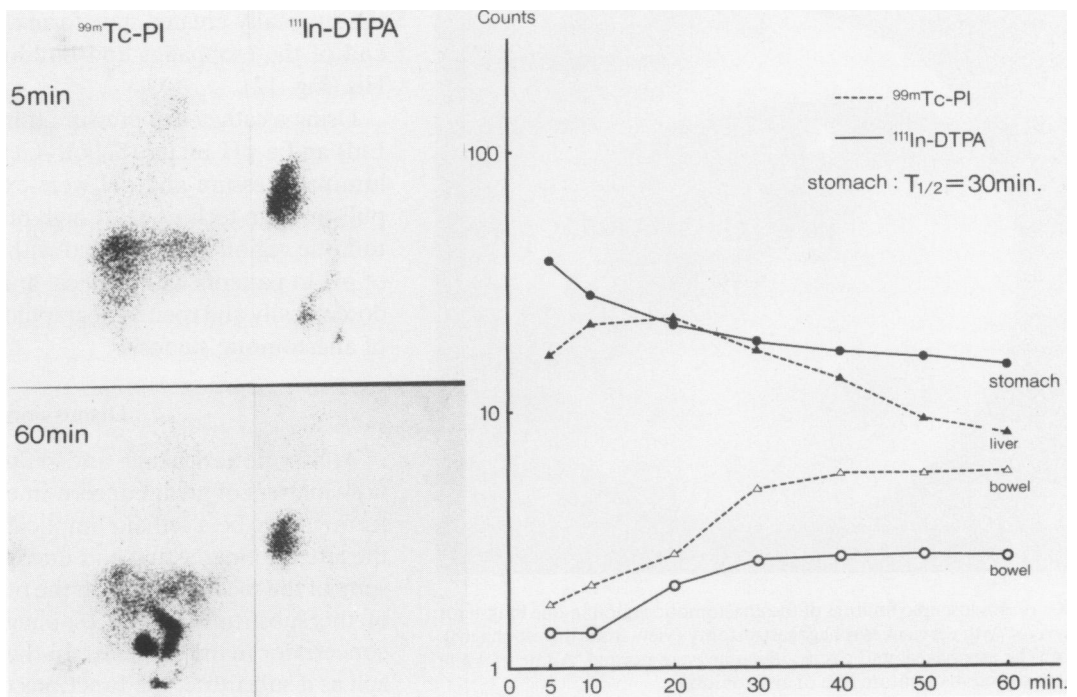


FIG. 8. Hepatobiliary and alimentary scintigrams and time activity curves in one long-term survivor who showed a mild stagnation of the food in the stomach. The half time of $^{111}\text{In-DTPA}$ in the stomach was 30 minutes.

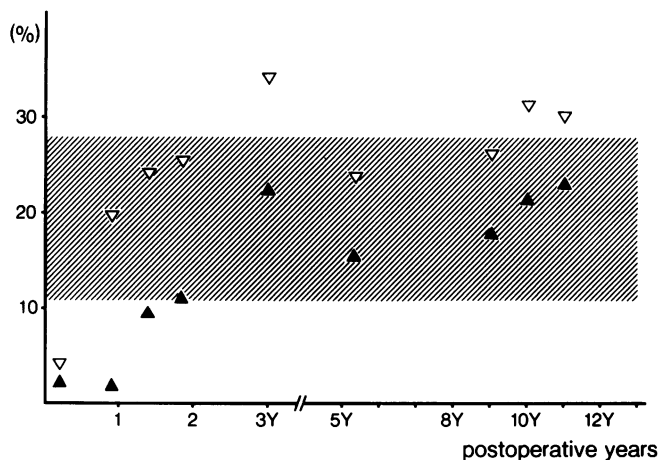


FIG. 9. The urinary excretion rate (%) of radioactive vitamin B_{12} . Coupled markers, \blacktriangle and ∇ , represent as follows, ∇ : excretion rate of ^{57}Co -vitamin B_{12} with intrinsic factor, \blacktriangle : excretion rate of ^{58}Co -vitamin B_{12} . A zone of slant lines represents the normal range of urinary excretion rate of ^{58}Co -vitamin B_{12} .

mal range of 11–28%, but those of ^{57}Co -VB $_{12}$ had values in the normal range of 12–30%. In the others who lived more than 22 months after operation, the excretion rate of ^{58}Co -VB $_{12}$ was normal, namely showing normal absorption of VB $_{12}$ (Fig. 9).

The Antireflux Function at the Esophagogastric Anastomosis

The antireflux function was examined in all long-term survivors. The mucosa of the anastomotic region, ob-

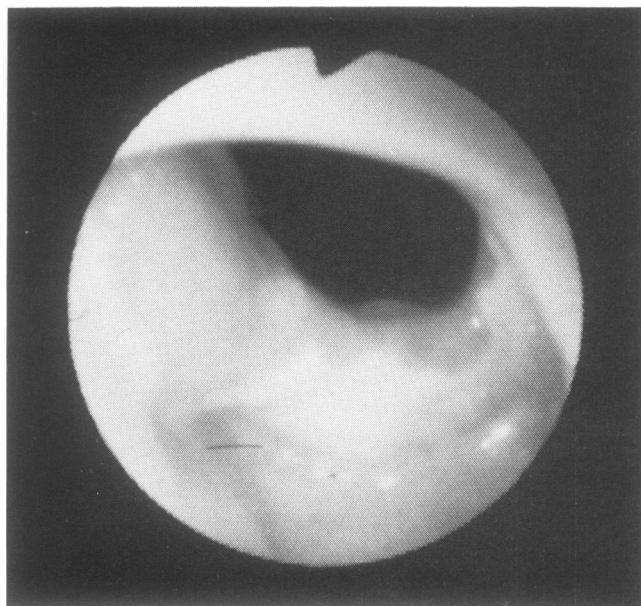


FIG. 10. Endoscopic findings of the anastomotic region in one long-term survivor with cervical esophagogastrostomy (view from the esophagus). Both the esophageal and gastric mucosae were normal. A line of white spots represents a suture line of anastomosis.

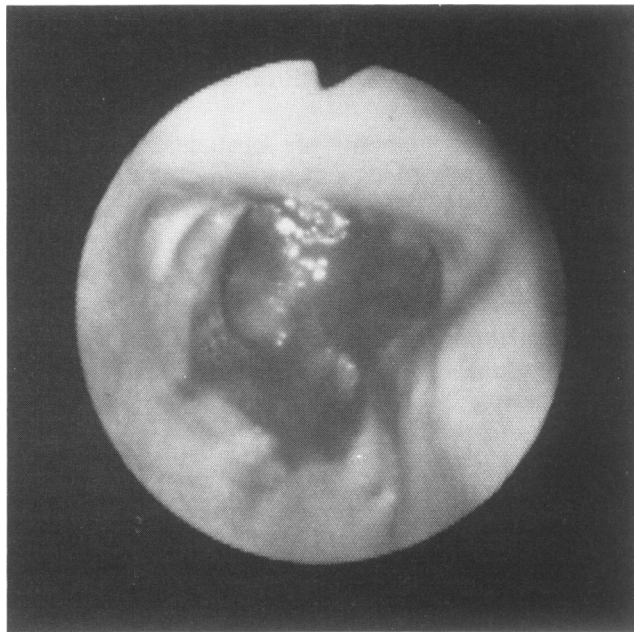


FIG. 11. Endoscopic findings of a mild esophagitis in the patient in whom the esophagogastrostomy was created above the upper margin of the aortic arch.

served endoscopically, resembled closely that of the esophagogastric junction of a healthy subject in all patients except one (Fig. 10). Although this exceptional one had no complaint of esophagitis, the endoscopic findings showed diffuse redness in the esophageal mucosa 1–2 cm above the anastomotic region (Fig. 11).

Roentgenographically, it was well demonstrated in all patients, including one with esophagitis, that, in head-down position, the contrast medium flowed quickly into the surgically created new fornix, compressing the distal end of the esophagus and building up a sharp angle of His (Fig. 12).

Using a cathetertip pressure transducer (Goodman Co., Ltd) and a pH meter (Schott-Gerate GmbH), the intraluminal pressure and pH were examined by means of a pull-through technique. A high pressure zone at the anastomotic region was recorded with concomitant elevation of pH in patients with cervical anastomosis (Fig. 13). Endoscopically and roentgenographically, there were no cases of anastomotic stenosis.

Discussion

Anastomotic leakage and reflux esophagitis are even now matters of great concern in esophageal surgery. The former may be a lethal complication in many cases and the latter a long-lasting and uncomfortable complaint, in spite of the medications. On the other hand, the functions of the substitute for the esophagus are also matters of concern for many surgeons. In the case of using the stomach as a substitute, the functions of the stomach are very

important in maintaining postoperative nutritional conditions. According to the Report of Treatment Results of Esophageal Carcinoma in Japan, published yearly by the National Cancer Center, Tokyo, in over 80% of patients the stomach has been utilized as a substitute for the esophagus. In our clinic the reconstruction of the esophagus has been made, in principle, with the whole stomach.

Secretion of Gastric Acid and the FSG Level

In esophageal surgery a complete truncal vagotomy is necessarily performed. The truncal vagotomy has been done in duodenal ulcer patients to reduce the gastric acid output.⁶⁻⁸ Recent knowledge⁹ has demonstrated the three stimulants of gastric acid secretion, namely acetylcholine, gastrin, and histamine. The vagal stimulation causes the release of acetylcholine.

In our patients the gastric acid output was examined by means of the endoscopic Congo-red method, which is a convenient way of estimating the degrees of acid output grossly. Poor acid secretion, observed in 11 of 13 patients who lived for less than 3 years after operation, may be ascribed to the vagotomy. Some investigators^{10,11} reported also the reduction of the gastric acid output in esophageal carcinoma patients after operation.

The fact that good or fair acid secretion was observed in five of seven long-term survivors may suggest the restoration of the acid-secreting function. In the duodenal ulcer patient it is not uncommon for the acid output to drop once after vagotomy and then increase again.^{12,13} Unlike the duodenal ulcer patient, the esophageal carcinoma patient has some distinctive features, such as normo- or hypoacidity before operation,^{11,14} elderly age at operation, and reduced blood flow of the stomach by operative procedures. The latter two features may be the causes of the atrophic gastritis¹⁵ and may be unfavorable to the recovery of the gastric acid secreting function. As far as we know, the restoration of the gastric acid secretion has not been reported in cases in which the gastric tube (rolle-shaped stomach) was utilized as a substitute for the esophagus. This may suggest that the adoption of the whole stomach, in case of which the blood flow of the stomach is preserved relatively well, is an important factor in the restoration of gastric acid secretion.

The truncal vagotomy was shown to bring about an increase in the FSG levels in duodenal ulcer patients¹⁶⁻¹⁸ and also in esophageal carcinoma patients.^{19,20} Of the causative factors of high serum gastrin levels after vagotomy, the reduction of the gastric acid output may be most important.¹¹ In various types of vagotomy, the relationships between the gastric acid output and serum gastrin levels were investigated and contrary results were obtained.^{21,22} These differences in the results may be due in part to the complicated mechanisms of acid secretion^{9,23} Lam et al.¹⁰ described the influence of postoperative time on the acid output in esophageal carcinoma patients. In

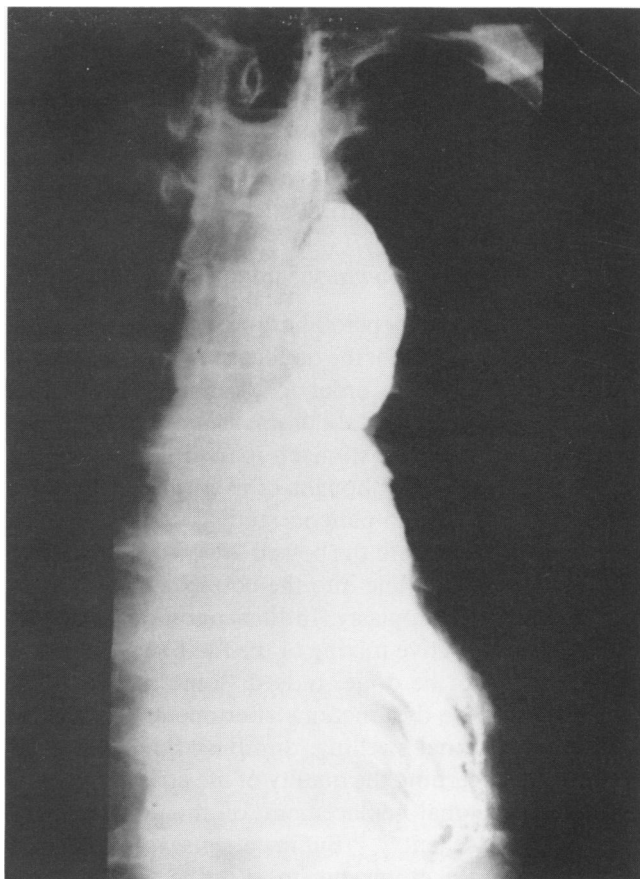


FIG. 12. Roentgenogram in head down position in one long-term survivor with left intrathoracic esophagogastrostomy. The new fornix was filled with the contrast medium and no reflux was observed.

our study, 6 of 7 patients who had good or fair acid secretion showed almost normal FSG levels. Therefore, we suppose that the FSG level may be a useful index to detect the restoration of gastric acid secretion.

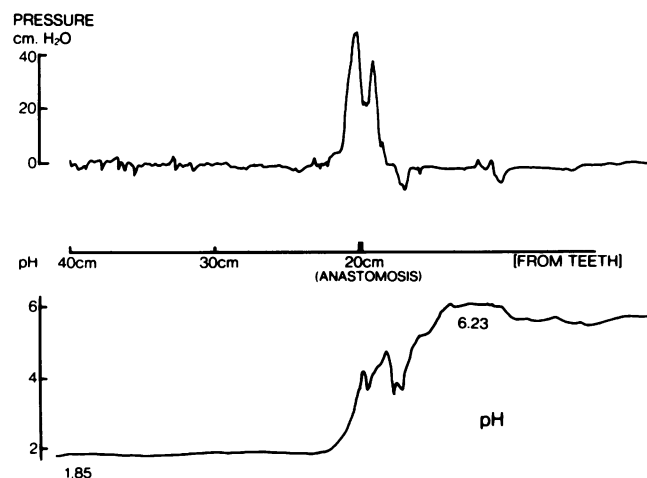


FIG. 13. The intraluminal pressure and pH by pull-through technique in one long-term survivor with left cervical anastomosis. The high pressure zone was recorded in the anastomotic region with a concomitant elevation of pH.

One long-term survivor, who showed a mild stagnation of the food in the stomach, had a high FSG level (310 pg/ml) in spite of good acid secretion. In this patient the gastrin secreting cell in the pyloric antrum was examined by the PAP method and no hyperplasia of gastrin secreting cells was observed. This result suggested that there were extra-antral sources of gastrin.^{18,24}

Hepatobiliary and Alimentary Scintigrams

The simultaneous hepatobiliary and alimentary scintigrams done by means of the double isotope method were primarily performed in order to estimate the postcibal asynchronism after upper abdominal surgery.²⁵ In esophageal surgery, when the stomach is used as a substitute for the esophagus, it is thought of as a tube for passing the food only. In 5 of 6 patients studied, the food in the stomach went down into the bowels 20–30 minutes faster than the excretion of bile into the bowels. Of course this may be due to pyloroplasty. In this condition there was a fear that the effective mixing of the food and bile in the bowels might not be done. Indeed, some reports^{14,26–28} described digestive dysfunctions after operation, such as diarrhea, abdominal swelling, dumping syndrome after meals, etc. Concerning the quality of life after esophageal surgery, the jejunal replacement of the esophagus is thought to be excellent.^{29–31} But in patients with the gastric replacement of the esophagus, most of the postoperative complaints come from the gastroesophageal reflux,^{28,29} and malnutrition has been reported only in early postoperative periods.²⁸ In our patients, especially in long-term survivors, there were no sustained abdominal complaints or severe malnutritions.

The patient who had a mild stagnation of food in the stomach (Fig. 8) had a slight narrowing in the stomach near the pyloric region roentgenographically; this may be due to a tight closure of the incised diaphragm through which the stomach passes.

Absorption of VB₁₂

In our previous reports^{2,32} the absorption of VB₁₂, which markedly decreased immediately after operation, recovered well 1½ years after operation. In the present study, a female patient who received the operation 1 month before the study had a marked reduction of VB₁₂ absorption in condition of the administration of the intrinsic factor. This may be due to dysfunctions of the bowels or the pancreas.^{33,34} In two other patients, 11 and 17 months after operation, the malabsorption of VB₁₂ was corrected by the administration of the intrinsic factor; the deficiency or reduction of the excretion of the intrinsic factor may be the cause of the malabsorption of VB₁₂. In the remaining six patients who lived more than 22 months after operation, the absorption of VB₁₂ was normal.

Concerning the absorption of VB₁₂ after vagotomy, Muyschondt et al.³⁵ described a marked reduction immediately after operation in experimental animals. In clinical studies Yamanaka³⁶ reported the normal levels of serum VB₁₂ in patients more than 4 years after vagotomy, and Johnson et al.³⁷ also reported the same results in patients more than 15 years after vagotomy. These reports agreed with our results. The malabsorption of VB₁₂ after vagotomy was shown to be due to the decreased excretion of the intrinsic factor from the parietal cells of the stomach.³³

In our study the relationship between the recovery of VB₁₂ absorption and the acid output was not determined.

Antireflux Function at the Anastomotic Region

In patients in the early postoperative periods, the invagination esophagogastronomy was shown to be very effective in preventing gastroesophageal reflux.¹ In the present study this antireflux function at the anastomotic region was well maintained also in patients of more than 10 years after operation. The roentgenographic findings demonstrated that the surgically created new fornix with a sharp angle of His played an important role.

In one patient, who had mild reflux esophagitis, the intrathoracic anastomosis was made above the upper margin of the aortic arch, and the angle of His became obtuse because of the incomplete fixing of the gastric convexity to the esophagus in a deep and limited operative field. The erythematous changes of the esophageal mucosa, which were observed in the early postoperative days, did not alter in degree and extent even 13 years later.

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