Laparoscopic function-preserving surgery for early gastric cancer in the upper third of the stomach: vagus-sparing proximal gastrectomy with side-to-side esophagogastric-tube anastomosis

Hideo MATSUI, Naoki IGARASHI, Osamu ITANO, Yasumasa KOYAMA, Makoto MIYAKITA

Department of Surgery, Eiju General Hospital, Tokyo, Japan

(Received August 6, 2007; Accepted September 3, 2007)

Objective: Proximal gastrectomy with an anti-reflux procedure has been a treatment option for gastric cancer in the upper third of the stomach. For early gastric cancer, laparoscopic function-preserving gastrectomy with limited lymphadenectomy can be performed. Objective of this study was to develop a new surgical technique for gastric cancer in the upper third of the stomach.
Methods: We present here our totally laparoscopic proximal gastrectomy with vagus-sparing lymphadenectomy and gastric-tube reconstruction. Six patients (five males and one female; mean age 74 years) with gastric cancer in the upper third of the stomach underwent the procedure. Detailed operative procedure and preliminary results were presented.
Results: We have successfully performed the procedure with no conversion to open surgery. The mean operative time and blood loss were 413 minutes and 85 mL. No intraoperative and postoperative complications occurred except for reflux esophagitis in one patient. At the mean follow up of 25 months, all patients were alive without any sign of recurrence.
Conclusion: Although long-term follow up and a larger number of patients are required to evaluate functional outcomes and oncological adequacy, our new technique provides a minimally invasive surgical option for early gastric cancer in the cardiac area.

Key words: stomach neoplasm; laparoscopic surgery; vagus nerve; linear stapler

INTRODUCTION

The incidence of gastric cancer located in the upper third of the stomach is increasing, for which total gastrectomy provides no survival benefit compared to proximal gastrectomy [1]. Although both total and proximal gastrectomy can be performed safely with a low mortality rate [1], total gastrectomy is associated with a significant weight loss due to an inadequate calorie intake [2], in addition to the postgastrectomy syndromes such as dumping syndrome, postvagotomy diarrhea, and alkaline reflux esophagitis. To overcome these problems, proximal gastrectomy combined with an antireflux procedure has been reported for proximal gastric cancer in the upper third of the stomach [3-9]. However, there have been few reports on totally laparoscopic procedures due to the technical difficulties encountered during reconstruction [7, 8, 10, 11]. Recently, laparoscopic partial gastrectomy with limited lymph node dissection and preservation of the vagus nerve has been reported for the treatment of early gastric cancer, which aim at reducing postgastrectomy disturbances such as reduced food intake, postprandial diarrhea, and gallstone formation [12, 13]. We report here on our totally laparoscopic proximal gastrectomy with vagus-sparing lymphadenectomy and gastric-tube reconstruction, which represents a new method of laparoscopic function-preserving surgery for early proximal gastric cancer in the upper third of the stomach.

PATIENTS

Lymph node numbers and staging were defined according to the Japanese Classification of Gastric Carcinoma published by Japanese Gastric Cancer Association (JGCA) [14]. The classification of early gastric cancer was used exclusively for T1 (intramucosal or submucosal layer) tumors. From November 2003 to March 2006, six patients (five males and one female; mean age 74 years; range, 62–83 years) with gastric cancer underwent laparoscopic proximal gastrectomy with vagus-sparing lymphadenectomy and gastric-tube reconstruction. The preoperative data on the patients were outlined in Table 1. The preoperative diagnostic examination included a barium-meal upper gastrointestinal series, endoscopy, and CT scan. Indications for this surgery included the tumor being located in the upper third of the stomach without esophageal inva-

Table 1 Patient preoperative data

Patient	Age	Sex	Location	Macroscopic appearance	Histology
1	81	F	U	0-I	pap
2	71	M	U	0-IIc	sig
3	62	M	U	0-I	tub1
4	71	M	U	0-IIc	tub1
5	76	M	U	0-III+IIc	tub1
6	83	M	U	0-IIc	tub2

Hideo Matsui, M.D., Department of Surgery, Tokai University Tokyo Hospital, 1-2-5 Yoyogi, Shibuya-ku, Tokyo 151-0053, JAPAN
Tel.: +81-3-3370-2321, fax.: +81-3-3379-1955 E-mail: hmatsui@tok.u-tokai.ac.jp

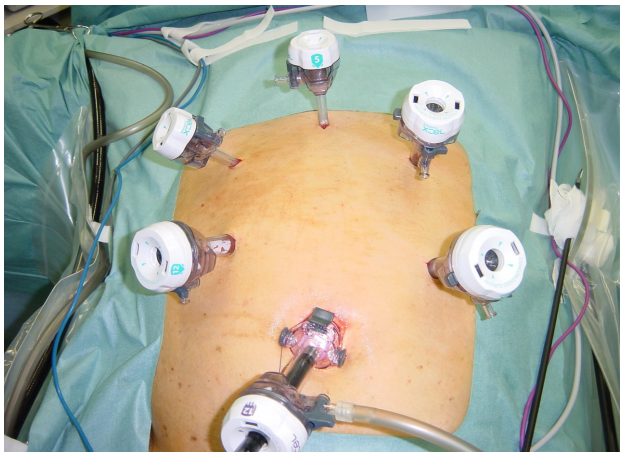


Fig. 1. Placement of trocars for laparoscopic proximal gastrectomy. The first trocar below the umbilicus allowed the introduction of a flexible fiberscope. Four trocars were inserted in the upper and middle abdomen on both midclavicular lines. One trocar under the xiphoid process was for the introduction of the liver retractor or a grasper.

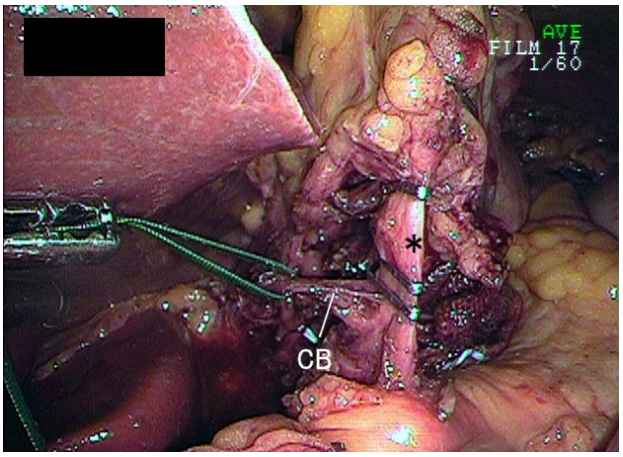
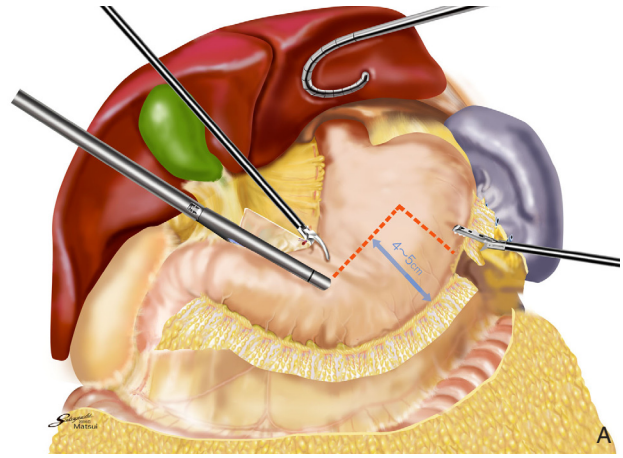


Fig. 3. Division of the left gastric artery.
The left gastric artery was clipped, and divided at the point (indicated by asterisk) distal to the celiac branch (CB) of the posterior vagus nerve. Retraction of the posterior trank of the vagus nerve toward the surgeon enabled the lymph node dissection along the left gastric artery.



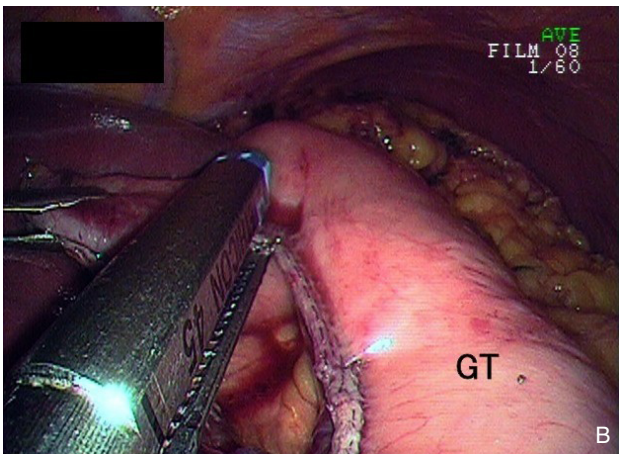


Fig. 2. Transection of the stomach in order to construct a gastric tube.
(A) A gastric tube, 4 to 5 cm wide and 15 cm long in the greater curvature, was made intracorporeally using endolinear staplers. (B) Laparoscopic view of gastric tublization. GT: gastric tube

sion, the depth of tumor invasion confined to T1, no lymph node involvement (N0), and lesions that could not be treated by endoscopic mucosal resection or local resection.

OPERATIVE TECHNIQUE

A six-port technique was used for access (Fig. 1). The first trocar was inserted below the umbilicus by the Hasson technique to allow the introduction of a flexible fiberscope (Fujinon, Saitama, Japan). Four trocars were inserted in the upper and middle abdomen on both midclavicular lines. One trocar was inserted under the xiphoid process for the introduction of a liver retractor or a grasper. The patients were placed in the reverse Trendelenburg position with the legs apart and the arms extended laterally. At the first step, the surgeon stood on the right side of the patient with the assistant on the left and the camera operator between the patient's legs. The gastrocolic ligament was divided toward the lower pole of the spleen using laparosonic coagulating shears (Ethicon Endo-Surgery, Cincinnati, OH). The left gastroepiploic vessels and short gastric vessels were exposed, clipped, and divided. The surgeon then moved to the left side of the patient and divided the right side of the gastrocolic ligament until the duodenum and the pancreas head were exposed, taking care not to injure the right gastroepiploic vessels. Any posterior adhesion of the distal portion of the stomach was also dissected. The surgeon then returned to the right side of the patient, and dissected the second branch of the right gastric artery free from surrounding fat tissue along the lesser curvature to allow the lymph node along the lesser curvature (no. 3 lymph node) to be dissected. The gastrohepatic ligament was dissected toward the esophagogastric junction whilst preserving a hepatic branch of the anterior vagus nerve. The phrenoesophageal membrane was then incised, and the anterior gastric branch of the vagus nerve was cut. The right crus of the diaphragm was exposed and posterior aspect of the esophagus was dissected. During this procedure, the posterior trunk of the vagus nerve was exposed

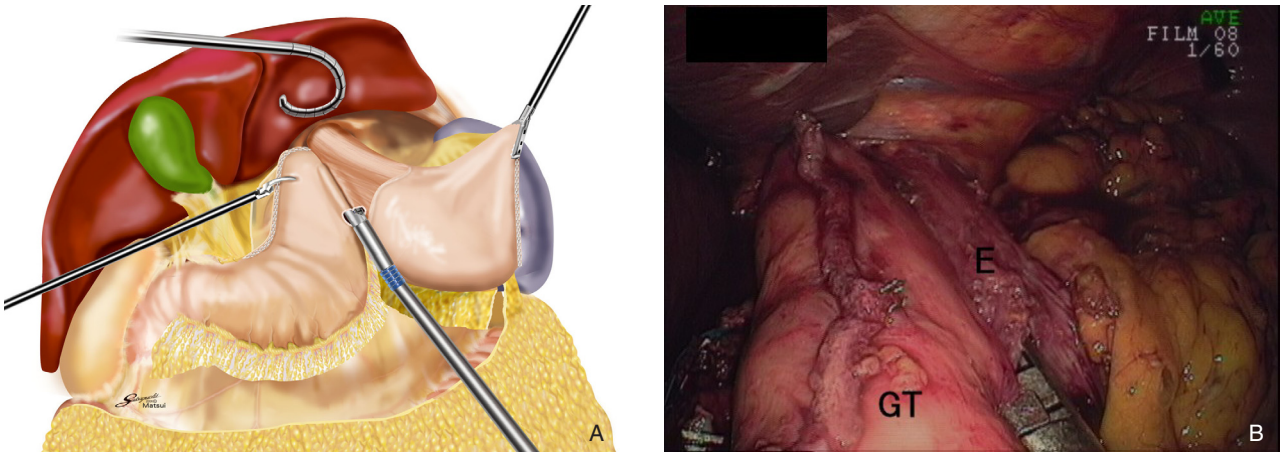


Fig. 4. Side-to-side esophagogastric-tube anastomosis using an endolinear stapler.
(A) The anvil and cartridge forks were inserted into the gastric tube and the esophagus, respectively, and the device was closed and fired. (B) Laparoscopic view of the procedure. GT: gastric tube, E: esophagus.

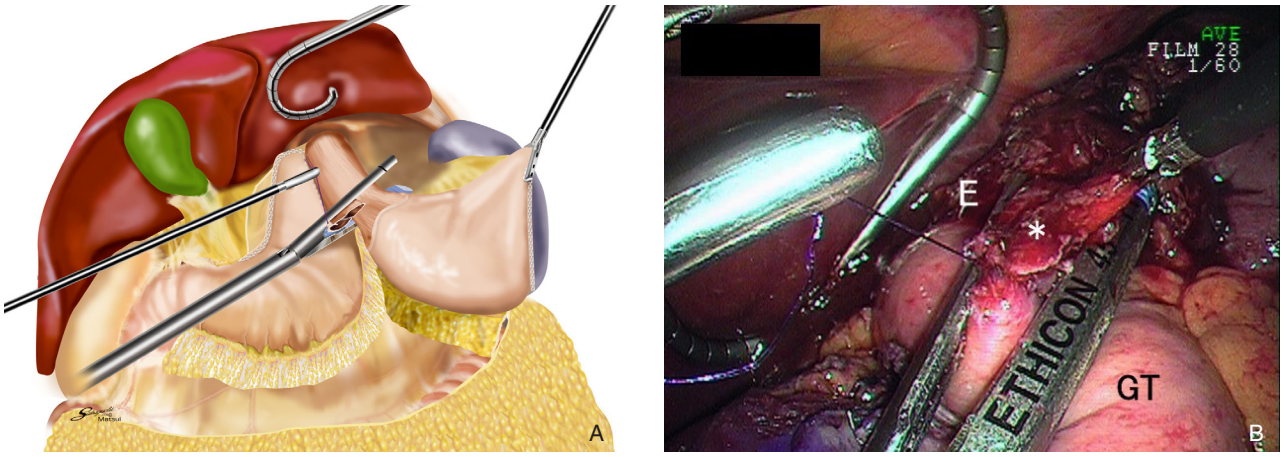
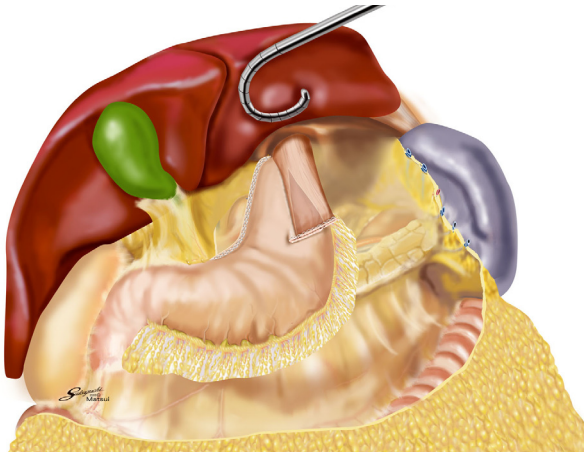


Fig. 5. Closure of an entry hole and transection of the esophagus.
(A) After placing anchoring sutures, the entry hole was closed and the esophagus was transected. (B) Laparoscopic view of the procedure. Initially, the entry hole (indicated by the asterisk) was closed. GT: gastric tube, E: esophagus.

and a vessel tape was applied circumferentially. The stomach was transected with endolinear staplers starting on the lesser curvature at the point distal to the first branch of the right gastric artery to a point in the avascular area between the short gastric artery and the left gastroepiploic artery in order to construct a gastric tube, which was approximately 4 to 5 cm wide and 15 cm long in the greater curvature (Fig. 2). We performed intraoperative endoscopy during the gastric tubulization to confirm the resection line that had been marked with clips preoperatively. The left gastric vein was exposed, clipped, and divided. Lymph nodes along the left gastric artery (no. 7 lymph node) were dissected, and the left gastric artery was clipped and divided at the root whilst preserving a celiac branch of the posterior vagus nerve (Fig. 3). Retraction of the posterior trank of the vagus nerve toward the surgeon enabled the lymph node dissection.

The posterior attachment of the lesser omentum along the lesser curvature of the stomach was dissected. Any attachments from the upper portion of the stomach and spleen were dissected free, and a 5-cm length of the abdominal esophagus was exposed. Esophagogastric-tube anastomosis was performed laparoscopically by constructing a side-to-side anastomosis with a 45-mm cartridge endolinear stapler (ETS Flex 45, blue cartridge; Ethicon Endo-Surgery). A stab wound was made on the posterior wall of the lower esophagus, then another wound was made on the anterior wall of the gastric tube 5 cm distal to the proximal end of the tube as well as 1 cm from the closed end of the tube. A linear stapler was inserted from the left lower port. The anvil and cartridge forks of the linear stapler were inserted into the gastric tube and the esophagus, respectively, and the device was closed and fired (Fig. 4). The common entry hole was inspected to check for bleeding from stapled line. The entry hole was closed after placing three anchoring sutures to secure full thickness approximation of the esophagus and the stomach wall as well as to avoid triple stapling, and the esophagus was transected using endolinear staplers that were inserted from the right lower port (Fig. 5). This technique allowed the side-to-side esophagogastric-tube anastomosis and the proximal gastrectomy to be completed at the same time (Fig. 6). No pyloroplasty was performed in order to preserve pyloric function. The resected specimen was placed in a plastic bag and delivered through the left middle



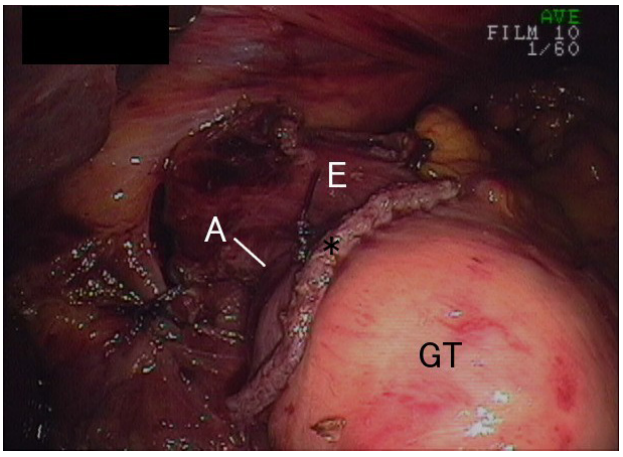


Fig. 6. A completed anastomosis.
(A) Side-to-side anastomosis was completed. (B) Laparoscopic view of an anastomosis.
A closed entry hole was indicated by black asterisk. GT: gastric tube, E: esophagus, A: anastomosis line

Table 2 Clinical outcome

Patient	Operative time (minutes)	Blood loss (mL)	Liquid diet (POD*)	Hospital stay (POD)
1	433	150	8	24
2	397	10	8	25
3	398	50	5	14
4	400	100	7	27
5	413	100	7	21
6	437	100	7	21
Mean	**413**	**85**	**7**	**22**

* postoperative days

Table 3 Clinicopathologic findings

Patient	T	N	Stage
1	T1(m)	N0	IA
2	T1(sm)	N0	IA
3	T1(sm)	N0	IA
4	T1(m)	N0	IA
5	T2(mp)	N0	IB
6	T1(sm)	N0	IA

wound extended to 4 cm.

RESULTS

We have successfully completed this surgical technique in six patients, with no conversions to open surgery. The mean operative time was 413 minutes (range, 397–437 minutes) and the mean blood loss was 85 mL (range, 10–150 mL). All the patients were ambulatory on the first postoperative day with only extradural anesthesia being required for analgesia, and were started on a liquid diet at a mean of 7 postoperative days (range, 5–7 days) after routine checks of the anastomosis. There was no leakage, and contrast media passed smoothly through the anastomosis into the duodenum, resulting in no marked regurgitation into the esophagus with the patient in the supine position. No remarkable postoperative complications occurred. The mean postoperative hospital stay was 22 days (range, 14–27 days). All patients could perform their normal activities with no postoperative symptoms at the time of discharge (Table 2).

The depth of tumor invasion was the mucosal layer in two patients, the submucosal layer in three, and the muscle layer in one; no lymph node metastasis was observed in a mean of 16.6 harvested nodes (range, 15–20 nodes). According to the JGCA staging system, the tumors were stage IA in five patients and stage IB in one patient (Table 3).

At the mean follow up of 25 months (range, 17–45 months), all patients were alive without any sign of recurrence. One patient developed Grade I reflux esophagitis that was diagnosed by a routine endoscopic examination at 6 months after the surgery. No food residue was observed in the five patients, and peristaltic movement originating from the distal portion of the gastric tube toward the pyloric ring was observed in three patients during endoscopic examination.

DISCUSSION

Proximal gastrectomy has been considered as a treatment option for gastric carcinoma of the upper third of the stomach [1, 3-7, 9, 15]. For tumors confined to the submucosal layer (i.e., T1 tumors or early gastric cancer), Kitamura and associates [15] have found that no lymph node metastasis was observed in lymph node station nos. 10 (lymph node at the splenic hilum), 11 (lymph node along the splenic artery), 4d (lymph node along the right gastroepiploic vessels), 5 (suprapyloric lymph node), and 6 (infrapyloric lymph node). This allows the lower portion of the stomach to be preserved with limited lymph node dissection. In our present series, the indication for this surgery was restricted to T1 gastric cancer of the upper third of the stomach. In one case, however, pathological diagnosis revealed that the tumor had invaded the muscle layer (i.e., T2 tumor), with a final staging of IB (Table 3). Due to the limits of accurate preoperative diagnosis of the depth of invasion in T1 gastric carcinoma, especially in cases with an ulcer scar, one case was underestimated. Oncological adequacy of this surgery for such a case remains to be elucidated by long-term follow up.

Reflux esophagitis after proximal gastrectomy adversely affects the postoperative quality of life. To prevent this complication, antireflux procedures such as fundoplication and interposition of the jejunal segment have been applied [4, 5, 7, 9]. However, performing these procedures laparoscopically is sometimes difficult and time consuming [7]. Kitano and associates [6] introduced gastric-tube reconstruction for laparoscopy-assisted proximal gastrectomy using a circular stapling device, and Adachi and associates [3] described the usefulness of gastric-tube reconstruction following open proximal gastrectomy to prevent reflux esophagitis. The other investigators reported the totally laparoscopic gastric tubulization technique, however they did not mention the incidence of reflux esophagitis [10, 11]. It is our impression that 4 to 5 cm width is sufficient in order to preserve submucosal collateral circulation of the gastric tube even after removing lymph nodes along the left gastroepiploic vessels and the lesser curvature. As for the length of the greater curvature, Hayashi and associates [16] reported that gastric motility was preserved if the length of the greater curvature was more than 20 cm, suggesting the importance of the size of the residual stomach after proximal gastrectomy. In our procedure, the anastomosis was created on the anterior wall, 5 cm distal to the tip of the gastric tube, therefore retroesophageal portion of the gastric tube may act as a short pouch, which can distend with air and may contribute to reduce gastroesophageal reflux [17], although clearance of the gastric content must also be considered. During gastric tubulization, it was important to confirm the tumor-free region that had been marked with clips preoperatively; intraoperative endoscopy to obtain a sufficient clearance of the tumor was essential in this procedure.

Totally laparoscopic esophagogastrostomy using a circular stapling device was reported; the anvil was inserted into the esophageal lumen either through the esophageal stump trans-abdominally, or trans-orally [10, 11]. A side-to-side esophagogastrostomy using a linear stapling device was reported by Chassin [18] after proximal gastrectomy. Recently, Orringer and associates [17] published their experience with 114 patients undergoing the procedure using an endolinear stapler in cervical anastomosis following esophagectomy describing larger anastomosis size and lower incidence of anastomotic leaks compared to the conventional manually sewn method. Laparoscopic application of this technique was first reported by Uyama and associates [8] for reconstruction following proximal gastrectomy in two patients with gastric cancer; the postoperative courses of the patients were excellent with no reflux esophagitis. These techniques, as well as a side-to-side esophagojejunostomy after a total gastrectomy [19], abolished the need for a purse-string suture to place the anvil head of the stapler into the esophagus. In the laparoscopic condition, (1) it was unnecessary to introduce the anvil into the esophageal lumen, (2) the axis of an articulating linear stapling device could be easily adjusted to that of the esophagus, and (3) importantly, a sufficient anastomosis lumen size was obtained using a linear stapler irrespective of the esophageal lumen size. We used this technique for esophagogastric-tube anastomosis, thus achieving a totally laparoscopic proximal gastrectomy with an antireflux procedure. None of our patients developed anastomotic leak or stricture, and only one patient developed asymptomatic reflux esophagitis that was diagnosed by endoscopy at 6 months after surgery.

The pyloric function includes a complex mechanism of clearance of gastric content coordinated with the peristaltic movement of the stomach and prevention of bile reflux to the stomach, which is only beginning to be elucidated [20]. We did not add pyloroplasty, and preserved the vagus nerve in order to partially maintain pyloric function. Fasting peristaltic movement was observed in three patients, and no residual food was observed during an endoscopic examination. Clinically, none of the patients had any sign of regurgitation such as chest burn, or postprandial diarrhea. These observations suggest that clearance of gastric content as well as reservoir function of the gastric tube can be maintained to some extent, although further evaluation remains necessary.

In conclusion, we have successfully performed a totally laparoscopic function-preserving proximal gastrectomy by introducing vagus-sparing lymphadenectomy and side-to-side esophagogastric-tube anastomosis using a linear stapling device. The postoperative pain was minimal and all patients returned to normal activity within a short time without remarkable clinical symptoms. A randomized controlled trial comparing this procedure with open method would be required to prove less invasiveness of the laparoscopic procedure. Although long-term follow up and a larger number of patients are required to evaluate functional outcomes and oncological adequacy, we believe that our new technique provides a minimally invasive surgical option for early gastric cancer of the upper third of the stomach, in particular those in the cardiac area.

REFERENCES

1) Harrison LE, Karpeh MS, Brennan MF. Total gastrectomy is not necessary for proximal gastric cancer. Surgery 1998;123:127-30.
2) Bradley EL, 3rd, Isaacs J, Hersh T, Davidson ED, Millikan W. Nutritional consequences of total gastrectomy. Ann Surg 1975; 182: 415-29.
3) Adachi Y, Inoue T, Hagino Y, Shiraishi N, Shimoda K, Kitano S. Surgical results of proximal gastrectomy for early-stage gastric cancer: jejunal interposition and gastric tube reconstruction. Gastric Cancer 1999; 2: 40-5.
4) Boyd AD, Cukingnan R, Engelman RM, Localio SA, Slattery L, Tice DA, *et al*. Esophagogastrostomy. Analysis of 55 cases. J Thorac Cardiovasc Surg 1975; 70: 817-25.
5) Katai H, Sano T, Fukagawa T, Shinohara H, Sasako M. Prospective study of proximal gastrectomy for early gastric cancer in the upper third of the stomach. Br J Surg 2003; 90: 850-3.
6) Kitano S, Adachi Y, Shiraishi N, Suematsu T, Bando T. Laparoscopic-assisted proximal gastrectomy for early gastric carcinomas. Surg Today 1999; 29: 389-91.
7) Uyama I, Sugioka A, Fujita J, Komori Y, Matsui H, Hasumi A. Completely laparoscopic proximal gastrectomy with jejunal interposition and lymphadenectomy. J Am Coll Surg 2000; 191: 114-9.
8) Uyama I, Sugioka A, Matsui H, Fujita J, Komori Y, Hatakawa Y, *et al*. Laparoscopic side-to-side esophagogastrostomy using a linear stapler after proximal gastrectomy. Gastric Cancer 2001; 4: 98-102.
9) Yoo CH, Sohn BH, Han WK, Pae WK. Proximal gastrectomy reconstructed by jejunal pouch interposition for upper third

gastric cancer: prospective randomized study. World J Surg 2005; 29: 1592-9.
10) Costi R, Himpens J, Bruyns J, Cadiere GB. Totally laparoscopic transhiatal esophago-gastrectomy without thoracic or cervical access. The least invasive surgery for adenocarcinoma of the cardia? Surg Endosc 2004; 18: 629-32.
11) Dulucq JL, Wintringer P, Perissat J, Mahajna A. Completely laparoscopic total and partial gastrectomy for benign and malignant diseases: a single institute's prospective analysis. J Am Coll Surg 2005; 200: 191-7.
12) Otani Y, Furukawa T, Kitagawa Y, Yoshida M, Saikawa Y, Kubota T, *et al*. New method of laparoscopy-assisted function-preserving surgery for early gastric cancer: vagus-sparing segmental gastrectomy under sentinel node navigation. J Am Coll Surg 2004; 198: 1026-31.
13) Uyama I, Sakurai Y, Komori Y, Nakamura Y, Syoji M, Tonomura S, *et al*. Laparoscopic gastrectomy with preservation of the vagus nerve accompanied by lymph node dissection for early gastric carcinoma. J Am Coll Surg 2005; 200: 140-5.
14) Japanese Gastric Cancer Association. Japanese classification of gastric carcinoma, 2nd English edition. Gastric Cancer 1998; 1: 10-24.
15) Kitamura K, Nishida S, Yamamoto K, Ichikawa D, Okamoto K, Taniguchi H, *et al*. Lymph node metastasis in gastric cancer in the upper third of the stomach--surgical treatment on the basis of the anatomical distribution of positive node. Hepatogastroenterology 1998; 45: 281-5.
16) Hayashi T, Kinami S, Fushida S, Fujimura T, Miwa K, Inoue K. Evaluation of residual stomach motility after proximal gastrectomy for gastric cancer by electrogastrography. Dig Dis Sci 2006; 51: 268-73.
17) Orringer MB, Marshall B, Iannettoni MD. Eliminating the cervical esophagogastric anastomotic leak with a side-to-side stapled anastomosis. J Thorac Cardiovasc Surg 2000; 119: 277-88.
18) Chassin JL. Stapling technic for esophagogastrostomy after esophagogastric resection. Am J Surg 1978; **136: 399-404.**
19) Matsui H, Uyama I, Sugioka A, Fujita J, Komori Y, Ochiai M, *et al*. Linear stapling forms improved anastomoses during esophagojejunostomy after a total gastrectomy. Am J Surg 2002; 184: 58-60.
20) Takahashi T. Pathophysiological significance of neuronal nitric oxide synthase in the gastrointestinal tract. J Gastroenterol 2003; 38: 421-30.