—Report on Experiments and Clinical Cases—

Laparoscopic Surgery for Gastric Cancer: 5 years' Experience

Teruo Kiyama, Takashi Mizutani, Takeshi Okuda, Itsuo Fujita,
Naoyuki Yamashita, Kengo Ikeda, Hitoshi Kanno, Toshiro Yoshiyuki,
Shunji Kato, Akira Tokunaga[1] and Takashi Tajiri

Surgery for Organ Function and Biology Regulation, Nippon Medical School Graduate School of Medicine
[1]Center for Gastrointestinal Disease, Nippon Medical School Musashikosugi Hospital

Abstract

The purpose of this study was to clarify the safety and value of laparoscopic surgery for gastric cancer. This retrospective study involved 101 patients with gastric cancer treated with laparoscopic surgery at the Nippon Medical School Hospital from February 2001 through July 2005. The following variables were evaluated: age, sex, comorbid conditions, tumor size, location, gross type, histological type, depth of wall invasion, and presence or absence of lymph node metastasis. The surgical variables investigated included operating time, blood loss, postoperative complications, and length of postoperative stay. Mean tumor diameter was 24.1 ± 18.4 mm, and most tumors were located in the lower third of the stomach. Endoscopic examination revealed that 98 of the tumors were early gastric cancers. The mean operation time was 255 ± 74 min, and mean blood loss was 128 ± 162 g. Local gastrectomy without lymphadenectomy was performed in 13 cases, and pylorus-preserving gastrectomy with perigastric lymphadenectomy was performed in 16 cases. Distal gastrectomy with systemic lymphadenectomy was performed in 56 cases. Proximal or total gastrectomy with lymph node dissection for tumors located in the upper half of the stomach was performed in 16 cases. The mean postoperative hospital stay was 13.3 ± 7.6 days. No patients died during the admission. Postoperative surgical complications occurred in 10 patients (10%) and consisted of anastomotic bleeding in 3 patients, pneumohypoderma in 1 patient, and remote infection in 6 patients. The only medical complication was a stroke in 1 patient. We conclude that laparoscopy-assisted gastrectomy is a safe and useful operation for most early gastric cancers. If patients are selected properly, laparoscopy-assisted gastrectomy can be a curative and minimally invasive treatment for gastric cancer.
(J Nippon Med Sch 2006; 73: 214–220)

Key words: gastric cancer, laparoscopic surgery, lymphadenectomy

Gastric cancer remains one of the most common causes of cancer death in Japan. The rate of detection of early gastric cancer has increased as a result of advances in diagnostic upper gastrointestinal endoscopy. Because early gastric cancer is associated with a low recurrence rate and a long survival time after surgical treatment, attention should be directed to patients' quality of life after surgery[1].

Since laparoscopic cholecystectomy has clear

Correspondence to Teruo Kiyama, Department of Surgery, Nippon Medical School, 1-1-5 Sendagi, Bunkyo-ku, Tokyo 113–8603, Japan
E-mail: kiyama@nms.ac.jp
Journal Website (http://www.nms.ac.jp/jnms/)

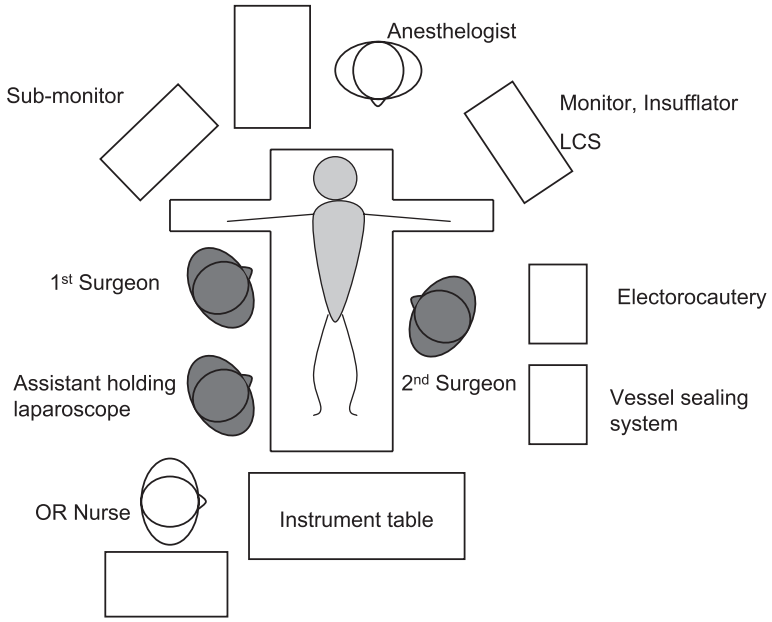

Fig. 1 Position of the surgical team in relation to the equipment.
The surgeon stands on the right side of the patient at the start of surgery. During dissection of the infrapyloric lymph nodes (#6) the surgeon moves to the left side of the patient. After transecting the duodenum, the surgeon returns to the right side of the patient.

advantages over open surgery, including earlier recovery of bowel function, earlier hospital discharge, and less pain[2,3], laparoscopic procedures have been adopted to treat gastric tumors. The first successful case of laparoscopy-assisted distal gastrectomy was reported in 1994[4], and several new laparoscopic procedures for specific gastric tumors, such as gastrointestinal submucosal tumor, have been developed[5]. Laparoscopic procedures for duodenal ulcer perforation and gastrointestinal submucosal tumor have been used in our hospital since 1996. Hand-assisted laparoscopic surgery has also been adopted for early gastric cancer, and distal gastrectomy was successfully performed laparoscopically in 2 cases in 2000. Since the field of view of the surgical site is limited and systemic dissection of regional lymph nodes remains difficult[6], flexible laparoscopes were developed for gastrointestinal endoscopy to expand the field of view with overhead or sidearm laparoscopy procedures and were introduced at our hospital in 2001. The purpose of this study was to clarify the safety and value of laparoscopic surgery for gastric cancer.

Patients and Methods

This retrospective study involved 101 patients with gastric cancer treated with laparoscopic surgery at the Nippon Medical School Hospital from February 2001 through July 2005. Laparoscopic surgery was selected on the basis of the results of preoperative assessment of depth of wall invasion by endoscopy, barium radiology, and endoscopic ultrasonography. Laparoscopic surgery for gastric cancer was indicated when the tumor was limited to the mucosal or submucosal layer in accordance with the guidelines for gastric cancer therapy[7].

Two procedures were used for laparoscopic local resection: laparoscopic wedge resection by a lesion-lifting method[5] and intragastric mucosal resection[8]. Local resection was used to treat early gastric cancers without lymph node metastasis that were not candidates for endoscopic mucosal resection because of tumor size or location.

Laparoscopy-assisted distal gastrectomy was performed with the standard technique as outlined below. The patient was positioned on the operating table in the reverse Trendelenburg position. The

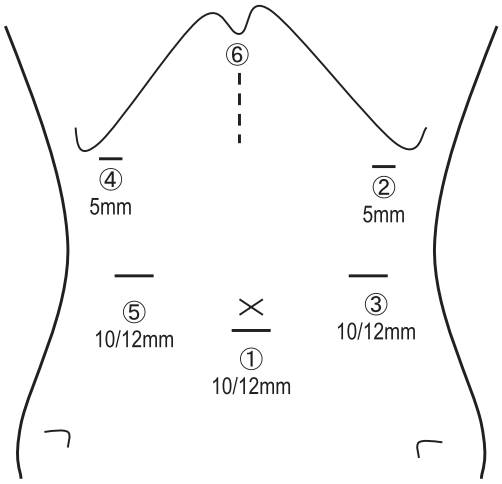

Fig. 2 Trocar placement. The first trocar (1) is placed below the umbilicus by the open technique. The abdomen is insufflated, and a flexible laparoscope is inserted. Four other trocars (2～5) are then placed. After transection of the duodenum, a small (4 to 7 cm) midline incision (6) is made in the upper abdomen. It should be large enough to pass the stomach through the wound.

Table 1 Clinical background of patients who underwent laparoscopy-assisted gastrectomy

Age (years)	68 ± 11	(41 ～ 94)
Sex (M/F)	71/33	
Comorbid conditions		
Cerebrovascular disease	5	
Cardiovascular disease	16	
Respiratory failure	3	
Liver cirrhosis	2	
Renal failure	3	
Diabetes	16	
RA (Steroid therapy)	2	
None	48	
Tumor size (mm)	24.1 ± 18.4	
Location		
Upper	12	
Middle	8	
Lower	81	
Macroscopic type		
0-I	8	(I + IIc, 1)
0-IIa	18	(IIa + IIc, 3)
0-IIb	9	(IIb + IIc, 2)
0-IIc	54	
0-III	2	
2	3	
Histological type		
Well differentiated	80	
Poorly differentiated	21	

RA: rheumatoid arthritis

main monitor was placed in the surgeon's field of vision, and a second monitor was placed on the opposite side **(Fig. 1)**. The light source, video system, insufflator, and laparoscopic coagulating shears were placed in the same rack as the main monitor. An electrocautery and bipolar vessel sealing system were positioned behind the second surgeon. After a CO_2 pneumoperitoneum of 8 mmHg was created by the open technique, the four other ports were placed in the upper abdomen **(Fig. 2)**. A flexible laparoscope (Olympus, Tokyo) was introduced through the infraumbilical port. The greater omentum, the lesser omentum, and gastrocolic ligament were dissected with laparoscopic coagulating shears (Sonosurg, Olympus). The right gastroepiploic vessels were cut with the bipolar vessel sealing system (Ligasure, Tyco, Norwalk, CT, USA) to dissect the subpyloric lymph nodes (number 6). The duodenum was transected 0.5 cm distal to the pylorus with an endoscopic stapling device. The suprapyloric lymph nodes were dissected after the right gastric artery was cut (number 5). The left gastric vessels were divided, and the left cardiac and superior gastric lymph nodes were dissected (number 1,3,7). The stomach and perigastric lymph nodes were removed through a minilaparotomy (4～7 cm) and placed on the upper abdomen. The stomach was transected extracorporeally with a linear stapler, and the en-bloc resection of the stomach and lymph nodes (D1+α) was completed. Reconstruction was usually performed with the Billroth I method and a double stapling device (29 mm in diameter).

Preoperatively, the operative procedure, the expected clinical outcomes, the number of procedures we had performed, and the guidelines of gastric cancer treatment were explained to all patients. All patients gave written informed consent.

Data were collected from medical charts, operation records, and pathology reports. The following variables were evaluated: age, sex, co-morbidity, tumor size, location, gross type, histological type, depth of wall invasion, and presence or absence of lymph node metastasis. The surgical variables evaluated were operating time,

Table 2 Results of laparoscopy-assisted gastrectomy

Operation time (min)	255 ± 74	
Blood loss (g)	128 ± 162	(not counted ～ 1,040)
Gastrectomy procedures		
Local gastrectomy	13	
Pylorus-preserving gastrectomy	16	
Distal gastrectomy	56	
Proximal gastrectomy	11	
Total gastrectomy	5	
Lymph node dissection		
None (D0)	13	
D1	4	
D1 + α	45	
D1 + β	38	
D2	1	
No. of lymph nodes dissected (D1, D2)	24 ± 17	(2 ～ 77)
Intraoperative complications	3	
Bleeding	2	
Failure of linear cutter	1	
Conversion to laparotomy	1	(duodenal stump rupture)
Postoperative stay (days)	13.3 ± 7.6	(median 12, 8 ～ 80)
Surgical complications	10 (9.9%)	
Bleeding	3	
Pneumohypoderma	1	
Remote infection	6	
Medical complications	1 (1%)	(Af, cerebral infarction)

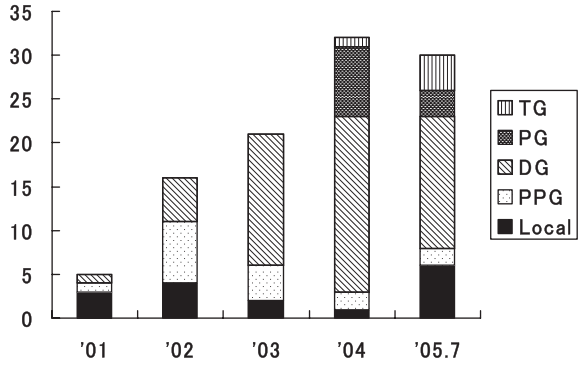

Fig. 3 Laparoscopy-assisted gastrectomy was adopted for gastric cancer in 2001. The number of procedures increased year by year, especially for distal gastrectomy.

blood loss, postoperative complications, and length of postoperative stay. Complications were classified as either surgical or medical. All data are expressed as means±standard deviations.

Results

The characteristics of the patients are shown in **Table 1**. Half of the patients had concurrent disease, including cardiovascular disease (n=16) and diabetes mellitus (n=16). The mean tumor diameter was 24.1 ± 18.4 mm, and most tumors were located in the distal third of the stomach. Endoscopic examination revealed that 98 of the tumors were early gastric cancers, and 80 tumors were histologically diagnosed as well-differentiated adenocarcinoma.

The clinical results are shown in **Table 2**. The mean operation time was 255 ± 74 min, and the mean blood loss was 128 ± 162 g. The number of cases of laparoscopic surgery for gastric cancer has increased **(Fig. 3)**. Local gastrectomy without lymphadenectomy (lesion-lifting method) was performed in the first case, and pylorus-preserving gastrectomy plus perigastric lymphadenectomy was performed in the second case. Distal gastrectomy plus systemic lymphadenectomy procedure was performed in 56 cases. Proximal and total gastrectomy plus lymph node dissection began to be used for tumors located in the upper half of the stomach in 2004 and has been performed in 16 cases.

Table 3 Clinicopathological findings of patients who underwent laparoscopy-assisted gastrectomy

Microscopic findings	
Pap	1
tub1	51
tub2	28
Por	11
Sig	10
Depth of tumor	
M	61
SM	30
MP	7
SS	1
SE	2
Lymph node metastasis	
N0	93
N1	6
N2	2
Stage	
IA	89
IB	8
II	2
IIIA	2

The extent of lymph node dissection was the perigastric lymph nodes (D1) in 4 cases, systemic perigastric lymph nodes (D1+α) in 45 cases, additional lymph node dissection along the common hepatic artery (D1+β) in 38 cases, and extended lymph node dissection (D2) in 1 case. Intraoperative complications occurred in 3 cases: bleeding from the midcoloic vein (940 g) in 1 case, bleeding from the left gastric artery (1,040 g) in 1 case, and a duodenal stump injury in 1 case. In the last case the procedure was converted to laparotomy to repair the duodenal stump. There were 6 one-stage operations, consisting of 5 cholecystectomies and 1 right hemicolectomy.

Pathological examination revealed tumor invasion of the mucosal and submucosal layers (T1) in 91 cases, invasion of the proper muscle and subserosa (T2) in 8 cases, and serosa exposure (T3) in 2 cases in **Table 3**. Although no lymph node metastasis (N0) was observed in 93 cases, perigastric lymph node metastasis (N1) occurred in 6 cases, and regional gastric lymph node metastasis (N2) occurred in 2 cases. The final stage was IA in 89 cases, IB in 8 cases, II in 2 cases, and IIIA in 2 cases.

The mean postoperative hospital stay was 13.3 ± 7.6 days. No patients died during the admission, and postoperative surgical complications occurred in 10 cases. Anastomotic bleeding developed in 3 cases and required endoscopic hemostat clipping and blood transfusion. Remote infections occurred in 6 cases and consisted of pneumonia due to atelectasis in 2 cases, septicemia in 2 cases, urinary tract infection in 1 case, and influenza (type A) in 1 case. Pneumohypoderma developed in one case. The medical complication was a stroke. Cerebral infarction occurred after surgery in an 80 year-old man with atrial fibrillation, and he was discharged to home unassisted on postoperative day 80.

Discussion

Laparoscopic surgery has not been as well accepted for gastric cancer as for colon cancer anywhere, including Japan. It remains an investigational procedure because of its technical difficulty and the lack of level I evidence from randomized studies[9]. The use of flexible laparoscopes has resulted in improved image quality as well as more efficient handling and safer procedures[10]. Analysis of the learning curve for laparoscopic colectomy has suggested that at least 30 to 50 cases are required to achieve technical proficiency[11]. In this paper we analyzed our data, including operating time, blood loss, incidence of surgical complications, length of postoperative hospital stay, and lymph node retrieval, and found that they compared favorably with the corresponding data from gastrectomy studies.

Mean operating time was almost 4 hours and was comparable with times in other studies[12]. Mean blood loss as a result of laparoscopic surgery was 128 g and was less than that lost during open surgery[13]. There were 3 intraoperative complications. It was possible to ligate the injured midcolic vein and left gastric artery via the small abdominal incision through which the resected stomach was removed, but a small injury to the duodenum during suturing of the stump through a small abdominal incision required conversion to laparotomy and repair of the duodenal stump. No patients died during the

admission, and the postoperative morbidity rate was 10% (10 of 101 patients). Postoperative surgical complications included anastomotic bleeding in 3 cases and pneumohypoderma in 1 case. All of complications occurred in the first 27 cases treated and may have been related to the learning-curve period[14]. There was no anastomotic leakage or organ/peritoneal abscesses. There were 6 remote infections (6%), and the incidence of remote infection was comparable to the incidence associated with open surgery[15].

The median postoperative hospital stay was 12 days and was shorter than for open surgery. However, implementation of a clinical pathway decreased the postoperative hospital stay from 28 days to 18 days[16]. The effect of laparoscopic surgery on hospital stay might not be as great as that of the clinical pathway. Weight loss associated with laparoscopy-assisted gastrectomy was less than that associated with open distal or total gastrectomy[17].

Whether laparoscopic surgery was indicated for gastric cancer was determined according to the guidelines of the Japanese Gastric Cancer Association, so 98 cases were early gastric cancer, T1 and N0/N1, preoperatively. Our cases included 3 advanced cancers, 1 each in an 87-year-old man with pheochromocytoma, a 75-year-old man with hepatocellular cancer treated by transarterial embolization, and a 75-year-old man with paralysis due to cerebral infarction. These patients had severe comorbid conditions, which would likely have complicated treatment with open surgery. Laparoscopic surgery was selected because of its minimal invasiveness and the early recovery from surgical insults. There were no tumor deaths in the short follow-up period.

The first laparoscopic gastrectomy procedure in our series was a laparoscopic wedge resection by a lesion-lifting method in 2001. Then, laparoscopic local resection, wedge resection or intragastric mucosal resection, was performed to treat 12 patients with early gastric cancer without lymph node metastasis who were not candidates for endoscopic mucosal resection (EMR) because of tumor size or differentiation. Because histological examination of 483 early gastric cancers revealed lymph node metastasis in 2.7% of mucosal cancers and in 14.9% of submucosal cancers, the standard surgery for early gastric cancer should include perigastric lymph node dissection[15].

Laparoscopy-assisted pylorus-preserving gastrectomy plus perigastric lymph node dissection was performed in 16 cases of early gastric cancer, but suprapyloric lymph node dissection was not performed so that the pyloric branch of the vagal nerve and the right gastric artery would be preserved. Gastric emptying was delayed 1 month postoperatively in most patients who underwent pylorus-preserving gastrectomy[18]. Laparoscopy-assisted distal gastrectomy plus systemic perigastric lymph node dissection (D1+α) and additional lymph node dissection along the common hepatic artery (D1+β) was performed in 56 cases of gastric cancer. Lymph node dissection was performed in 88% of cases (88 of 101 cases). The mean number of lymph nodes retrieved was 7 for D0, 13 for D1, 16 for D1+α, 31 for D1+β, and 33 for D2. We previously reported results of a retrospective analysis of 483 patients with early gastric cancer treated with gastrectomy plus D1 or D2 lymph node dissection[15]; however, the 5-year survival rate of patients with n1-positive submucosal cancer was 91% for those who underwent D2 dissection but was 80% for those who underwent D1 dissection. The criteria for lymph node numbering has changed, and D2 dissection in the retrospective study is comparable to D1+β dissection in the present series[19]. The above results indicate that the percentage of patients treated with distal gastrectomy plus D1+β dissection increased in the latter half of this series and in Japan[20].

Laparoscopy-assisted proximal gastrectomy plus perigastric lymph node dissection was performed in 11 cases of early gastric cancer of the upper stomach in this study. The gastrointestinal tract reconstruction consisted of 10 esophago-remnant stomach anastomoses and a double-tract reconstruction. Laparoscopy-assisted total gastrectomy plus systemic lymph node dissection was carried out in 5 cases of early gastric cancer in the upper third and middle third of the stomach but was still technically difficult, especially the

reconstruction using a 40- to 50-cm antecolic jejunal Roux limb[20].

Conclusion

We conclude that laparoscopy-assisted gastrectomy is a safe and useful operation for most early gastric cancers. If patients are selected properly, laparoscopy-assisted gastrectomy can be a curative and minimally invasive treatment for gastric cancer.

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(Received, February 17, 2006)
(Accepted, June 23, 2006)