ORIGINAL ARTICLE

Laparoscopy-Assisted Billroth I Gastrectomy Compared With Conventional Open Gastrectomy

Yosuke Adachi, MD; Norio Shiraishi, MD; Akio Shiromizu, MD; Toshio Bandoh, MD; Masanori Aramaki, MD; Seigo Kitano, MD

Background: Although several studies compare surgical results of laparoscopic and open colonic resections, there is no study of laparoscopic gastrectomy compared with open gastrectomy.

Hypothesis: When compared with conventional open gastrectomy, laparoscopy-assisted Billroth I gastrectomy is less invasive in patients with early-stage gastric cancer.

Design: Retrospective review of operative data, blood analyses, and postoperative clinical course after Billroth I gastrectomy.

Setting: University hospital in Japan.

Patients: The study included 102 patients who were treated with Billroth I gastrectomy for early-stage gastric cancer from January 1993 to July 1999: 49 with laparoscopy-assisted gastrectomy and 53 with conventional open gastrectomy.

Main Outcome Measures: Demographic features examined were operation time; blood loss; blood cell counts of leukocytes, granulocytes, and lymphocytes; serum levels of C-reactive protein, interleukin 6, total protein, and albumin; body temperature; weight loss; analgesic requirements; time to first flatus; time to liquid diet; length of postoperative hospital stay; complications; proximal margin of the resected stomach; and number of harvested lymph nodes.

Results: Significant differences ($P<.05$) were present between laparoscopy-assisted and conventional open gastrectomy when the following features were compared: blood loss (158 vs 302 mL), leukocyte count on day 1 (9.42 vs 11.14×10^9/L) and day 3 (6.99 vs 8.22×10^9/L), granulocyte count on day 1 (7.28 vs 8.90×10^9/L), C-reactive protein level on day 7 (2.91 vs 5.19 mg/dL), interleukin 6 level on day 3 (4.2 vs 26.0 U/mL), serum albumin level on day 7 (35.6 vs 33.9 g/L), number of times analgesics given (3.3 vs 6.2), time to first flatus (3.9 vs 4.5 days), time to liquid diet (5.0 vs 5.7 days), postoperative hospital stay (17.6 vs 22.5 days), and weight loss on day 14 (5.5% vs 7.1%). There was no significant difference between laparoscopy-assisted and conventional open gastrectomy with regard to operation time (246 vs 228 minutes), proximal margin (6.2 vs 6.0 cm), number of harvested lymph nodes (18.4 vs 22.1), and complication rate (8% vs 21%).

Conclusions: Laparoscopy-assisted Billroth I gastrectomy, when compared with conventional open gastrectomy, has several advantages, including less surgical trauma, less impaired nutrition, less pain, rapid return of gastrointestinal function, and shorter hospital stay, with no decrease in operative curability. When performed by a skilled surgeon, laparoscopy-assisted Billroth I gastrectomy is a safe and useful technique for patients with early-stage gastric cancer.

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From the First Department of Surgery, Oita Medical University, Oita, Japan.

In Japan, detections of early-stage gastric cancer have been increasing because of rapid advances in diagnostic instruments and increased use of mass screening or individual examination.[1-3] Recently, various laparoscopic approaches have been introduced to treat patients with small gastric cancer confined to the mucosa.[4-7] Since the first report of our experience of laparoscopy-assisted Billroth I gastrectomy (LAG) in 1994,[8] laparoscopic distal gastrectomy for gastric cancer has been quickly adopted, and the number of operations has been increasing. In our department, patients with early-stage gastric cancers in the lower half of the stomach are candidates for this less invasive surgery. Our recent study on 40 patients who underwent LAG showed that this operation was safe and useful for patients with early-stage gastric cancer.[9]

See Invited Critique at end of article

Although several studies have compared the surgical results of colonic resection between laparoscopic and open procedures,[10-12] there is no study of lapa-

SUBJECTS AND METHODS

This study included 102 consecutive patients with early-stage gastric cancer who had undergone Billroth I gastrectomy at the First Department of Surgery, Oita Medical University, Oita, Japan, between January 1993 and July 1999. All tumors were histologically adenocarcinomas that invaded only the mucosa or submucosa of the stomach. Forty-nine patients underwent LAG, and 53 underwent COG. The patients were assigned to 1 of the 2 procedures based on the depth of wall invasion estimated by preoperative gastric endoscopy and barium meal study: LAG for tumors restricted to the mucosa and COG for those that invaded the submucosa. Patients with other organ cancer and those with cardiac, pulmonary, or hepatic insufficiency were not included.

As described previously, LAG consisted of the following procedures[8,9]: (1) laparoscopic dissection of lesser omentum and greater omentum, mobilization of the stomach, ligation and division of right gastroepiploic vessels, right gastric vessels, and left gastric vessels under pneumoperitoneum or abdominal wall–lifting method and (2) resection of the distal two thirds of the stomach followed by hand-sawn anastomosis between the gastric remnant and duodenal stump through a 5-cm-long minilaparotomy incision. Conventional open gastrectomy was performed in a usual manner through an upper midline laparotomy incision from xiphoid process to umbilicus.

The age, sex, height, and weight of patients, symptoms on admission, how to detect the lesion, and concurrent illness were documented, and the following demographic features were obtained from medical charts: operation time, estimated blood loss, leukocyte count, granulocyte count, lymphocyte count, C-reactive protein (CRP) level, total protein level, albumin level, body temperature, and weight loss during the hospital stay. For the 22 patients,10 undergoing LAG and 12 undergoing COG, venous blood samples were drawn on ice 1, 3, and 7 days after surgery and stored at –80°C. Interleukin 6 (IL-6) was measured using a commercially available enzyme-linked immunosorbent assay with monoclonal antibodies specific for human IL-6 (Amersham Pharmacia Biotech UK Limited, Buckinghamshire, England).

Analgesic requirements after operation were determined by the total number of times that intramuscular meperidine hydrochloride and diclofenac sodium suppositories were given at the request of patients. Postoperative days when first passage of flatus was observed, when liquid diet was permitted, and when body temperature became less than 37°C were checked, and the length of postoperative hospital stay was examined. Complications included pneumonia, intra-abdominal abscess, anastomotic leakage, severe enteritis, and delayed gastric emptying, gastric stasis, anastomotic stenosis, or adhesive ileus, which needed the prohibition of oral intake.

All resected stomachs were opened immediately after operation, and dissected lymph nodes were divided according to the guideline of the Japanese Gastric Cancer Association.[13] On formalin-fixed specimens, the size, location, gross type, and histologic type of tumors; length of lesser curvature; length of greater curvature; and proximal margin of the resected stomach were measured. Using hematoxylin-eosin–stained sections, the depth of wall invasion, number of harvested lymph nodes, and presence or absence of lymph node metastasis were determined histologically.

Results of the patients undergoing LAG and COG were compared, and statistical analysis was performed using the *t* test and Mann-Whitney *U* test for continuous variables. For both tests, $P<.05$ was interpreted as a significant difference, and values were expressed as mean ± SD. Statistical analysis for categorical variables was performed using the χ^2 test, and $P<.05$ was regarded as significant.

roscopic gastrectomy compared with open gastrectomy. This study was undertaken to evaluate the surgical results of LAG compared with conventional open gastrectomy (COG) for patients with early-stage gastric cancer. The usefulness of laparoscopic surgery in the management of gastric cancer was assessed.

RESULTS

Both groups were similar in symptoms, diagnostic method, and concurrent illness (**Table 1**). Operation time of LAG (246 minutes) was not significantly longer than that of COG (228 minutes), and estimated blood loss of LAG (158 mL) was less than that of COG (302 mL). Although grossly elevated and histologically well-differentiated type tumor occurred more often in the LAG group than in the COG group, the location of tumors, length of lesser curvature, proximal margin, and number of harvested lymph nodes of the LAG group were comparable with those of the COG group.

Significant differences were present between the 2 groups when the following features were compared: leukocyte count on day 1 (9.42 vs 11.14 × 10^9/L) and day 3 (6.99 vs 8.22 × 10^9/L), granulocyte count on day 1 (7.28 vs 8.90 × 10^9/L), and albumin level on day 7 (35.6 vs 33.9 g/L) (**Table 2**). Serum CRP and IL-6 levels showed a marked increase after operation in both groups, but the decrease was more rapid in the LAG group than in the COG group, showing significant differences in the CRP level on day 7 (2.91 vs 5.19 mg/dL) (**Figure**) and the IL-6 level on day 3 (4.2 vs 26.0 U/mL).

Body temperature returned to a normal level quicker after LAG compared with COG (5.0 vs 6.5 days) (**Table 3**). The number of times analgesics were required was less frequent in patients with LAG than in those with COG (3.3 vs 6.2). Time to first flatus (3.9 vs 4.5 days), time to liquid diet (5.0 vs 5.7 days), and length of postoperative hospital stay (17.6 vs 22.5 days) were shorter in the LAG group than in the COG group, and weight loss on day 14 was less for the LAG group than for the COG group (5.5% vs 7.1%). Complication rate was not significantly different between the LAG and COG groups (8% vs 21%), and all patients in the LAG group were alive without recurrence or port-site metastasis during a follow-up period from 5 to 60 months, with a median of 36 months and a mean of 37.3 months.

Table 1. Clinicopathologic Data of Patients With Gastrectomy*

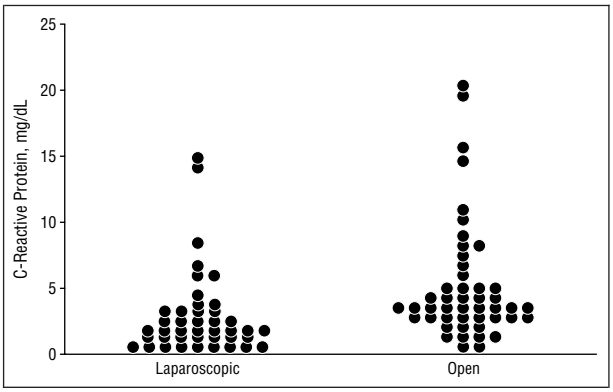
Factor	Laparoscopic (n = 49)	Open (n = 53)	P
Age, y	65.7 ± 9.7	62.1 ± 13.7	.12
Male/female	28/21 (57/43)	31/22 (58/42)	.89
Height, cm	157.4 ± 9.3	159.1 ± 8.8	.34
Weight, kg	54.2 ± 9.0	56.9 ± 11.0	.17
Symptoms, absent/present	27/22 (55/45)	27/26 (51/49)	.67
Diagnostic method, endoscopy/barium study	42/7 (86/14)	38/15 (72/28)	.08
Concurrent illness			
Absent/present	30/19 (61/39)	28/25 (53/47)	.39
Hypertension	7	14	
Diabetes mellitus	7	6	
Cardiac angina	6	3	
Arrhythmia	2	3	
Chronic hepatitis	1	4	
Cerebral infarction	2	1	
Renal dysfunction	1	1	
Operation time, min	246 ± 61	228 ± 73	.19
Blood loss, mL	158 ± 121	302 ± 211	<.001
Lesser curvature, cm	13.6 ± 2.6	14.0 ± 2.3	.25
Greater curvature, cm	20.7 ± 4.2	23.0 ± 4.3	.01
Proximal margin, cm	6.2 ± 3.6	6.0 ± 2.9	.80
Perigastric lymph nodes	15.5 ± 7.8	18.6 ± 9.8	.10
Left gastric artery nodes	2.9 ± 2.9	3.5 ± 2.9	.22
Tumor size, cm	2.2 ± 1.3	3.1 ± 1.9	.02
Location, middle/lower	23/26 (47/53)	29/24 (55/45)	.43
Gross type, elevated/depressed	15/34 (31/69)	7/46 (13/87)	.03
Histologic type, well/poorly differentiated	42/7 (86/14)	27/26 (51/49)	<.001
Depth of wall invasion, mucosa/submucosa	31/18 (63/37)	28/25 (53/47)	.28
Lymph node metastasis, absent/present	46/3 (94/6)	46/7 (87/13)	.19

*Data are given as mean ± SD or number (percentage).

Table 2. Blood Analyses After Laparoscopic vs Open Gastrectomy*

Factor	Laparoscopic (n = 49)	Open (n = 53)	P
Leukocyte, $\times 10^9$/L			
Day 1	9.42 ± 3.05	11.14 ± 3.04	.01
Day 3	6.99 ± 2.71	8.22 ± 2.40	.03
Day 7	5.54 ± 2.09	6.09 ± 1.50	.15
Granulocyte, $\times 10^9$/L			
Day 1	7.28 ± 2.47	8.90 ± 2.98	.02
Day 3	5.15 ± 2.32	6.16 ± 2.24	.06
Day 7	3.33 ± 1.48	3.88 ± 1.14	.07
C-reactive protein, mg/dL			
Day 1	7.48 ± 3.64	9.21 ± 4.16	.07
Day 3	12.45 ± 9.71	15.35 ± 8.54	.15
Day 7	2.91 ± 3.25	5.19 ± 4.69	.009
Interleukin 6, U/mL			
Day 1	44.0 ± 13.2	55.8 ± 9.2	.30
Day 3	4.2 ± 2.2	26.0 ± 7.5	.009
Total protein, g/L			
Day 7	58.9 ± 5.5	58.3 ± 5.9	.57
Day 14	60.3 ± 5.4	61.3 ± 5.5	.50
Albumin, g/L			
Day 7	35.6 ± 3.9	33.9 ± 3.9	.03
Day 14	35.9 ± 3.5	35.5 ± 3.2	.61
Lymphocyte, $\times 10^9$/L			
Day 7	1.24 ± 0.43	1.24 ± 0.41	.97
Day 14	1.40 ± 0.51	1.60 ± .056	.16

*Values are expressed as mean ± SD.



Serum C-reactive protein level on day 7 was significantly different between the patients with laparoscopic gastrectomy and those with open gastrectomy (2.9 vs 5.2 mg/dL; P<.01).

COMMENT

To our knowledge, this is the first comprehensive study on the surgical and pathologic results of LAG compared with COG for cure of gastric cancer. Our study was based on a single-institute experience with a large group of patients and showed several advantages of LAG over COG. These short-term benefits of LAG included less surgical trauma, less impaired nutrition, less pain, rapid return of gastrointestinal function, and shorter hospital stay, with no decrease in operative curability.

Our study clarified that postoperative increase of leukocyte count, granulocyte count, CRP level, IL-6 level, and body temperature was less pronounced, and the decrease of these inflammatory parameters was more rapid after LAG than after COG. The results indicated that the laparoscopic approach could reduce acute-phase response after surgery and minimize surgical trauma and immunosuppressive effect of operation. Furthermore, postoperative decrease of serum albumin level was not marked, weight loss during hospital stay was mild, and postoperative complications were rare in patients undergoing LAG. The results suggested that the laparoscopic procedure was less invasive, brought a favorable nutritional effect, and might result in a low morbidity rate. When applied carefully to patients with early-stage gastric cancer, laparoscopic surgery did not result in port-site metastasis or other unusual complications associated with pneumoperitoneum with carbon dioxide.[14-16] We believe that LAG is a safe and useful operation for patients with early-stage gastric cancer.

Many studies[17,18] have shown favorable results of laparoscopic colonic resection for cure of colon cancer. The application of laparoscopic technique improves short-term outcome after colonic surgery, which included less pain, rapid recovery of bowel function, short hospital stay, and early return to daily activity.[11,12,18] Recently, these findings were confirmed by prospective randomized trials comparing laparoscopic and open colonic resections.[19,20] The results of the present study on Billroth I gastrectomy for

Table 3. Clinical Course After Laparoscopic vs Open Gasrectomy*

Factor	Laparoscopic (n = 49)	Open (n = 53)	*P*
Body temperature, °C			
Day 1	38.0 ± 0.4	38.1 ± 0.4	.25
Day 3	37.3 ± 0.5	37.4 ± 0.5	.16
Day 7	36.7 ± 0.4	36.8 ± 0.4	.08
No. of days to body temperature <37°C	5.0 ± 2.1	6.5 ± 2.4	.001
No. of times analgesics given	3.3 ± 2.5	6.2 ± 3.5	<.001
No. of days to first flatus	3.9 ± 1.0	4.5 ± 0.9	.002
No. of days to liquid diet	5.0 ± 0.9	5.7 ± 1.1	<.001
Postoperative hospital stay, d	17.6 ± 6.2	22.5 ± 8.7	.009
Weight loss, %			
Day 7	4.2 ± 2.0	4.7 ± 2.2	.18
Day 14	5.5 ± 1.9	7.1 ± 2.2	.001
Complications, No.			
Delayed gastric emptying	2	4	
Adhesive ileus	1	2	
Pneumonia	1	1	
Intra-abdominal abscess	0	3	
MRSA enteritis	0	3	
No. (%) of patients with complications	4 (8)	11 (21)	.06

**Values are expressed as mean ± SD unless otherwise indicated. MRSA indicates methicillin-resistant* Staphylococcus aureus.

gastric cancer confirmed and enhanced the results of these previous studies on colonic resection, and short-term benefits of laparoscopic approach have become more evident in the field of gastrointestinal surgery.

Initial criticism against laparoscopic colonic surgery focused on the complicated surgical procedure and long operation time of this new approach.[21,22] With advances of instruments and improvements in techniques, operation time for laparoscopic colectomy has decreased comparable with that of open colectomy.[10-12] In our series of Billroth I gastrectomy, operation time of laparoscopic procedure (246 minutes) was not longer than that of conventional technique (228 minutes). Laparoscopic gastrectomy has been done mostly by one surgeon (S.K.), who is familiar with both laparoscopic digestive surgery and gastric cancer surgery.[8,23,24] Operation time in our experience of laparoscopic gastrectomy was not significantly different between the procedures performed for the first 24 patients (240 minutes) and those for the last 25 patients (251 minutes). Thus, when performed by a skilled and experienced surgeon, LAG does not take any more time than COG.

In our series, patients in the LAG and COG groups were discharged 18 and 22 days after gastrectomy, respectively. Postoperative hospital stay in Japan is known to be longer than that in western countries. Because the hospitalization is not expensive, owing to special insurance systems in Japan, most patients want to get sufficient rest after surgery and are permitted to spend a long time in the hospital.[25] It is possible that when LAG is performed in western countries, postoperative hospital stay will be much shorter than in our series.

Pathologic examination confirmed that LAG and COG were not different with regard to the proximal margin of the resected stomach and number of harvested lymph nodes around the stomach and along the left gastric artery. In the LAG group, 3 (17%) of 18 tumors microscopically invading the submucosa had lymph node metastasis. In these 3 patients, metastasis was restricted to the perigastric lymph nodes, and removal of regional lymph nodes was considered sufficient. If needed at operation, complete dissection of the lymph nodes along the celiac trunk, common hepatic artery, and hepatoduodenal ligament can be done through a minilaparotomy incision with the same techniques and instruments used for COG.

A reduced morbidity and rapid recovery after LAG have been shown by some authors. Goh et al[26] analyzed early international results of LAG based on the questionnaire sent to 16 surgeons in 12 countries. They demonstrated that 10 surgeons (62%) found the procedure superior to COG because of less pain, faster recovery, and better cosmesis. Recently, we examined quality of life of patients who had undergone LAG.[27] The 24-item questionnaire answered by the 76 patients clarified that surgical results of LAG, when compared with COG, were significantly better with regard to weight loss, difficulty in swallowing, heartburn or belch, and early dumping syndrome. Laparoscopic gastrectomy was better accepted by the patients as a good procedure and promptly brought the patients back to their previous lifestyle and activities of daily living. Thus, long-term subjective results, including physical condition and performance status, after LAG were superior to those after COG.

CONCLUSIONS

Laparoscopy-assisted Billroth I gastrectomy, when compared with COG, has several advantages, including less surgical trauma, less impaired nutrition, less pain, rapid return of gastrointestinal function, and shorter hospital stay, with no decrease in operative curability. When performed by a skilled surgeon, LAG is a safe and useful technique for patients with early-stage gastric cancer.

Reprints: Yosuke Adachi, MD, First Department of Surgery, Oita Medical University, 1-1 Idaigaoka, Hasama-machi, Oita 879-5593, Japan.

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Invited Critique

Adachi and his colleagues are to be commended for their results in a large series of patients with early-stage gastric cancer who underwent laparoscopy-assisted Billroth I gastrectomy (LAG) or conventional open gastrectomy (COG). They demonstrated several advantages of LAG over COG, including less surgical trauma, less impaired nutrition, less pain, rapid return of gastrointestinal function, shorter hospital stay, no decrease in operative curability. This approach has been adopted by more than a few Japanese surgeons since the first case of LAG for early gastric cancer performed by the same authors in 1994. Briefly, LAG consists of 2 procedures: (1) laparoscopic approach under the pneumoperitoneum and (2) resection of the stomach followed by hand-sawn anastomosis through a minilaparotomy incision.

The authors assigned patients with early-stage gastric cancer to undergo either LAG or COG based on the depth of wall invasion as determined by preoperative gastric fiberscopy and barium meal study—LAG for tumors restricted to the mucosa and COG for those invading the submucosa. Recently, progress has been made in endoscopic and laparoscopic procedures for the treatment of intramucosal carcinoma of the stomach. The most minimally invasive procedure is an endoscopic mucosal resection, which is widely used in Japan. Laparoscopically, a lesion-lifting method for local resection and a method of intragastric surgery for mucosal lesion of early gastric cancer have also been developed in Japan. We should, however, note that these approaches are limited to only mucosal carcinoma without lymph node metastases, since these approaches cannot allow any lymph node dissection. On the other hand, LAG can allow enough proximal margin of the resected stomach and sufficient dissection of regional lymph nodes. Accurate preoperative diagnosis of the depth of cancer invasion is extremely important, since the indications for LAG are also considered for early gastric cancer with invasion restricted to the mucosa. Histological examination revealed that there were 18 tumors (37%) invading the submucosa in the LAG group of 49 patients, all of whom had been preoperatively determined to have early gastric cancer with invasion restricted to the mucosa. This clearly reflects the difficulty in the preoperative accurate evaluation of the depth of wall invasion of early gastric cancer. It is widely accepted that endoscopic ultrasonography is the most reliable method for precise diagnosis of the staging and the depth of wall invasion of gastric cancer. Although the authors did not provide any data or comment on endoscopic ultrasonagraphy in the present article, this should be mentioned. The incidence of lymph node metastases is very low, ranging from 1% to 3% in mucosal carcinoma of the stomach, mostly restricted in the perigastric area. This evidence theoretically supports the indication of LAG for mucosal carcinoma.

On the contrary, the incidence of lymph node metastases in submucosal carcinoma of the stomach is much more frequent, ranging from 15% to 20%. Actually, the rate of lymph node metastases in submucosal carcinoma was 17% in the study by Adachi et al. The authors were able to remove regional lymph nodes sufficiently using the LAG method, since lymph node metastases were found to be restricted only to the perigastric area. However, lymph node metastases in submucosal carcinoma sometimes show extension to the left gastric arterial area, celiac trunk area, common hepatic arterial area, and, occasionally, to the splenic arterial area or hepatoduodenal ligament. The problem is that it is almost impossible to perform a precise intraoperative evaluation of the extent of lymph node metastases in submucosal carcinoma of the stomach. It is essential to decide intraoperatively how to manage lymph node dissection, performing lymphadenectomy only around perigastric area or performing extended lymphadenectomy. It might be recommended that these authors perform intraoperative evaluation of the depth of the wall invasion of the resected specimen of the stomach and intraoperative histological examination of the frozen section of the dissected lymph nodes when the tumor is suspected to invade the submucosa.

Although a prospective randomized study is awaited, this study demonstrates that LAG is a safe and useful technique for patients with early-stage gastric cancer. Laparoscopy-assisted Billroth I gastrectomy might be one of the promising therapeutic choices for early-stage gastric cancer.

Kazutomo Inoue, MD
Kyoto, Japan