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Laparoscopic versus open D2 gastrectomy for advanced gastric cancer: a retrospective cohort study

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Abstract
Background The oncologic safety and feasibility of laparoscopic D2 gastrectomy for advanced gastric cancer are still uncertain. The aim of this study is to compare our results for laparoscopic D2 gastrectomy with those for open D2 gastrectomy.
Methods Between 1998 and 2008, a total of 336 patients with clinical T2, T3, or T4 tumors underwent laparoscopic ($n = 186$) or open ($n = 150$) gastrectomy involving D2 lymph node dissection with curative intent. To produce this study population, 123 patients in the open group who matched those of the laparoscopic group with regard to age, sex, body mass index (BMI), American Society of Anesthesiologists (ASA) score, tumor location, and clinical tumor stage were retrospectively selected. The short- and long-term outcomes of these patients were examined.
Results Laparoscopic D2 gastrectomy was associated with significantly less operative blood loss and shorter hospital stay, but longer operative time, compared with open D2 gastrectomy. The mortality and morbidity rates of the laparoscopic group were comparable to those of the open group (1.1 % vs. 0, $P = 0.519$, and 24.2 % vs. 28.5 %, $P = 0.402$). The 5-year disease-free and overall survival rates were 65.8 and 68.1 % in the laparoscopic group and 62.0 and 63.7 % in the open group ($P = 0.737$ and $P = 0.968$). There were no differences in the patterns of recurrence between the two groups.
Conclusions This study suggests that laparoscopic D2 gastrectomy provides reasonable oncologic outcomes with acceptable morbidity and low mortality rates. Although operation time is currently long, this approach is associated with several advantages of laparoscopic surgery, including quick recovery of bowel function and short hospital stay. Laparoscopic D2 gastrectomy may offer a favorable alternative to open D2 gastrectomy for patients with advanced gastric cancer.

Keywords Laparoscopic gastrectomy · Stomach neoplasm · D2 dissection · Mortality and morbidity · Outcome

Although the annual incidence of and mortality from gastric cancer have been decreasing year on year worldwide, gastric cancer is still one of the most common causes of cancer-related death in East Asia [1, 2]. Adjuvant chemotherapy improves the survival of these patients, but radical gastrectomy and D2 lymph node dissection still remain the only curative therapies for gastric cancer [3–5].

Successful laparoscopic gastrectomy for gastric cancer was first reported by Kitano et al. in 1994 [6]. Since then, a growing number of reports of laparoscopic gastrectomy for gastric cancer have appeared in the literature [7]. Over the last decade, laparoscopic surgery has been regarded as the treatment of choice for early gastric cancer (invading only the mucosa or submucosa), in which the optimal lymph node dissection levels were D1 + alpha and/or D1 + beta [8]. The documented benefits of laparoscopic gastrectomy over conventional open gastrectomy include less pain, better cosmesis, shorter postoperative hospital stay, more

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rapid bowel function, and reduced immunosuppression [9, 10]. Furthermore, several multicenter studies have shown similar outcomes for laparoscopic gastrectomy and open gastrectomy during oncologic resection for early gastric cancer [11, 12].

Recently, one of the hot issues in laparoscopic gastric surgery has been whether the indication can be safety extended to advanced gastric cancer (invading beyond the submucosa). As techniques and instruments in laparoscopic surgery improve, highly experienced laparoscopic surgeons are performing D2 lymph node dissection by laparoscopic approach, including dissections of the lymph nodes in the hepatoduodenal ligament and along the superior mesenteric vein and/or a concomitant splenectomy to completely retrieve station 10 lymph nodes [13–15]. This laparoscopic approach was shown to be technically feasible with complication rates comparable to open D2 gastrectomy [13–15]. Indeed, several authors have recently reported their experience with laparoscopic D2 gastrectomy for advanced gastric cancer [15, 16]. However, the indications for and necessity of laparoscopic gastrectomy for advanced gastric cancer remain controversial. There are several concerns about the technical feasibility and safety of laparoscopic D2 gastrectomy for advanced gastric cancer and the lack of long-term results from any controlled studies.

The aim of the current study is to investigate the clinical outcome of laparoscopic gastrectomy involving D2 lymph node dissection for advanced gastric cancer in comparison with open D2 gastrectomy in terms of surgical results and survival rates.

Patients and methods

Patients

A computer database at Fujita Health University School of Medicine, Aichi, Japan, containing information about gastric cancer patients was started in September 1997. Between October 1997 and December 2008, 792 patients underwent laparoscopic gastrectomy for gastric cancer. In 1998, we started performing D2 lymph node dissection entirely by laparoscopy for patients with potentially curable stage T2, T3, or T4 gastric cancer. All patients had histologically verified adenocarcinoma of the stomach. Of these, 512 patients with clinical T1 gastric cancer were excluded from the present study. The remaining 280 patients were diagnosed to have clinical T2, T3, or T4 gastric cancer. Patients who underwent laparoscopy-assisted ($n = 4$) or hand-assisted ($n = 11$) surgery that required a minilaparotomy incision for anastomosis of the bowel and/or dissection of extraperigastric lymph nodes were excluded from the present study. Patients who demonstrated clinical evidence of distant metastases ($n = 17$) or who had history of previous malignant disorders ($n = 7$) or gastrectomy for benign and malignant disease ($n = 20$) were excluded. In addition, 35 patients who underwent palliative gastrectomy owing to the presence of free cancer cells in their lavage fluid during surgery were excluded from this study. For this study, we analyzed our first 186 patients who underwent laparoscopic gastrectomy with D2 lymph node dissection for clinically advanced gastric cancer and compared their results with those of matched patients from our gastric resection database who had undergone conventional open D2 gastrectomy during the same period.

This study was approved by our institutional review board and involved prospective data collection and retrospective analysis of data obtained from patients undergoing laparoscopic or open gastrectomy. All patients and their families were informed of the innovative nature of the study, and written informed consent was obtained before surgery.

Surgical techniques

All patients were treated with radical gastrectomy and D2 lymph node dissection according to the Japanese classification of gastric carcinoma (JCGC) by the Japanese Gastric Cancer Association [17]. Depending on the location and macroscopic type of the tumor, the surgeon performed distal subtotal, total, or proximal subtotal gastrectomy. Pancreaticosplenectomy was only performed when necessitated by tumor invasion. Until March 2008, all patients were treated by a single surgeon (I.U.). Thereafter, laparoscopic gastrectomy operations were performed or guided by three surgeons (I.U., S.K., K.T.) who had performed at least 30 laparoscopic D2 gastrectomy procedures for early gastric cancer. The open D2 gastrectomy procedures were performed by gastric surgeons who had more than 10 years of surgical experience. Patients were selected for laparoscopic or open approach at the discretion of the attending surgeon.

Laparoscopic D2 gastrectomy was performed using methods that we developed previously [18, 19]. In brief, using a five-port technique, the lymph nodes along the common hepatic (station 8a) and proper hepatic (station 12a) arteries were removed en bloc just anterior to the portal vein. The root of the left gastric artery was double-clipped and divided, before dissection of the lymph nodes along the celiac artery (station 9) and the left gastric artery (station 7). The fatty connective tissue including the lymph nodes around the splenic artery (stations 11p and 11d) was completely removed. During total or proximal gastrectomy for proximal tumors, the spleen was removed in principle to achieve adequate removal of the lymph nodes at the splenic hilus (station 10). The lower esophagus was

adequately mobilized and transected using an endoscopic stapling device. For patients in whom invasion of the esophagus was suspected intraoperatively, part of the excised portion of the esophagus was submitted for frozen-section examination using hematoxylin–eosin staining. An anastomosis was performed intracorporeally using a stapling technique. In cases involving distal tumors, Roux-en-Y gastrojejunostomy or delta-shaped Billroth I anastomosis was performed [20]. For patients with proximal tumors, a side-to-side esophagogastrostomy was performed after proximal gastrectomy. After total gastrectomy, an esophagojejunostomy was mechanically created using a functional end-to-side anastomotic technique [21].

Perioperative management

Pre- and postoperative management was standardized for the two groups. All patients received broad-spectrum antibiotics for 48 h during their postoperative hospitalization. No prophylactic somatostatin or octreotide was used routinely. Oral feeding was started after passage of flatus. Patients were discharged once they were free from any complications. Demographic details, perioperative data such as operative time, estimated blood loss, presence or absence of postoperative complications, length of postoperative hospital stay, clinicopathological tumor–node–metastasis (TNM) stage (according to the International Union Against Cancer staging) [22], and the 5-year survival rate were evaluated. Major postoperative complications were defined as surgical complications, including anastomotic problems (leakage or stenosis), pancreatic fistulas, abdominal abscesses, and wound infection. Anastomotic leakage was radiologically evaluated using water-soluble contrast material on the third postoperative day. Anastomotic stenosis was defined as a condition that required endoscopic dilatation. Pancreatic fistula was defined as a spontaneous or surgically released purulent discharge. Abdominal abscess was defined as a purulent discharge with positive cultures obtained from abdominal drains placed during surgery or fluid collection requiring drainage. Wound infection was defined in accordance with the Centers for Disease Control and Prevention criteria [23]. Other postoperative complications were defined as adverse events resulting in delayed discharge from the hospital or readmission to the hospital within 30 days of discharge. Hospital mortality was defined as death during hospitalization or postoperative death of any cause within 30 days.

In accordance with our protocol, postoperative adjuvant chemotherapy with 5-fluorouracil (5-FU) alone, 5-FU plus cisplatin (patients entered from October 1997 to August 2002), or S-1 and cisplatin (patients entered from September 2002 to December 2008) was given to some patients with stage II, IIIA, IIIB, or IV tumors during the study period. Patients were followed by the surgical team at 3-month intervals for the first 2 years after surgery and every 6 months thereafter. The main patterns of recurrence were recorded as the first site of detectable failure at time of diagnosis, and patients were divided into three groups: locoregional, peritoneal, and hematogenous recurrence.

Statistical analysis

All statistical analyses were performed using SPSS statistical software (SPSS release 15.0 J for Windows; SPSS Japan Inc., Tokyo, Japan). To compare treatment groups, the chi-square test or Fisher's exact test was used to compare categorical variables, and the Student t test or Mann–Whitney's U test was used to compare continuous variables, as appropriate. The patients in the laparoscopic group who required conversion to the open procedure were analyzed with the laparoscopic group on an intention-to-treat basis. Disease-free and overall survival rates were calculated using the Kaplan–Meier method and examined by the log-rank test. For the analysis of oncological outcomes, patients with pathological tumor stage IA disease and patients of missing follow-up were excluded. P value of less than 0.05 was considered statistically significant.

Results

Figure 1 illustrates the yearly distribution of patients with potentially resectable gastric cancer at our department. Comparing the periods from 1998 to 2003 and from 2004 to 2008, there was a 100 % increase in the number of procedures in the later period, and the annual rate of laparoscopic gastrectomy increased progressively. A total of 336 patients with clinical T2, T3, or T4 tumors underwent curative laparoscopic ($n = 186$) or open ($n = 150$) gastrectomy with D2 lymph node dissection during this 11-year period. Among this study population, 123 patients from the open group who matched the patients of the laparoscopic group with regard to age, sex, body mass index, American Society of Anesthesiologists (ASA) classification, tumor location, and preoperative clinical tumor stage were retrospectively selected.

Table 1 summarizes the characteristics and clinical tumor stage of the patients. None of these variables differed significantly between the two groups. Four (2.2 %) of the 186 patients in the laparoscopic group required conversion to the open procedure and were analyzed with the laparoscopic group on an intention-to-treat basis. The surgical data of the two groups are presented in Table 2. Mean operative time of the laparoscopic group was significantly longer than that of the open group (370 min versus 264 min, $P < 0.001$). The open group was

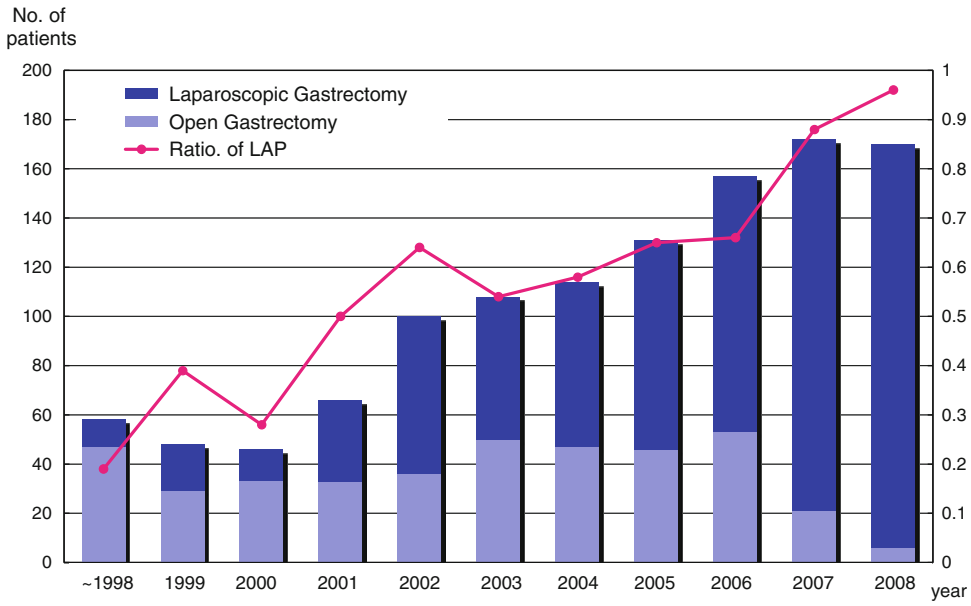

Fig. 1 Distribution of type of surgery by year

Table 1 Characteristics of patients and tumors

	Laparoscopic gastrectomy ($n = 186$)	Open gastrectomy ($n = 123$)	P value
Age (years)[a]	61.4 (11.7)	63.1 (9.9)	0.179
Sex, n (%)			0.963
Male	129 (69.4)	85 (69.1)	
Female	57 (30.6)	38 (30.9)	
BMI (kg/m^2)[a]	21.5 (3.2)	21.4 (3.3)	0.825
Comorbidity, n (%)	80 (43.0)	52 (42.3)	0.907
ASA class, n (%)			0.666
I	102 (54.8)	71 (57.7)	
II	77 (41.4)	50 (40.7)	
III	7 (3.5)	2 (1.6)	
Previous laparotomy, n (%)[b]	24 (12.9)	15 (12.2)	0.854
Tumor location, n (%)			0.719
Upper third of stomach	42 (22.6)	26 (21.1)	
Middle third of stomach	94 (50.5)	63 (51.2)	
Lower third of stomach	46 (24.7)	34 (27.6)	
Histologic type, n (%)			0.835
Differentiated	90 (48.4)	61 (49.6)	
Undifferentiated	96 (51.6)	62 (50.4)	
Preoperative T stage, n (%)			0.852
cT2	115 (61.8)	77 (62.6)	
cT3	68 (36.6)	43 (35.0)	
cT4	3 (1.6)	3 (2.4)	

BMI body mass index, *ASA* American Society of Anesthesiologists

[a] Values in parentheses are mean (standard deviation)

[b] Previous abdominal surgery excluding appendectomy

associated with greater blood loss than the laparoscopic group (389 ml versus 154 ml, $P < 0.001$). Blood transfusions were required approximately threefold more often in the open group compared with the laparoscopic group. Over one-third of the patients underwent total or proximal subtotal gastrectomy in each group. Among the four patients converted to open gastrectomy in the laparoscopic group, three patients had to be converted to open gastrectomy due to intraoperative complications (one each of common bile duct injury, hemorrhaging, and failure of the linear stapler), and another patient required conversion due to dense adhesion after open sigmoidectomy.

Postoperative variables are presented in Table 3. The overall rate of complications was 24.2 % (45 of 186 patients) in the laparoscopic group and 28.5 % (35 of 123 patients) in the open group ($P = 0.402$). There were no significant differences between the two groups with regard to the incidences of pancreatic fistula ($P = 0.985$), abdominal abscess ($P = 0.238$), anastomotic leakage ($P = 0.503$), anastomotic stenosis ($P = 0.491$), or non-surgical complications ($P = 0.283$). Conversely, the incidence of wound infection was significantly higher for the open group than the laparoscopic group (8.1 % versus 1.1 %, $P = 0.004$). In the laparoscopic group, eight patients with surgical complications required second operations; of these, four were for internal hernia beneath the jejunal loop, and one each for early postoperative obstruction, esophagogastrostomy anastomotic leakage, intra-abdominal fluid collection, and postoperative bleeding. Among them, five patients were treated via a laparoscopic approach, and the other three patients required open laparotomy. The frequency of second operations was somewhat higher in the laparoscopic group than in the open group,

Table 2 Surgical outcomes

	Laparoscopic gastrectomy ($n = 186$)	Open gastrectomy ($n = 123$)	P value
Duration of surgery (min)[a]	369.7 (109.5)	263.6 (76.9)	<0.001
Estimated blood loss (ml)[a]	154.3 (281.7)	388.7 (272.8)	<0.001
Blood transfusion, n (%)	11 (5.9)	23 (18.7)	<0.001
Type of gastrectomy, n (%)			0.158
Distal	119 (64.0)	76 (61.8)	
Total	62 (33.3)	38 (30.9)	
Proximal	5 (2.7)	9 (7.3)	
Pancreaticosplenectomy, n (%)	3 (1.6)	0 (0.0)	0.279
Splenectomy, n (%)	39 (21.0)	27 (22.0)	0.836
Conversion to open from laparoscopic gastrectomy, n (%)	4 (2.2)	–	–

[a] Values in parentheses are mean (standard deviation)

Table 3 Postoperative outcomes

Complications, n (%)	Laparoscopic gastrectomy ($n = 186$)	Open gastrectomy ($n = 123$)	P value
Overall	45 (24.2)	35 (28.5)	0.402
Surgical complications	32 (17.2)	30 (24.4)	0.123
Pancreatic fistula	12 (6.5)	8 (6.5)	0.985
Abdominal abscess	9 (4.8)	9 (7.3)	0.238
Anastomotic leak	5 (2.7)	5 (4.1)	0.503
Anastomotic stenosis	4 (2.2)	5 (4.1)	0.491
Wound infection	2 (1.1)	10 (8.1)	0.004
Nonsurgical complications	12 (6.5)	13 (10.6)	0.283
Requiring reoperation, n (%)	8 (4.3)	2 (1.6)	0.325
Time to ambulation (days)[a]	2 (0.5)	3.2 (0.6)	<0.001
Time to oral intake (days)[a]	3.4 (1.5)	5.7 (4.4)	<0.001
Duration of hospitalization (days)[a]	16.3 (9.8)	24.3 (11.9)	<0.001
Hospital death, n (%)	2 (1.1)	0 (0.0)	0.519

[a] Values in parentheses are mean (standard deviation)

but the difference did not reach statistical significance (4.3 % versus 1.6 %, $P = 0.325$). Mean times to postoperative ambulation and oral feeding were significantly shorter in the laparoscopic group than in the open group (2 days versus 3.2 days, $P < 0.001$, and 3.4 days versus 5.7 days, $P < 0.001$). The duration of postoperative hospital stay was longer by a mean of 1 week in the open gastrectomy group ($P < 0.001$). Two patients died in hospital, both belonging to the laparoscopic group (1.1 %). One died from a rapidly progressive tumor, and the other died of postoperative complications on postoperative day 20.

Table 4 presents the pathological data of the two groups. All patients underwent potentially curative D2 gastrectomy, and resection margins were free of invasion in all patients. Mean number of lymph nodes harvested per patient was 45 for the laparoscopic group and 44 for the open group ($P = 0446$). The distribution of tumors according to the TNM classification of the International Union Against Cancer staging was similar between the two groups, and no significant difference was found in the percentage of patients who received perioperative chemotherapy.

As previously mentioned, for the evaluation of long-term survival, patients with pathological tumor stage IA disease and patients of missing follow-up were excluded. Median follow-up period was 48.8 (interquartile range 25–58.5) months; six patients in the laparoscopic group and five in the open group were lost to follow-up. The calculated 5-year disease-free survival (DFS) rate for all stages was 65.8 % [95 % confidence interval (CI): 55.7–76.5 %] in the laparoscopic group and 62.0 % (95 % CI: 51.4–72.6 %; $P = 0.737$) in the open group (Fig. 2). Figure 3 demonstrates the calculated DFS rates for the patients after laparoscopic and open D2 gastrectomy: 94.3 % (95 % CI: 88.0–100 %) versus 91.8 % (95 % CI: 81.0–100 %) for the patients with stage IB disease ($P = 0.760$), 71.3 % (95 % CI: 58.6–84.0 %) versus 61.0 % (95 % CI: 41.8–80.2 %) for the patients with stage II disease ($P = 0.836$), 51.7 %

Table 4 Pathologic characteristics

	Laparoscopic gastrectomy ($n = 186$)	Open gastrectomy ($n = 123$)	P value
No. of retrieved lymph nodes[a]	45.3 (16.9)	43.8 (17.2)	0.446
Pathological T stage, n (%)			0.726
pT1	25 (13.4)	17 (13.8)	
pT2	96 (51.6)	58 (47.2)	
pT3	65 (34.9)	48 (39.0)	
Pathological N stage, n (%)			0.767
pN0	73 (39.2)	44 (35.8)	
pN1	65 (34.9)	49 (39.8)	
pN2	45 (24.2)	28 (22.8)	
pN3	3 (1.6)	1 (0.8)	
TNM stage, n (%)[b]			0.239
IA/IB	70 (37.6)	43 (35.0)	
II	49 (26.3)	33 (26.8)	
IIIA/IIIB	48 (25.8)	41 (33.3)	
IV	19 (10.2)	6 (4.9)	
Perioperative chemotherapy, n (%)	114 (61.3)	72 (58.5)	0.628

[a] Values in parentheses are mean (standard deviation)

[b] According to the UICC staging [22]

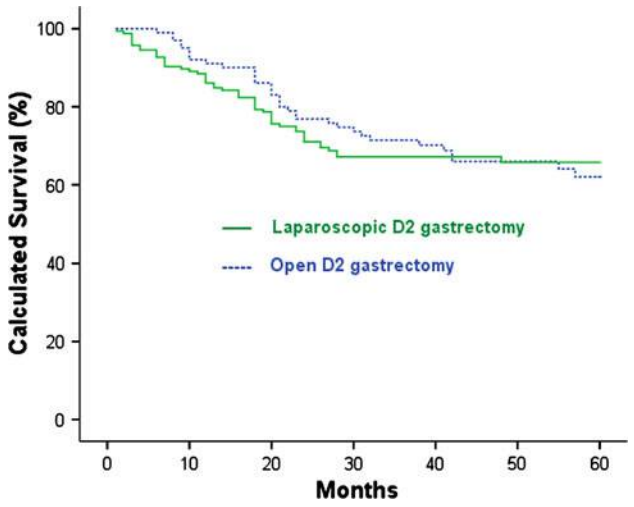

Fig. 2 Kaplan–Meier curves for DFS between the laparoscopic gastrectomy and the open gastrectomy groups

(95 % CI: 36.0–67.4 %) versus 45.8 % (95 % CI: 29.1–62.5 %) for the patients with stage III disease ($P = 0.457$), and 0 % versus 0 % for the patients with stage IV disease ($P = 0.629$), respectively. There were no differences between the groups with regard to tumor stage. The calculated 5-year overall survival (OS) rates for all stages were 68.1 % (95 % CI: 58.7–77.5 %) in the laparoscopic group and 63.7 % (95 % CI: 52.3–75.1 %; $P = 0.968$) in the open group (Fig. 4). Figure 5 demonstrates the calculated OS rates for the patients after laparoscopic and open D2 gastrectomy: 95.9 % (95 % CI: 90.4–100 %) versus 95.8 % (95 % CI: 87.8–100 %) for the patients with stage IB disease ($P = 0.944$), 78.1 % (95 % CI: 65.0–91.2 %) versus 61.9 % (95 % CI: 38.0–85.8 %) for the patients with stage II disease ($P = 0.896$), 54.1 % (95 % CI: 36.5–71.7

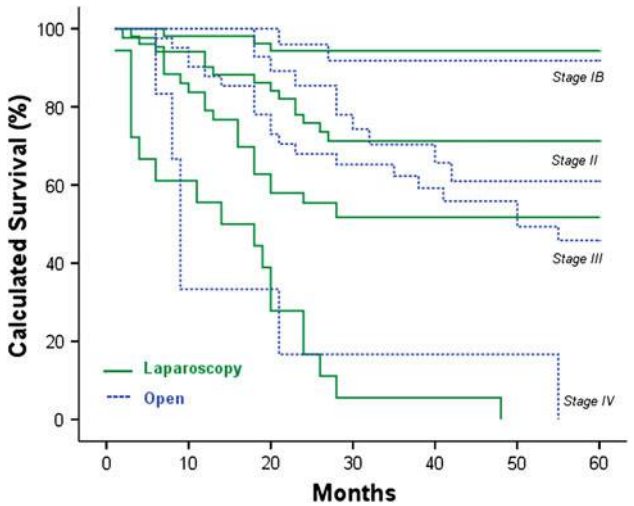

Fig. 3 Kaplan–Meier curves for DFS between the laparoscopic gastrectomy and the open gastrectomy groups according to pathology of UICC staging

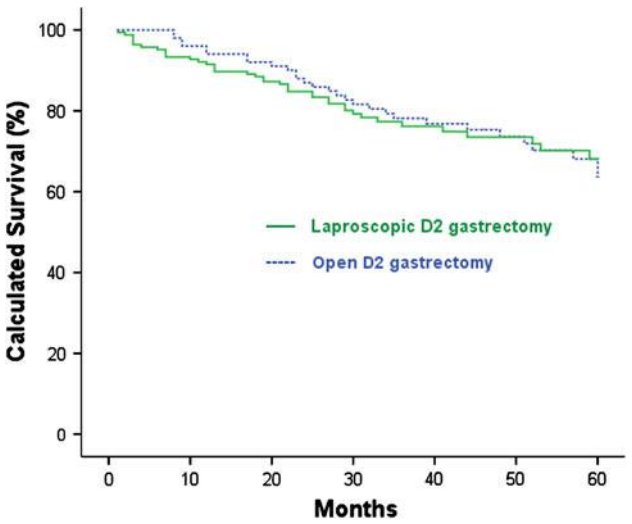

Fig. 4 Kaplan–Meier curves for OS between the laparoscopic gastrectomy and the open gastrectomy groups

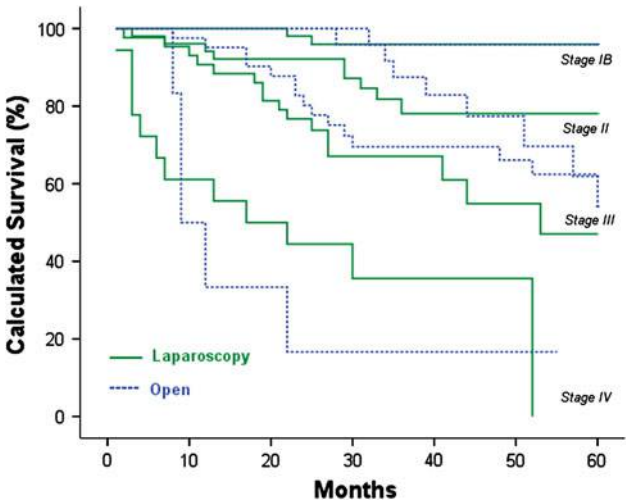

Fig. 5 Kaplan–Meier curves for OS between the laparoscopic gastrectomy and the open gastrectomy groups according to pathology of UICC staging

%) versus 47.1 % (95 % CI: 25.0–69.0 %) for the patients with stage III disease ($P = 0.393$), and 0 % versus 16.7 % (95 % CI: 0–46.0 %) for the patients with stage IV disease ($P = 0.787$), respectively. There were no differences between the groups with regard to tumor stage.

Fifty-three patients in the laparoscopic group developed tumor recurrence, 29 (54.7 %) from peritoneal recurrence, 23 (43.4 %) from distant or hematogenous recurrence, and 15 (28.3 %) from locoregional or lymphatic recurrence; the corresponding findings in the open group were 17 (50 %), 15 (44.1 %), and 11 (32.6 %), respectively. The pattern of recurrence was similar in the two groups, and no unexpected tumor dissemination or port-site recurrence was observed.

Discussion

This study was designed to compare the clinical outcomes of laparoscopic and open D2 gastrectomy for advanced gastric cancer with particular attention paid to postoperative morbidity and mortality, and survival rates. To the best of our knowledge, this is the largest matched cohort study of this technique. In the present study, laparoscopic D2 gastrectomy was associated with significantly less operative blood loss and shorter hospital stay, but longer operative time, compared with open D2 gastrectomy. Consequently, we observed that laparoscopic D2 gastrectomy offers both similar morbidity and mortality rate to that of open D2 gastrectomy, and the oncological outcomes were comparable between the two groups.

Lymph node metastasis of advanced gastric cancer is frequently encountered around the suprapancreatic area such as in stations 7, 8, 9, and 11 [24]. Complete dissection of this area is an important element of curative surgical treatment for advanced gastric cancer [25]. Our technique consists of dissection of the suprapancreatic lymph nodes with initial mobilization of the pancreatic body and downward retraction of the pancreas by gauze traction to obtain extensive surgical field at the upper border of the pancreas [18]. These steps and the high quality of laparoscopic view with magnified visualization have helped us to perform meticulous dissection of lymph nodes. From a clinical standpoint, extent of lymphadenectomy is a well-recognized marker of quality of oncologic resection in gastric cancer [26]. The number of retrieved lymph nodes in our series is comparable to these of skilled teams [4, 27, 28] and did not differ between laparoscopic and open surgery (45 versus 44 per case), indicating that laparoscopic approach has not jeopardized the quality of nodal dissection.

According to the guidelines of the JCGC, D2 dissection entails removal of the lymph nodes along the proper hepatic (station 12a) or the superior mesenteric vein (station 14v) for distal gastrectomy and of the lymph nodes at the splenic hilus (station 10) for total or proximal gastrectomy with concomitant splenectomy. However, dissection of this area is sometimes technically demanding because of the serious risk of bleeding and/or bile and pancreatic leakage from a major vessel or organ injury. As in open resections, nodal dissection was considered to increase morbidity and mortality [29–31]. In the present study, the hospital mortality rate and the overall morbidity rate did not differ between laparoscopic and open D2 gastrectomy (1.1 % versus 0, and 24.2 % versus 28.5 %, respectively). Our results are comparable to the mortality rates of 0.8–3.1 % and the morbidity rates of 20.1–33.5 % reported from specialized centers with sufficient experience of open D2 lymph node dissection for advanced gastric cancer [27, 28, 32, 33]. Furthermore, in the present study, the mean patient age, sex, ASA score, body mass index, and the distribution of tumor location were similar to those of previously published series, and the spleen was removed in over 62 % of total or proximal gastrectomy cases, suggesting that our patient selection was not substantially different from those of most comparative open D2 gastrectomy studies [27, 29, 30]. Therefore, compared with open D2 gastrectomy, laparoscopic D2 gastrectomy could be considered a safe and feasible treatment for advanced gastric cancer as well.

Operation time in our experience of laparoscopic D2 gastrectomy for advanced gastric cancer was quite longer, while median blood loss and the transfusion rate were remarkably lower than those of open D2 gastrectomy. Our prolonged operation time might be attributable to a substantial number of total or proximal gastrectomies and the low conversion rate. We expect that this problem will be solved in the near future by improvements in laparoscopic devices and techniques. On the other hand, reduction of tissue trauma is clearly one of the benefits of laparoscopic surgery. Our patients experienced very fast recovery with median time to postoperative ambulation of 2 days and median time to oral feeding of 3 days. This is consistent with the faster recovery noted for laparoscopic surgery for early gastric cancer [12]. The mean hospital stay after laparoscopic D2 gastrectomy was significantly shorter than after open D2 gastrectomy, but relatively longer than in other series from Western centers [16, 34]. This long hospital stay may be explained, in part, by differences in healthcare structures. At our institution, the majority of patients with stage II, III, and IV gastric cancer received adjuvant chemotherapy during the same hospitalization, and in Japan, subacute care, such as that given in nursing facilities or rehabilitation centers, is not well developed, and most patients are discharged from the hospital when their condition becomes perfect. Nevertheless, laparoscopic surgery has a clear benefit regarding postoperative hospital stay.

To date, oncologic outcome after laparoscopic versus open gastrectomy for treatment of advanced gastric cancer has been reported in two randomized and three case–control studies [16, 34–37]. Although oncologic safety seems to be identical between the groups, the number of patients was relatively small and some series analyzed mainly early gastric cancer. This study reported the results of a series of 309 consecutive patients who underwent laparoscopic D2 gastrectomy and open D2 gastrectomy for clinical T2, T3 or T4 gastric cancer. All patients were treated with curative intent, with median follow-up of over 48 months. In the present study, the OS rates at 5 years after laparoscopic and open D2 gastrectomy were 95.9 % and 95.8 % for stage IB disease, 78.1 % and 61.9 % for stage II disease, and 54.1 % and 47 % for stage III disease. The previous reports on open

D2 gastric surgery showed 5-year OS of 73–90 % for stage IB disease, 60–76 % for stage II disease, and 42–49 % for stage III disease [38, 39]. It is difficult to directly compare these results with ours, but the rate of 5-year OS from our study seemed to be comparable to the previous studies from Japan and some specialized Western centers. Although our results still have limitations because of the nature of our consecutive but retrospective study design and may have been biased by the patient selection criteria, the current data support the concept that laparoscopic D2 gastrectomy is an oncologically safe treatment for advanced gastric cancer.

One of the major concerns regarding the application of the laparoscopic approach for tumors with serosal invasion has been the possibility of peritoneal seeding of malignant cells during the procedure. Several proposed theories regarding the etiology of port-site recurrences associated with pneumoperitoneum and visceral manipulation have emerged [40]. Initially, we excluded patients with bulky or serosa-positive tumors from the criteria for laparoscopic resection. However, the availability of technical refinements and accumulated experience has contributed significantly to reduce the risk of tumor manipulation. As shown in Fig. 1, we have approached most cases of gastric cancer by laparoscopy since 2007. The report by Shoup et al. indicated that port-site recurrence for advanced disease was relatively rare [41], and on the basis of numerous studies focused on the oncologic outcomes with colorectal cancer, use of the laparoscopic approach did not cause any specific recurrence [42]. In the present study, the pattern of recurrence did not differ between the two groups, and in spite of 35 % of patients presenting with pathological T3 tumor, there was no incidence of unexpected tumor dissemination or port-site recurrence in the laparoscopic group.

In conclusion, this preliminary retrospective study was informative and suggests that laparoscopic D2 gastrectomy for advanced gastric cancer produces acceptable morbidity and low mortality rates and is safe with good long-term oncological outcomes. Further randomized trials will provide valuable evidence for the oncological safety of laparoscopic gastrectomy for treatment of advanced gastric cancer.

Disclosures Drs Shinohara, Satoh, Kanaya, Ishida, Taniguchi, Isogaki, Inaba, Yanaga, and Uyama have no competing interests and financial disclosures.

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