Laparoscopic Completion total Gastrectomy as an Alternative Procedure for Gastric Stump Cancer: A Case Control Study

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Abstract

Background

Complete gastrectomy for gastric stump cancer can be challenging due to severe adhesions; therefore, advanced techniques are required to perform laparoscopic surgery. This study aimed to evaluate the clinical outcomes of laparoscopic completion total gastrectomy for the treatment of gastric stump cancer.

Methods

Patient records from January 2010 to October 2018 were retrospectively evaluated. The patients were divided into two groups depending on whether they underwent open or laparoscopic gastrectomy. We compared patient characteristics; operative, clinical, and pathological data; survival rates; and prognosis between the groups.

Results

Twenty open and 17 laparoscopic completion total gastrectomies were performed. No significant differences in the distribution of the clinical T and N categories, clinical stage, and reconstruction methods of the initial gastrectomy between the two groups were observed. Laparoscopic gastrectomy resulted in a significantly longer operation time (230 vs. 182.5 min; $p = 0.026$), lower blood loss (14 vs. 105 mL; $p = 0.0000179$), and shorter period to the first flatus passage (2 vs. 3 days; $p = 0.0000401$) than open gastrectomy. No significant differences in the number of retrieved lymph nodes, duration of hospital stay, complication rate, and postoperative analgesic usage between the two groups were observed. No patients required conversion to open surgery in the laparoscopic-treatment group. Pathological findings revealed that the laparoscopic group had a smaller tumor size (not pathological T category) and less metastatic lymph nodes than the open group; this led to an earlier distribution of the pathological stage and better overall or disease-free survivals in the laparoscopic group.

Conclusions

Laparoscopic completion total gastrectomy was safely conducted without complications and mortality implicating the oncological validity for the treatment of gastric stump cancer. With sophistication of laparoscopic skills and advanced technologies, laparoscopic completion total gastrectomy may be the best way to perform less invasive surgery in terms of decreased blood loss and earlier recovery of intestinal peristalsis.

Background

The prognosis of gastric cancer after gastrectomy has improved, however, the incidence of cancer in the remnant stomach is increasing [1, 2]. Newly developed gastric cancer after partial gastrectomy for benign disease or gastric cancer is defined as remnant gastric cancer or gastric stump cancer (GSC), which is found in 1.1-6% of patients [2–6]. Complete resection of the carcinoma combined with a radical lymph node dissection is the only way to secure curability and improve the prognosis in patients who have no other complications [7]. Mesenteric lymph node metastasis around the gastrojejunostomy may worsen the prognosis of GSC [5]. A reported 5-year disease-specific survival rate for GSC was 7–20% due to the advanced tumor stage [2]. However, recent reports have stated that the overall 5-year survival for GSC has improved to approximately 53–56%, which remains at a lower level than that of proximal gastrectomy for primary gastric cancer (PGC) [4, 5, 8–10]. Therefore, the diagnosis of GSC at an early stage in patients who have undergone gastrectomy is important to reduce complications. However, complete gastrectomy for GSC has been difficult and invasive due to the severe adhesions that can occur fromthe previous procedures.

Laparoscopic gastrectomy has been confirmed to be safe with improved postoperative pain and earlier recovery than open gastrectomy [11–13]. However, only a few studies have reported the feasibility of laparoscopic completion total gastrectomy (LCTG) for GSC [14–21]. This study aimed to evaluate the feasibility, safety, and clinical outcomes of LCTG compared with those of open completion total gastrectomy (OCTG) to prove the oncological validity of LCTG.

Methods

Study design and patient characteristics

We performed a database search and identified 40 patients who had undergone surgery for GSC at Ishikawa Prefectural Central Hospital in Japan from January 2010 to December 2018. One patient who underwent bypass surgery, one patient who underwent staging laparoscopy, and one patient who underwent robot-assisted completion total gastrectomy were excluded from this study. The remaining 37 patients underwent gastrectomy for GSC and were further divided into two groups according to the initial approach of the operation: the LCTG group (n = 17) and OCTG group (n = 20). The mean age of patients in the LCTG and OCTG groups was 71.9 ± 8.1 and 68.9 ± 9.1 years, respectively. The male-to-female ratios in the LCTG and OCTG groups were 12 to 5 and 16 to 4, respectively. The medical records of all patients were retrospectively evaluated to compare the short-term surgical and long-term oncological outcomes. The patient characteristics are shown in Table 1.

Table 1
Patient Characteristics

	LCTG (n = 17)	OCTG (n = 20)	*P* value
Age (years: mean ± SD)	71.9 ± 8.1	68.9 ± 9.1	0.288
Gender (M : F)	12 : 5	16 : 4	0.779
BMI (kg/m^2: median)	20.49 (15.5–28.2)	20.63(16.7–28.0)	0.821
Comorbidity	3 (0–4)	1 (0–4)	0.378
Initial disease (Benign : Malignant)	5 : 12	4 : 16	0.779
Time interval (years)	11 (1–56)	15.5 (2–56)	0.385
Tumor location			0.9699
Anastomotic site	3	3	
Non anastomotic site	12	14	
Sutured site	1	1	
Whole stomach	1	2	
cT stage (1a/1b/2/3/4a/4b)	0/13/2/2/0/0	1/7/5/3/1/3	0.114
cN stage (0/1/2)	20/0/0	17/1/2	0.489
cStage(I/IIA/IIB/III/IVA/IVB)	15/0/2/0/0/0	12/1/2/2/2/1	0.359
Initial approach (laparoscopy : open)	6 : 11	3 : 17	0.294
Initial gastrectomy (ODG:OPG:OPPG: LDG:LPG:LPPG:LSG:Others)	9:2:0:3:1:1:1	13:0:3:3:0:0:0	0.117
Initial reconstruction (BI:BII:RY:E-G:G-G:others)	7:4:1:2:2:1	8:4:4:0:3:1	0.705

LCTG laparoscopic completion total gastrectomy, *OCTG* open completion total gastrectomy, *BMI* body mass index, *ODG* open distal gastrectomy, *OPG* open proximal gastrectomy, *OPPG* open pylorus preserving gastrectomy, *LDG* laparoscopic distal gastrectomy, *LPG* laparoscopic proximal gastrectomy, *LPPG* laparoscopic pylorus preserving gastrectomy, *LSG* laparoscopic segmental gastrectomy, *BI* Billroth I, *BII* Billroth II, *RY* Roux-en Y, *E-G* esophagogastrostomy, *G-G* gastrogastrostomy

Indication

The use of LCTG for GSC was introduced to our institution in 2010. The exclusion criteria for LCTG are remarkable direct tumor invasion to other organs and patient conditions that preclude laparoscopy.

Surgical Procedures

A five-port surgical approach was used. The first 12-mm trocar was inserted at the umbilical area using the Hassan method. The other trocars were subsequently inserted carefully under laparoscopic viewing as in conventional laparoscopy [22]. A 10-mm, 30-degree oblique viewing laparoscope was used, and the CO_2 pressure was maintained at 10–12 mmHg. The Harmonic Scalpel (Ethicon EndoSurgery Inc., Cincinnati, OH), which is an ultrasonic-activated device, and the LigaSure (Medtronic, Minneapolis, MN) were used for adhesiolysis and radical lymphadenectomy. The extent of lymph node dissection was based on the recommendations for total gastrectomy from the Japanese gastric cancer treatment guidelines [23]. In cases of benign disease at the initial surgery, the intact gastric vessels were dissected from the root, and the resected specimen was extracted through the umbilical incision, which was enlarged to the minimum size required for extraction.

Patients who underwent Billroth I reconstruction during the initial surgery

The gastrosplenic ligament was resected, starting with the opening of the omental bursa, and adhesions between the posterior gastric wall and pancreas were carefully divided. The dissection was carefully performed because the inferior surface of the left lateral segment of the liver was often severely adhesive to the remnant gastric wall. Moreover, the pneumoperitoneum yielded bloodless dissection. After encirclement of the gastro-duodenal anastomosis, the duodenum was transected using a linear stapler. Next, the remaining dissection around the remnant stomach including the vessels was completed, and the lower esophagus was transected in the same manner.

Patients who underwent Billroth II or Roux-en Y reconstruction during the initial surgery

The afferent and efferent loops of the jejunum or Roux limb were resected, securing sufficient distance from the anastomosis. The mesenteric lymph nodes were dissected depending on the tumor size or invasion.

Reconstruction after the complete removal of the GSC was performed with the Roux-en-Y method. The jejunum was transected 25 cm from the ligament of Treitz. Approximately 20 cm of the jejunum on the anal side was sacrificed, and the Roux limb was prepared. Jejunojejunostomy was performed with the Y limb. The Roux limb was ascended through the antecolic route, and esophagojejunostomy was performed using the overlap procedure. The mesenteric gap at the Y limb and Petersen's mesenteric defect were closed by continuous suturing using barbed string.

Statistical analysis

Patient ages are presented as the mean ± standard deviation, and all other values are expressed as the median with range. All statistical analyses were completed using R statistical software, version 3.5.0 (R Foundation for Statistical Computing, Vienna, Austria). Chi-squared, Fisher's exact, and Mann–Whitney U tests were performed for comparisons between the two groups. The cumulative 5-year survival rates were calculated according to the Kaplan–Meier method, and survival curves were compared using the log-rank test. The statistical significance level was set at $p < 0.05$.

Results

No significant differences between the two groups in sex distribution, body mass index, and comorbidity incidence were observed. A total of 5 and 12 initial gastrectomies were performed in the LCTG group for benign and malignant diseases, respectively; a total of 4 and 16 initial gastrectomies were performed in the OCTG group for benign and malignant diseases, respectively. However, the difference observed between the groups was not statistically significant. The median time from the initial gastrectomy to the development of GSC was comparable between the LCTG and OCTG groups (11 vs 15.5 years, respectively; p = 0.385). The most common tumor location in the LCTG and OCTG groups was the non-anastomotic site (12 [70.6%] and 14 [70%] cases, respectively). However, only three cases in each group had the tumor detected at the anastomotic site (17.6% and 15% in the LCTG and OCTG groups, respectively).

Two (11.8%) and seven (35%) patients in the LCTG and OCTG groups, respectively, were diagnosed with tumor depth invasion greater than clinical T stage 3. However, no significant difference in the distribution of the clinical T stage between the groups was observed. No patients in the LCTG group had preoperative lymph node metastasis. Therefore, patients in the LCTG group, except for those with clinical T stage 3, were considered to be at clinical stage I. The clinical stages in the OCTG group were diversely distributed; however, no significant difference in the stage distribution between the groups was observed. In the initial gastrectomy, several patients in both groups were treated with laparoscopy. The type and reconstruction of the initial gastrectomies were diverse; however, no significant difference in the distributions for both groups was observed. The most common reconstruction method in the initial gastrectomy was Billroth I anastomosis in seven (41.2%) and eight (40%) patients in the LCTG and OCTG groups, respectively.

Operative And Postoperative Short-term Outcomes

The surgical outcomes are depicted in Table 2. The median operation time was 230 (140–260) min and 182.5 (130–217.5) min in the LCTG and OCTG groups, respectively, representing a significant difference (p = 0.026). The median estimated blood loss was significantly different between the two groups: 14 (4–100) mL in the LCTG group and 105 (8–840) mL in the OCTG group (p = 0.0000179). No significant difference in the extent of lymphadenectomy and morbidity was observed between the two groups, although three patients in the OCTG group had major complications (Clavien–Dindo classification > grade IIIa). No conversion to open surgery was reported in the LCTG group. The median time to first flatus passage was significantly shorter in the LCTG group than that in the OCTG group (2 vs. 3 days; p = 0.0000401). No significant difference between groups in analgesic usage after postoperative day 5 (0 vs. 1 time; p = 0.334) or in the duration of postoperative hospitalization (13 vs. 14 days; p = 0.657) was observed.

Table 2
Operative and Postoperative Short-term Outcomes

	LCTG (n = 17)	**OCTG (n = 20)**	***P* value**
Operation time (min : median)	230 (140–400)	182.5 (130–360)	0.026
Estimated blood loss (ml)	14 (4-100)	105 (5-840)	0.0000179
Lymphadenectomy			
D0 : D1 : D1+ : D2	2 : 10 : 4 : 1	4 : 11 : 4 : 1	0.899
Complication (Clavien-Dindo)	0	3	0.288
< IIIa : ≥IIIa	0	1 : 2	
Conversion to Open	0	-	
First Flatus passage (POD)	2 (1–3)	3 (2–6)	0.0000401
Analgesic usage (≥ d5)	0 (0–14)	1 (0–19)	0.334
Postoperative hospital stay (days)	13 (9–26)	14 (9–271)	0.657

LCTG laparoscopic completion total gastrectomy, *OCTG* open completion total gastrectomy, *POD* post operative days, *d5* day 5

Pathological Outcomes

The pathological findings of the resected specimens are shown in Table 3. The median tumor size in the LCTG group was significantly smaller than that in the OCTG group (26 vs. 40 mm; p = 0.0457). No significant difference between groups in the median number of retrieved lymph nodes (11 vs. 9.5; p = 0.437), depth of the tumor invasion (p = 0.12), extent of lymphatic metastasis (p = 0.0509), distant metastasis ratio (p = 1), and variation of histological type (p = 1) were observed. However, the median number of metastatic lymph nodes was significantly lower in the LCTG group than that in the OCTG group (0 vs. 0.5; p = 0.0108). Additionally, the pathological stage distribution in the LCTG group was lower than that in the OCTG group (p = 0.0346).

Table 3
Pathological Outcomes

	LCTG (n = 17)	OCTG (n = 20)	*P* value
Tumor size (mm)	26 (12–77)	40 (8–120)	0.0457
Retrieved LN	11 (0–49)	9.5 (0–46)	0.437
Metastatic LN	0 (0–2)	0.5 (0–9)	0.0108
pT (1a/1b/2/3/4a/4b)	3/9/2/3/0/0	2/4/2/6/3/3	0.12
pN (0/1/2/3a)	15/2/0/0	10/4/4/2	0.0509
pM (0/1)	17/0	19/1	1
pStage (IA/IB/IIA/IIB/IIIA/IIIB/IIIC/IV)	12/2/1/2/0/0/0/0	5/1/3/3/4/3/0/1	0.0346
Histological type			
Differentiated : Undifferentiated	9 : 8	11 : 9	1

LCTG laparoscopic completion total gastrectomy, *OCTG* open completion total gastrectomy, *LN* lymph node

Postoperative Long-term Outcomes

The postoperative long-term outcomes are shown in Table 4. The median follow-up duration was 41 and 31 months for the LCTG and OCTG groups, respectively (p = 0.427). In the LCTG group, one patient died from recurrence, and one patient died from pneumonia. In the OCTG group, six patients died from recurrence, and three patients died from other diseases. Specifically, one patient in the LCTG group (5.88%) and 11 patients in the OCTG group (55%) developed recurrence, representing a significant difference (p = 0.004679). Recurrence in the patient in the LCTG group was due to metastasis to the mediastinal lymph nodes. In the OCTG group, seven cases of metastasis in the liver, three in the peritoneum, two in the pleura or regional lymph nodes, and one in the lung were reported. The 5-year overall survival rate was significantly higher in the LCTG group than that in the OCTG group (84.4% vs. 48.5%; p = 0.0373) (Fig. 1). The 5-year disease-free survival of the LCTG group was significantly higher than that of the OCTG group (93.3% vs. 41.9%; p = 0.00274) (Fig. 2).

Table 4
Postoperative Long-term Outcomes

	LCTG (n = 17)	OCTG (n = 20)	*P* value
MST (month)	41 (0–99)	31 (4–80)	0.427
Death	2 (11.8%)	9 (45.0%)	0.06528
Cause of death	Original (1) Pneumonia (1)	Original (6) Sepsis (1) Pneumonia (1) Malignant disease (1)	
DFS (month: median)	41 (0–99)	24 (0–80)	0.123
Recurrence	1 (5.88%)	11 (55.0%)	0.004679
Location	LYM (1)	Liver (7) Peritoneum (3) Pleura (2) LYM (2) Lung (1)	

LCTG laparoscopic completion total gastrectomy, *OCTG* open completion total gastrectomy, *MST* mean survival time, *DFS* disease free survival, *LYM* lymph node

Table 5 Summary of Case Reports of LCTG for GSC

Author	Year	n	age	sex (M/F)	initial disease (B / M)	previous ope (O / L)	previous reconstruction	interval (yrs)	Operation time (min)	Blood loss (ml)	open CV (n)	Morbidity (C-D III>) (n)	Retrieved LN (n)	Hospital stay (days)
Yamada H, et al.	2005	1	69	1 / 0	0 / 1	1 / 0	BII	10	274	30	-	-	-	-
Corcione F, et al.	2008	3	59 - 73	3 / 0	3 / 0	3 / 0	BII (3)	15	210 (160-260)	19 (0-264)	-	fistula (1)	18 (12-26)	11 (8-18)
Cho HJ, et al.	2009	2	37 / 68	1 / 1	0 / 1	1 / 1	BII (2)	1.5	487.5 (435-540)	425 (400-450)	-	-	14.5 (9-20)	-
Qian F, et al.	2010	15	53.5 (40-76)	13 / 2	-	-	BI (2) BII (13)	-	205 ± 25	110 ± 40	1	SSI (1)	18 ± 5	-
Shinohara T, et al.	2013	5	70.4 (54-84)	3 / 2	1 / 4	-	BI (3) BII (2)	-	370.8 (258-540)	63.6 (10-233)	-	-	18.2 (12-24)	8.8 (8-9)
Pan et al.	2014	3	68.7 (55-76)	3 / 0	2 / 1	3 / 0	BII (2) RY (1)	22 (6 - 30)	251.7 (225-280)	76.7 (50-100)	-	-	16.7 (10-22)	8 (7-9)
Kim HI, et al.	2015	1	83	0 / 1	0 / 1	1 / 0	BII	28	200	100	-	-	24	13
Korehisa S, et al.	2015	4	76.5 (62-83)	4 / 0	1 / 3	3 / 1	BI (2) BII (1) RY (1)	19 (0.1-50)	413.3 (367-488)	270.3 (33-500)	-	bleeding (1)	-	18 (13-26)
Kim DJ, et al.	2016	1	73	1 / 0	0 / 1*	1 / 0	GJ	25	295	200	-	-	20	7
Yajima K, et al.	2016	1	72	1 / 0	0 / 1	1 / 0	JI	7	395	40	-	-	-	10

M male, *F* female, *B* benign, *M* malignant, *O* open, *L* laparoscopy, *Cv* conversion, *C-D III>* clavien dindo classification III>

LN lymph node, *BI* BillrothI, *BII* BillrothII, *RY* Roux Y, *GJ* gastrojejunostomy, *JI* jejunal interposition

Table 6 Summary of Comparative Studies of LCTG for GSC

Author	Year	LCTG OCTG	n	initial disease (B / M)	Previous ope Open/ Lap	Operation time (min)	Blood loss (ml)	open CV (%)	Morbidity (C-D III>) (%)	Retrieved LN (n)	Hospital stay (days)	OS
Nagai E, et al.	2014	Lap	12	7 / 5	12 / 0	362.3 ± 68.4*	65.8 ± 62.0	0	0	23.7 ± 10.7	11.3 ± 2.8*	77.8% (3yr)
		Open	10	2 / 8	10 / 0	270.5 ± 94.9	746.3 ± 577.1*	-	2 (20)	15.9 ± 7.6	24.9 ± 10	100%
Kwon IG, et al.	2014	Lap	18	2 / 16	11 / 7*	266.2 ± 77.2*	182.2 ± 188.7	1 (5.6)	3 (16.7)	8 (0-37)	6 (5–44)*	94.9% (5yr)
		Open	58	12 / 46	54 / 4	203.3 ± 52.2	193.1 ± 227.6	-	9 (15.5)	7 (0-36)	9 (6–28)	100%
Kim HS, et al.	2014	Lap	17	0 / 17	10 / 7	197.2 ± 60.6*		0	4 (23.5)	12.9 ± 8.7	11.1 ± 8.7	
		Open	50	0 / 50		149.3 ± 46.9		-	15 (30)		13.8 ± 9.4	
Son SY, et al.	2015	Lap	17	7 / 10	11 / 6*	234.4 ± 65.2*	227.6 ± 245.0	8 (47.1)	1 (5.9)	18.8 ± 12.3	9.3 ± 3.2	66.7% (5yr)
		Open	17	6 / 11	17 / 0	170.0 ± 39.5	184.1 ± 123.1	-	1 (5.9)	22.3 ± 14.4	9.3 ± 3.1	60.3%
Tsunoda S, et al.	2016	Lap	10	4 / 6	10 / 0	324.5 ± 40.6	55.4 ± 60.7	0	0	22.4 ± 15.0	12.5 ± 2.7	
		Open	6			289	893	-	2 (33)	7	24	
Nakaji Y, et al.	2019	Lap	4	6 / 16		455 *	158	0	2 (50.0)	15	15	94% (5yr)
		Open	18			293	625	-	5 (27.8)	11	16	
Booka E, et al.	2019	Lap	8	4 / 4	5 / 3	307.5 ± 56.0	135.5 ± 181.2*	2 (25)	3 (37.5)	8.8 ± 4.6	10.6 ± 3.7	
		Open	23	6 / 17	21 / 2	295.8 ± 81.7	568.3 ± 446.4	-	6 (26.1)	6.0 ± 6.9	21.3 ± 37.3	
Otsuka R, et al.	2019	Lap	7	5 / 2	6 / 1	364 ± 95	70 ± 71 *	0	2 (28.6%)	22 ± 13	13 ± 5	
		Open	20	11 / 9	18 / 2	309 ± 104	1066 ± 1428	-	10 (50%)	12 ± 9	27 ± 21	
our data	2020	Lap	17	5 / 12	11 / 6	242.6 ± 64.8	24.4 ± 27.0 *	0	0	14.8 ± 11.9	14.8 ± 5.1	88.2% (5yr)*
		Open	20	4 / 16	17 / 3	202.5 ± 67.6	212.5 ± 230.8	-	2 (10.0)	12.0 ± 10.4	29.1 ± 56.3	55.0%

LCTG laparoscopic completion total gastrectomy, *GSC* gastric stump cancer, *OCTG* open completion total gastrectomy, *B* benign disease, *M* malignant disease, *Lap* laparoscopy, *C-D III>* clavien dindo classification III>, *LN* lymph node, *OS* overall survival, * *P* value <0.05

Discussion

Our results confirm the feasibility of LCTG for the treatment of GSC. Patients in the LCTG group had significantly longer operation times but significantly less blood loss and earlier flatus passage than the OCTG group. Furthermore, no conversion to open surgery and no higher morbidity than Clavien Dindo class III were reported in the LCTG group.

Yamada et al. [24] were the first to present a case report for laparoscopy-assisted resection of gastric remnant cancer in 2005; many additional studies reported successful applications of the technique [25–33]. Therefore, we searched reports of LCTG for GSC from the PubMed database in English literature and summarized the data by case reports (Table 5) and comparative studies (Table 6). Many surgeons have successfully applied LCTG, and this technique is considered the preferred treatment option (Table 5) [24–33]. As shown in Table 6, our results are consistent with those of comparative studies [14–21].

Table 5
Summary of Case Reports of LCTG for GSC

Hospital stay	**(days)**	**-**	**11 (8–18)**	**-**	**-**	**8.8 (8–9)**	**8 (7–9)**	**13**	**18 (13–26)**	**7**
Retrieved LN	(n)	-	18 (12–26)	14.5 (9–20)	18 ± 5	18.2 (12–24)	16.7 (10–22)	24	-	20
Morbidity (C-D III>)	(n)	-	fistula (1)	-	SSI (1)	-	-	-	bleeding (1)	-
Open conversion	(n)	-	-	-	1	-	-	-	-	-
Blood loss	(ml)	30	19 (0-264)	425 (400–450)	110 ± 40 ml	63.6 (10–233)	76.7 (50–100)	100	270.3 (33–500)	200
Operation time	(min)	274	210 (160–260)	487.5 (435–540)	205 ± 25 min	370.8 (258–540)	251.7 (225–280)	200	413.3 (367–488)	295
interval	(yrs)	10	15	1.5	-	-	22 (6–30)	28	19 (0.08-50)	25
Previous reconstruction		BII	BII (3)	BII (2)	BI (2) / BII (13)	BI (3) / BII (2)	BII (2) / RY (1)	BII	BI (2) / BII (1) / RY (1)	GJ with braun
previous ope	(Open / Lap)	1 / 0	3 / 0	1 / 1	-	-	3 / 0	1 / 0	3 / 1	1 / 0
initial disease	(B / M)	0 / 1	3 / 0	0 / 1	-	1 / 4	2 / 1	0 / 1	1 / 3	0 / 1*
gender	(M / F)	1 / 0	3 / 0	1 / 1	13 / 2	3 / 2	3 / 0	0 / 1	4 / 0	1 / 0
age		69	59–73	37 / 68	53.5 (40–76)	54–84 (70.4)	68.7 (55–76)	83	76.5 (62–83)	73
n		1	3	2	15	5	3	1	4	1
Year		2005	2008	2009	2010	2013	2014	2015	2015	2016
Author		Yamada. H, et al.	Corcione. F, et al.	Cho. HJ, et al.	Qian F, et al.	Shinohara. T, et al.	Pan et al.	Kim HI, et al.	Korehisa S, et al.	Kim DJ, et al.

M male, *F* female, *B* benign, *M* malignant, *Lap* laparoscopy, *LN* lymph node, *C-D III >* clavien dindo classification III>, *BI* BillrothI, *BII* BillrothII, *RY* Roux-en Y, *GJ* gastrojejunostomy, *** common bile duct cancer

Table 6
Summary of Comparative Studies of LCTG for GSC

OS		**77.8% (3 year)**	**100%**	**94.9% (5 year)**	**100%**			**66.7% (5 year)**	**60.30%**			**94% (5 year)**
Hospital stay	(days)	11.3 ± 2.8 *	24.9 ± 10	6 (5–44) *	9 (6–28)	11.1 ± 8.7	13.8 ± 9.4	9.3 ± 3.2	9.3 ± 3.1	12.5 ± 2.7	24	15
Retrieved LN	(n)	23.7 ± 10.7	15.9 ± 7.6	8 (0–37)	7 (0–36)	12.9 ± 8.7		18.8 ± 12.3	22.3 ± 14.4	22.4 ± 15.0	7	15
Morbidity (C-D III>)	(%)	0	2 (20)	3 (16.7)	9 (15.5)	4 (23.5)	15 (30)	1 (5.9)	1 (5.9)	0	2(33)	2 (50)
Open conversion	(%)	0	-	1 (5.6)	-	0	-	8 (47.1)	-	0	-	0
Blood loss	(ml)	65.8 ± 62.0	746.3 ± 577.1*	182.2 ± 188.7	193.1 ± 227.6			227.6 ± 245.0	184.1 ± 123.1	55.4 ± 60.7	893	158
Operation time	(min)	362.3 ± 68.4 *	270.5 ± 94.9	266.2 ± 77.2*	203.3 ± 52.2	197.2 ± 60.6*	149.3 ± 46.9	234.4 ± 65.2*	170.0 ± 39.5	324.5 ± 40.6	289	455 *
previous ope	(Open / Lap)	12 / 0	10 / 0	11 / 7*	54 / 4	10 / 7		11 / 6*	17 / 0	10 / 0		
initial disease	(B / M)	7 / 5	2 / 8	2 / 16	12 / 46	0 / 17	0 / 50	7 / 10	6 / 11	4 / 6		6 / 16
n		12	10	18	58	17	50	17	17	10	6	4
LCTG	OCTG	Lap	Open	Lap	Open	Lap	Open	Lap	Open	Lap	Open	Lap
Year		2014		2014		2014		2015		2016		2019
Author		Nagai E, et al.		Kwon IG, et al.		Kim HS, et al.		Son SY, et al.		Tsunoda S, et al.		Nakaji Y, et al.

LCTG laparoscopic completion total gastrectomy, *GSC* gastric stump cancer, *OCTG* open completion total gastrectomy, *B* benign disease, *M* malignant diseas overall survival, * *P* value < 0.05

The patients in the LCTG group had smaller tumor size, lower numbers of metastatic lymph nodes, and lower pathological stages than patients in the OCTG group; however, the clinical stage distribution, dissection, and retrieved lymph nodes showed no significant differences between the groups. Additionally, the number of retrieved lymph nodes was equal to that reported in other studies (Table 6) [14–21]. The OCTG group had a higher number of recurrences and deaths than the LCTG group, because the OCTG group had more advanced cases, leading to a worse 5-year overall survival rate than the LCTG group. Recently, the number of lower stages of GSC has been increasing due to the strict postoperative surveillance for PGC; this surveillance combined with the feasibility and validity of LCTG can improve patient survival [7].

The most difficult part of the operative procedure for GSC is the adhesiolysis, which is the key factor to safely performing LCTG [18]. A precise and sharp dissection between the adjacent organ and remnant stomach is necessary to avoid organ injury, and less bowel manipulation leads to early recovery [15, 18]. We consider laparoscopy an effective solution to overcome this difficulty in the treatment of GSC. The advantages of laparoscopic surgery are pneumoperitoneum, which widens the dissectible layer between the adhered organs, and a magnified view that enables detection of the loose and dissectible layer. Moreover, progressive high definition (HD) imaging significantly contributes to the benefits from such magnified views. We have been using the HD scope system (Karl Storz SE & Co. KG, Tuttlingen, DE) since the introduction of LCTG in our institution. Advanced energy devices and forceps also contribute to refining the quality of surgery, reducing bleeding, reducing the trauma to organs, and refining the precision of lymphadenectomy. Our sophisticated dissection techniques combined with these advanced developments enable us to perform LCTG with an extremely reduced blood loss compared to previous case–controlled studies (Table 6), leading to earlier recovery of digestive peristalsis.

Robotic gastrectomy could be a future advancement for the treatment of GSC in terms of its visual improvement in the surgical field, which is referred to as robotically enhanced surgical anatomy [34]. The refined anatomical view of robotic gastrectomy could achieve precise movement of forceps without hand tremors, which could increase operative accuracy. In fact, robotic gastrectomy for PGC has decreased the complication rate despite longer operative time and higher cost than laparoscopic gastrectomy [35, 36]. Robotic surgery has already been applied to GSC and reviewed retrospectively, which has shown a lower conversion rate and comparative short-term outcomes to LCTG [37]. We have also introduced robotic surgery to GSC and expect superior results.

We acknowledge some limitations in our study. First, this study had a retrospective design, which could have led to potential selection biases. Therefore, a randomized, controlled study should be completed. Second, due to the low incidence of GSC, the sample size was too small to elucidate the universal results and superiority of LCTG over OCTG for GSC. A multicenter study is necessary to validate our results.

Conclusion

LCTG was safely conducted without complications and mortality, implicating the oncological validity of LCTG for the treatment of GSC. With sophistication of laparoscopic skills and advanced technologies, LCTG is less invasive, results in reduced blood loss, and leads to earlier recovery of intestinal peristalsis.

Abbreviations

GSC
Gastric stump cancer; PGC:Primary gastric cancer; LCTG:Laparoscopic completion total gastrectomy; OCTG:Open completion total gastrectomy; HD:High definition

Declarations

Ethics approvaland consent to participate

All procedures performed in this study that involved human participants were in accordance with the ethical standards of the institutional and/or national research committee and the 1964 Helsinki declaration and its later amendments or comparable ethical standards. This study was reviewed and approved by the Ethics Committee of Ishikawa Prefectural Central Hospital. Reference number: 1438. Informed consent was obtained from all individual participants included in the study.

Consent for publication

Not applicable

Availability of data and materials

All data and materials are contained within the manuscript.

Competing interests

The authors declare that they have no competing interests.

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Authors' contributions

Study conception and design: ToTa, NI. Analysis and interpretation of data: ToTa, NI, ToTs SK. Drafting of manuscript: ToTa, DY, HK. Acquisition of data: ToTa, HS, YS, KH. Critical revision of manuscript: ToTa, NI, SK, HB. All authors have read and approved the final manuscript.

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Figures

Fig. 1

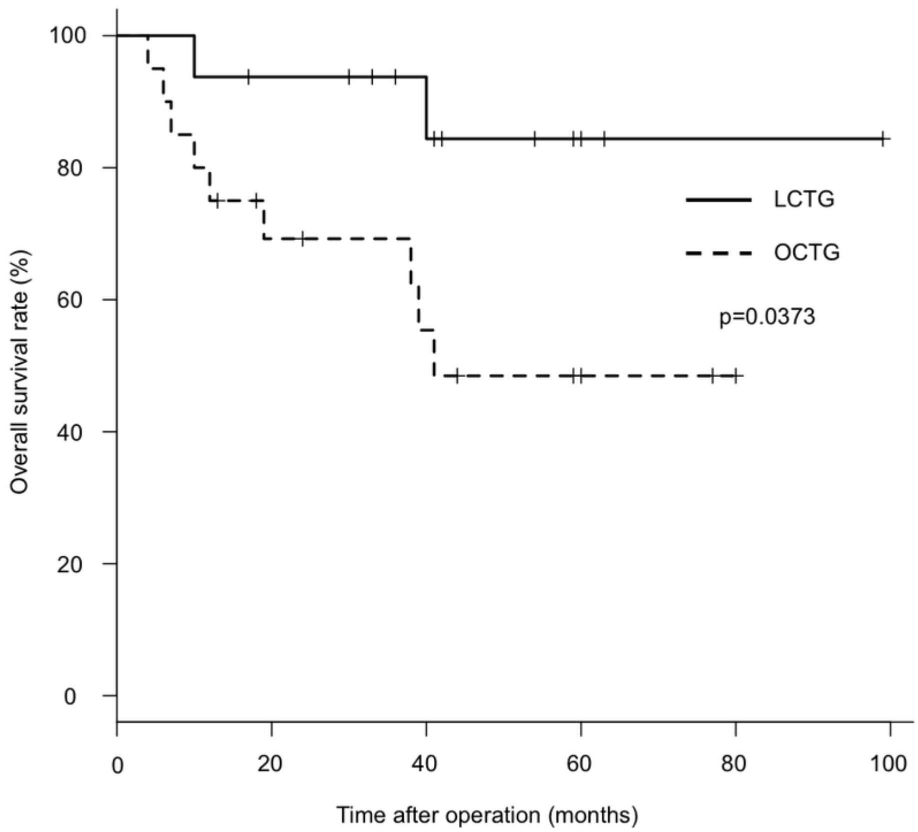

Figure 1

Overall survival rate Kaplan–Meier estimates of overall survival probability. The straight and dotted lines indicate the laparoscopic (LCTG) and open completion total gastrectomy (OCTG) groups, respectively. There was a significant difference between the two groups in the log-rank test ($p = 0.0373$)

Fig. 2

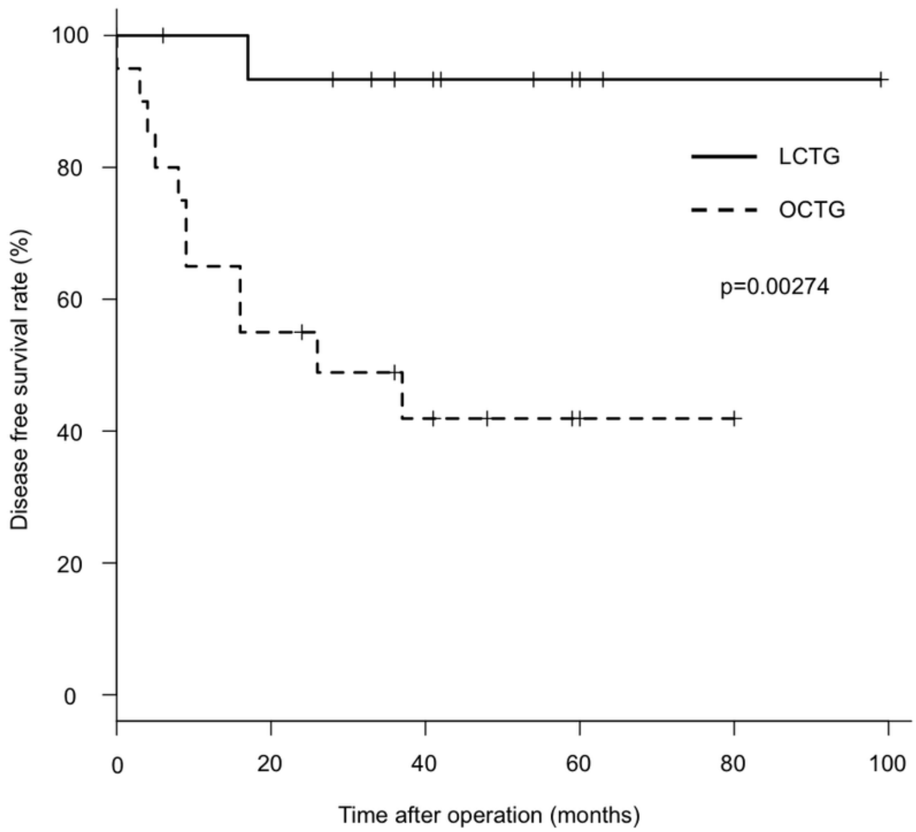

Figure 2

Disease-free survival rate Kaplan–Meier estimates of disease-free survival probability. The straight and dotted lines indicate the laparoscopic (LCTG) and open completion total gastrectomy (OCTG) groups, respectively. There was a significant difference between the two groups in the log-rank test (p = 0.00274)