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Surgical outcomes in the newly introduced phase of intracorporeal anastomosis following laparoscopic distal gastrectomy is safe and feasible compared with established procedures of extracorporeal anastomosis

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Abstract
Background Totally laparoscopic distal gastrectomy (TLDG) with intracorporeal anastomosis has been introduced to achieve safer anastomosis with good vision, and a small wound. However, little is known about the surgical outcomes of newly introduced TLDG compared with established procedures of laparoscopy-assisted gastrectomy (LADG) with extracorporeal anastomosis.
Methods This retrospective study included 114 patients who underwent laparoscopic distal gastrectomy (LDG) between January 2010 and September 2012. The patients were classified into two groups according to the approach of reconstruction (LADG group: $n = 74$; TLDG group: $n = 40$). The parameters analyzed included patients, operation details, and operative outcomes.
Results No complication was observed in the TLDG group. Surgical outcomes of the TLDG group, such as mean operation time, estimated blood loss, and rate of conversion to laparotomy were not inferior to the LADG group. Furthermore, postoperative hospital stay of the TLDG group was significantly shorter than the LADG group ($p < 0.05$).
Conclusion Surgical outcomes in the newly introduced phase of TLDG were safe as well as feasible compared with established LADG. TLDG has several advantages over LADG, such as shorter post-hospital stay, no incidence of operative complication, adequate working space, and small wound size. Although prospective, randomized control studies are warranted, we submit that TLDG can be used as a standard procedure for LDG.

Keywords Laparoscopy · Distal gastrectomy · LADG · TLDG · Intracorporeal anastomosis · Retrospective

First reported in 1994 [1], laparoscopic distal gastrectomy (LDG) for early gastric cancer has been widely used because its minimal invasiveness and long-term outcomes were comparable with open resections [2–5]. In general, LDG can be divided into laparoscopy-assisted and totally laparoscopic techniques. With laparoscopy-assisted gastrectomy (LADG), lymph node dissection is performed laparoscopically, but the transection of the stomach and the anastomosis are performed through an epigastric mini-laparotomy. An extracorporeal reconstruction has the advantage that surgeons can perform an anastomosis similarly as in open surgery. However, performing the anastomosis in this narrow and restricted space is often difficult, especially on obese patients or on patients with a small remnant stomach. In April 2006, we introduced LDG with extracorporeal anastomosis through a mini-laparotomy incision. Since extracorporeal anastomosis is conducted in a limited working space with restricted vision it was difficult, especially on obese patients. On obese patients, the mini-laparotomy incision reached a length of 60–70 mm in some cases. In July 2010, we introduced a totally laparoscopic distal gastrectomy (TLDG) that was performed

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entirely intracorporeally with an endoscopic linear stapler and intracorporeal hand-sewn sutures.

The feasibility and benefits of introducing intracorporeal anastomosis was studied by retrospectively comparing our surgical outcomes of established LADG and TLDG using a consecutive series of patients in our institution.

Materials and methods

Patients

We retrospectively assessed clinical outcomes of patients who had undergone LDG with gastrointestinal reconstructive anastomosis for gastric cancer during the period January 2010 and September 2012 in the Hyogo Cancer Center. The LADG cases that were studied were restricted to those that were performed by surgeons who had experienced at least 30 cases of LADG, and who had become regular members of the surgical team in our institute. Three patients who had synchronous operations for colonic cancers were excluded from the study. Indications for LDG at our institute include all tumors confined to the muscularis propria that are not amenable to endoscopic mucosal resection, with lymph node involvement limited to N1. To exclude the effect of difficulty with D2 lymphadenectomy, the study was limited to cases that had undergone LDG with D1 + lymphadenectomy (perigastric LNs plus 7, 8a, 9). Indication for LDG with D1 + lymphadenectomy at our institute includes all early gastric cancers that are not amenable to endoscopic mucosal resection, with lymph node involvement limited to N0. Patients requiring salvage surgery after incomplete endoscopic resection were also included. LDG is indicated for distal and middle-third gastric cancers with tumor margins of at least 20 mm.

Surgical technique

The LDG procedures were carried out in all cases as follows. A 12-mm trocar was inserted through an umbilical wound via the open surgical method, and pneumoperitoneum was established. Another 12-mm trocar was inserted 10 mm above and to the right of the umbilicus, and a 5-mm trocar was inserted 20 mm above and to the left of the umbilicus under laparoscopic guidance. A 5-mm trocar was inserted into the right costal margin as well as a 12-mm trocar into the left. The intra-abdominal pressure was maintained at a constant 10 mmHg. After inspection of the peritoneal cavity, mobilization of the stomach and dissection of the lymph nodes were carried out. Surgical procedures for gastrointestinal anastomosis after LDG were as follows. Two anastomosis techniques were performed after LDG. The Billroth I (B-I) reconstruction was the first choice where possible; however, the Roux-en-Y (R-Y) reconstruction was used when tension was expected on the anastomosis, as when the patient had reflux esophagitis or a hiatus hernia.

Extracorporeal anastomosis in laparoscopic distal gastrectomy

The location of the tumor was marked with a clip during endoscopy before surgery. The stomach was taken out via a 5-cm mini-laparotomy incision in the epigastrium for resection and anastomosis. B-I gastroduodenostomy was performed with a circular stapled technique. R-Y gastrojejunostomy was extracorporeally performed using a linear stapler and sutures.

Intracorporeal anastomosis in totally laparoscopic distal gastrectomy

The location of the tumor was marked with black ink during endoscopy before surgery. The excised specimen was removed through the umbilical port wound. B-I reconstruction was performed intracorporeally with delta-shaped anastomosis [6]. In the original method, after a V-shaped stapler entry hole between the stomach and the duodenum was made using four linear staplers, the entry hole was closed by staples. The entry hole for a linear stapler was closed with the Albert-Lembert two-layer suture in our patient series who underwent delta-shaped anastomosis. In both two-layers—the full-thickness and seromuscular layers—closure was started from the corner of the lesser curvature toward the greater curvature with an intracorporeal continuous suture using 3-0 absorbable thread. R-Y reconstruction was also intracorporeally performed using a linear stapler and the entry hole as well as B-I was closed using an intracorporeal hand-sewn technique.

Surgical outcomes and operative complications

Operative time, estimated blood loss, number of retrieved lymph nodes, type of reconstruction, data of postoperative clinical course, and intraoperative and postoperative complications were retrieved from the retrospective database. Postoperative complications included all major and minor complications and were graded according to the Clavien-Dindo classification [7]. Reconstruction-related complications that occurred within 30 days after operation or during prolonged hospital stay were recorded. They included anastomotic leakage, anastomotic bleeding, anastomotic stenosis, delayed gastric emptying, intestinal obstruction, and ileus. Delayed gastric emptying was defined as an emptying disturbance with starvation for more than 3 days,

Table 1 Clinicopathologic characteristics of patients

	LADG ($n = 74$)	TLDG ($n = 40$)	p value
Mean age (year)	66 ± 9	63 ± 12	0.11
Gender			0.22
Male	51	23	
Female	23	17	
BMI	22.8 ± 3.1	23.3 ± 4.3	0.55
Tumor location			0.67
Middle	51	26	
Lower	23	14	

Data are presented as mean ± SD

BMI body mass index, *LADG* laparoscopy-assisted gastrectomy, *TLDG* totally laparoscopic distal gastrectomy

in the absence of an anastomotic stenosis or mechanical bowel obstruction.

Postoperative clinical course

For postoperative pain management, all patients received continuous epidural analgesia (0.2 % ropivacaine) for 3 days after surgery. Patients who underwent LDG began walking the day after surgery. In both groups, oral intake was resumed on the third postoperative day without any major complication, and discharge was permitted on the eighth postoperative day in patients without symptoms and inflammatory reactions.

Statistical analysis

Statistical analysis of the data was performed using JMP ver.8.0 software (SAS Institute Inc., Cary, NC, USA). All data are presented as the mean ± standard deviation (SD) or as the number and percentage of patients. Continuous variables are expressed as mean ± SD, and comparisons between groups were performed using the t test. Comparisons of categorical variables were performed with the Fisher's exact test. A p value of <0.05 was considered significant.

Results

Clinicopathological findings

LDG was performed on 114 patients: 74 (64.9 %) underwent LADG with extracorporeal anastomosis and 40 (35.1 %) underwent TLDG with intracorporeal anastomosis. These cases did not include laparoscopic pylorus-preserving gastrectomies, laparoscopic segmental gastrectomies, and laparoscopic wedge resections.

Table 2 Surgical outcomes of operative course

	LADG ($n = 74$)	TLDG ($n = 40$)	p value
Operation time (min)	286 ± 55	278 ± 54	0.47
Estimated blood loss (g)	94 ± 261	37 ± 32	0.17
Retrieved lymph nodes	52 ± 17	53 ± 19	0.72
Rate of B-I reconstruction (%)	66	73	0.49
Intraoperative complication	1	0	0.46
Conversion to laparotomy	1	0	0.46
Time to first flatus (days)	1.4 ± 0.8	1.6 ± 0.8	0.21
Time to resumed oral intake (days)	3.2 ± 0.9	3.2 ± 0.6	0.99
Postoperative hospital stay (days)	12.2 ± 4.5	10.7 ± 2.1	0.02

Data are presented as mean ± SD

LADG laparoscopy-assisted gastrectomy, *TLDG* totally laparoscopic distal gastrectomy, *B-I* Billroth I

Table 3 Surgical outcomes in obese patients (BMI ≥25)

	LADG ($n = 11$)	TLDG ($n = 11$)	p value
Rate of B-I reconstruction (%)	45	55	0.66
Postoperative complications	0	0	1.00
Postoperative hospital stay (day)	11.5 ± 2.5	10.9 ± 1.9	0.51

Data are presented as mean ± SD

BMI body mass index, *LADG* laparoscopy-assisted gastrectomy, *TLDG* totally laparoscopic distal gastrectomy, *B-I* Billroth I

There were no differences in age, gender distribution, body mass index (BMI), or tumor location between the two groups (Table 1). Tumor locations were defined using the Japanese classification of gastric carcinoma [8] as being in the upper (U), middle (M) or lower (L) third of the stomach.

Intraoperative surgical outcomes

Intraoperative surgical outcomes are shown in Table 2. The mean operating time was 286 ± 55 min for the LADG group, and 278 ± 54 min for the TLDG group. The mean intraoperative blood loss was 94 ± 261 ml for the LADG group, and 37 ± 32 ml for the TLDG group. The mean retrieved lymph nodes were 52 ± 17 for the LADG group, and 53 ± 19 for the TLDG group. The rate of B-I reconstruction was 66 % for the LADG group and 73 % for the TLDG group.

There was no difference in operating time, estimated blood loss, retrieved lymph nodes, and rate of B-I reconstruction between the two groups. In obese patients

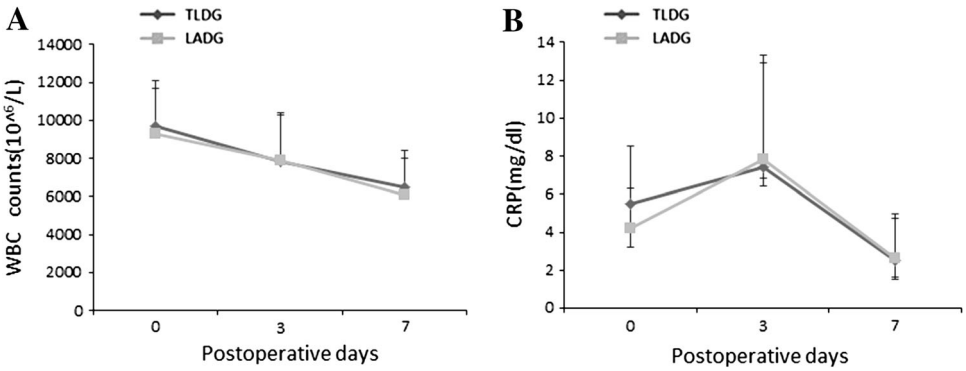

Fig. 1 **A** Changes in serum WBC counts, **B** changes of plasma concentrations of CRP. *WBC* white blood cell, *TLDG* totally laparoscopic distal gastrectomy, *LADG* laparoscopy-assisted gastrectomy, *CRP* C-reactive protein. *x*-axis indicates day after the operation, and *y*-axis indicates the estimated level of **A** WBC or **B** CRP

(BMI $\geq$ 25.0 kg/m^2) there were also no differences in operation time and rate of B-I reconstruction between the two groups (Table 3).

One patient in the LADG group experienced major intraoperative bleeding from the splenic artery during lymphadenectomy. This case required conversion to laparotomy for hemostasis. In the TLDG group, all cases were completed by a totally laparoscopic approach without conversion to LADG or laparotomy.

Postoperative surgical outcomes

There was no difference between the two groups in the time to first flatus, time to resume oral intake (Table 2), white blood cell (WBC) count, and the level of serum C-reactive protein (CRP) of the third and seventh postoperative days (Fig. 1). In contrast, the postoperative hospital stay of the TLDG group was significantly shorter than the LADG group (Table 2; 10.7 ± 2.1 vs. 12.2 ± 4.5; $p = 0.02$).

Postoperative complication

Postoperative complication data are shown in Table 4. Postoperative complications were observed in four patients (5.4 %) in the LADG group. Although there was no postoperative complication in the TLDG group, there was no difference in the frequency of postoperative complications between the two groups. Major complications related to reconstruction, such as anastomotic leakage, stenosis, and intra-abdominal abscess, were not found in both groups. Delayed gastric emptying was only observed in one patient (1.4 %) in the LADG group. This case with gastric stasis improved spontaneously in 1 week. Three other complications in three patients, including two wound infections and one pulmonary edema, were not related to reconstruction. The case with acute pulmonary edema required mechanical ventilation for 24 h after surgery. This case was successfully treated and discharged 12 days after surgery. Mortality in this patient series of postoperative complications was 0 %.

Table 4 Postoperative complication

	LADG ($n = 74$)	TLDG ($n = 40$)	p value
Delayed gastric emptying	1	0	0.46
Grade II[a]	1	–	
Wound infection	2	0	0.29
Grade I	2	–	
Acute pulmonary edema	1	0	0.46
Grade IVa	1	–	
Total	4	0	0.13

[a] Grade is according to the Clavien-Dindo classification

Discussion

A few reports have described the benefits of intracorporeal anastomosis, such as small wound size and early bowel recovery [9, 10]. Regardless of the benefits, there was some fear that introducing TLDG would result in longer operation times, a higher incidence of operative complications, and more conversions to open laparotomy than LADG, especially during the introductory phase of TLDG. In the current study, there were no differences in the two groups for operation time, estimated blood loss, and incidence of conversions to open surgery, and operative complications. Furthermore, there were no operative complications in the TLDG group. This indicates that the early phase of performing intracorporeal anastomoses following LDG was safe and feasible compared with cases performed with the established LADG.

To exclude data with the early phases of performing LDG, the cases performed by surgeons who had experience with at least 30 cases of with D1 + lymphadenectomy were studied. Numerous recent studies have reported that

the learning curve of LADG can be completed without difficulty. It has been demonstrated that 30–60 cases are required to achieve competence in LADG [11]. There were no postoperative complications associated with lymphadenectomy in both groups, such as pancreatic fistula, intra-abdominal abscess, and postoperative bleeding in the current study. Furthermore, there was no difference in the mean retrieved lymph nodes between the two groups. These facts indicate that the procedure of D1 + lymphadenectomy in our institute was performed with adequate experience, and there were very few effects on surgical outcome that depended on the technique of lymphadenectomy in the two groups.

TLDG could be introduced safely by surgical members who had experience with LADG. However, TLDG requires more skill with laparoscopic techniques than LADG, and it is necessary that a surgeon be well trained when beginning to perform TLDG. We consider the curability with appropriate lymphadenectomy is most important for LDG for early gastric cancer to be performed safely without complications in any approach of reconstruction.

In our early phase of performing TLDG, the entry hole was closed using an intracorporeal hand-sewn technique. Reconstruction can be done safely without hand suturing by using a functional end-to-end anastomosis technique in totally laparoscopic gastrectomy [12]. However, in intracorporeal anastomosis, the intracorporeal hand-sewn technique was required to repair any injuries, or to close the entry hole in difficult cases with a stapler. In these troubling cases, the more difficult intracorporeal hand-sewn technique was required.

The current study also indicated the post-hospital stay of the TLDG group was significantly shorter than the LADG group. Discharge on the eighth postoperative day was permitted if patients had no symptoms or inflammatory reactions. The TLDG group showed shorter post-hospital stay than the LADG group, and there were no differences in operative complication, time to flatus, duration of fever after surgery, WBC count, and level of serum CRP. TLDG has been shown to lead to earlier recovery of bowel function than with LADG and open resections [13, 14]. Small wound size, no incidence of operative complication, and earlier bowel function recovery appeared to be associated with shorter post-hospital stay of the TLDG group. There is a possibility that TLDG is a less invasive procedure than LADG.

Extracorporeal anastomosis is conducted in a limited working space with restricted vision, thus making it a difficult procedure, especially on obese patients. Extension of the laparotomy is often necessary to obtain a better view for secure anastomosis following LADG on obese patients. TLDG was introduced in the hope of overcoming the difficulty of reconstruction, especially on obese patients. There was no difference in postoperative complications and postoperative hospital stay. A previous report [15] showed the R-Y reconstruction was required more often after LADG on obese patients than on normal patients, as in the current study (data not shown). The current study showed the TLDG group had a higher rate of B-I reconstruction than the LADG group, although lacking significance on all cases (73 vs. 66 %; $p = 0.49$), and obese cases (55 vs. 45 %; $p = 0.66$). This indicates the possibility that extracorporeal reconstruction caused a higher rate of R-Y reconstruction due to limited working space with restricted vision, especially on obese patients. In both groups, LDG was performed safely with few complications regardless of BMI. However, TLDG is more suitable for all patients, including obese individuals due to adequate working space with good vision.

Conclusion

Surgical outcomes from the early phase of performing TLDG were safe as well as feasible compared with established LADG. The current study showed that TLDG has several advantages over LADG, such as shorter post-hospital stay, no incidence of operative complication, adequate working space, and small wound size. Although prospective randomized control studies are warranted, we submit that TLDG can become a standard procedure for LDG.

Disclosures Drs. Shingo Kanaji, Hitoshi Harada, Shunji Nakayama, Takashi Yasuda, Taro Oshikiri, Kentaro Kawasaki, Masashi Yamamoto, Tatsuya Imanishi, Tetsu Nakamura, Satoshi Suzuki, Kenichi Tanaka, Yasuhiro Fujino, Masahiro Tominaga, and Yoshihiro Kakeji have no commercial association that might create a conflict of interest in connection with any of the products mentioned in this article.

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