T-shaped Modified Delta Anastomosis as a Simple Intracorporeal Gastroduodenostomy

Chan Gyun Park, M.D., You Seong Yang, M.D., Jong Myeong Lee, M.D.

Department of Surgery, Presbyterian Medical Center, Jeonju, Korea

Purpose: A delta-shaped anastomosis (DA) is a widely accepted technique used for a totally laparoscopic distal gastrectomy (TLDG). Several studies have suggested various modifications to overcome the drawbacks of an original DA. We present our novel technique—a T-shaped modified delta anastomosis (TDA), and we report the early outcomes with its use in a case series.

Methods: We retrospectively reviewed the medical records of 40 patients who underwent a TLDG with TDA for early gastric cancer at OOO between February 2016 and May 2017. Perioperative outcomes, postoperative complications, and operating time were analyzed, and all data were expressed as means±standard deviation.

Results: We observed no major complications that required immediate postoperative intervention. Other minor and non-surgical complications were delayed gastric emptying (n=1), pneumonia (n=2), atelectasis (n=3), dumping symptom (n=1), and symptomatic bile reflux (n=1). No wound infection was reported in any patient. The total operative time was 206.5±25.4 min and the estimated blood loss was 27.8±33.5 ml. The mean time required to perform the anastomosis was 20.9±6.7 min, and the mean number of cartridges used during the operation was 4.78±0.66.

Conclusion: We conclude that a TDA following a laparoscopic distal gastrectomy was successfully developed and showed acceptable clinical outcome.

Keywords: Laparoscopic surgery, Gastroduodenostomy, Intracorporeal anastomosis, Gastric cancer

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Corresponding author

Jong Myeong Lee

Department of Surgery, Presbyterian

Medical Center, 365 Seowon-ro,

Wansan-gu, Jeonju 54987, Korea

Tel: +82-63-230-1408

Fax: +82-63-230-1409

E-mail: gslee52kr@naver.com

ORCID:

<http://orcid.org/0000-0002-9985-7308>

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INTRODUCTION

Gastroduodenostomy is the most commonly used anastomotic method following a distal gastrectomy, and its safety and feasibility are well known in Korea.^{1,2} Recently, the incidence of early gastric cancer has risen in Korea¹ and Japan,³ and the number of laparoscopic gastrectomies performed in Korea has been increasing.² A laparoscopic gastrectomy is the treatment of choice for the management of early gastric cancer owing to several advantages over open surgery such as causing lesser postoperative pain, and better postoperative recovery, quality-

of-life and cosmetic effects.⁴⁻⁷ Additionally, the feasibility of a laparoscopic gastrectomy for the treatment of even advanced gastric cancer has been reported in recent studies.^{8,9} Presently, a safe and feasible laparoscopic gastroduodenal anastomotic method needs to be established in this regard.

Laparoscopy-assisted distal gastrectomy (LADG) with extracorporeal gastroduodenostomy is the most commonly used technique in a laparoscopic distal gastrectomy because intracorporeal gastroduodenostomy is the most challenging step when performing a totally laparoscopic distal gastrectomy (TLDG). However, performing an intracorporeal anastomosis

has become relatively easy since Kanaya et al. first introduced the intracorporeal delta-shaped anastomosis (DA) using only a linear stapler in 2002.¹⁰ Since then, TLGD with DA has been widely used, and its safety and feasibility have been proven.^{11–16}

However, conventional delta anastomosis (cDA) is associated with certain drawbacks. A few authors have reported a risk of injury to the duodenal feeding vessels¹⁷ and an anastomotic leak because of the presence of 2 weak points where the staple lines are observed to cross.¹⁸ Furthermore, twisting the duodenum and the stomach during the cDA is technically difficult, for which modifications have been attempted.^{18–21} Noshiro et al. reported an anastomotic leak in 6 of 71 patients who underwent TLGD with DA, which was considered a technical drawback associated with a cDA. They developed a modification that involved performing an additional suture to prevent anastomotic leakage.¹⁹ Huang et al. dissected the duodenal cutting edge and performed an inverted T-shape modification whereby the intersection between staple lines was reduced to 1, which was aimed at improving the safety of the anastomosis.¹⁸

At our hospital, we have attempted to perform a cDA; however, the risk of ischemia and the technical difficulty associated with the procedure necessitated the development of a T-shaped modified delta anastomosis (TDA) to reduce the risk of anastomotic leakage and improve the repeatability of the procedure by simplifying the technique. A recent study reported by Jang et al.²⁰ and Byun et al.²¹ is in agreement with ours in terms of minimizing the dissection of the posterior duodenal wall and simplifying the technique by performing the anastomosis between the anterosuperior wall of the duodenum and the greater curvature of the stomach without twisting. However, Jang et al. and Byun et al. anastomosed the duodenum after creating an orifice on the greater curvature of the stomach at a distance of proximal 6 cm from the stapling line of the remnant stomach, but we made it easier to approximate the stomach to the duodenum by creating the orifice over the posterior wall of the stomach at a distance of proximal 2 cm, and we reduced the intersection between the staple lines to 1 to minimize the risk of anastomotic leakage.

We retrospectively investigated the short-term outcome of a TDA and assessed its acceptability. We introduce this method and report the results in this case series.

MATERIALS AND METHODS

Patients

We retrospectively reviewed the medical records of patients who underwent laparoscopic distal gastrectomy between February 2016 and May 2017 at Presbyterian Medical Center, Jeonju, Korea. During this period, 43 patients underwent the

surgery. Patients who underwent a Billroth I anastomosis with TDA (n=40) were included in this study, whereas 3 patients who underwent a Billroth II procedure with a Braun anastomosis were excluded. All surgical procedures were performed by a single surgeon (J.M.Lee). Patients underwent an endoscopic examination and computed tomography (CT) prior to surgery to determine their clinical stage and tumor location. In patients showing lesions located in the mid-third of the stomach, endoscopic clipping was performed in the proximal portion of the cancer prior to surgery, and radiographic imaging was performed to determine whether a Billroth I, Billroth II with Braun, or Roux-en-Y anastomosis should be performed.²² Patients in whom gallstones were detected on abdominal CT performed prior to surgery, or those demonstrating signs of chronic cholecystitis were informed that cholecystitis could worsen after gastrectomy; thus, a laparoscopic cholecystectomy was performed concomitantly with a gastrectomy in these patients after receiving their consent.

We retrospectively obtained information regarding: sex, age, body mass index (BMI), type of operation performed, the American Society of Anesthesiologists (ASA) score, intraoperative blood loss, patients who underwent a combined cholecystectomy, operative time, time required to perform the DA, the number of stapler cartridges used, the extent of lymph node (LN) dissection, the number of retrieved LNs, tumor size, tumor location, distal resection margin, proximal resection margin, pTNM stage, time until resumption of a soft diet, length of postoperative hospitalization, postoperative complications, mortality, and patients' symptoms. Clinical and pathological staging was performed based on the American Joint Committee on Cancer (AJCC) Staging Manual: 7th Edition.²³

Fig. 1. Trocar placement for a totally laparoscopic distal gastrectomy (TLGD).

Surgical procedure

The patient was placed in a reverse Trendelenburg position under general anesthesia, and 4 trocars were inserted (Fig. 1). The operator stood to the right side of the patient, a camera assistant stood to the right side of the operator, holding a camera in his left hand (a 30-degree camera was used), and assisting with his right hand. The role of the camera assistant was rather insignificant; he could provide assistance without having to be in the legs apart position as shown in the figure.

We began the procedure with adequate LN dissection. The extent of LN dissection was determined by the Japanese gastric cancer treatment guidelines 2010 (ver. 3).²⁴ During dissection of the short gastric arteries, only 1~2 branches were dissected and the others were left intact.

During LN dissection, the liver was retracted without placement of an additional port. A monofilament nylon suture (Monosof™ ST 2~0) was fixed to the lesser omentum attached to the liver using a Hem-o-lok clip (Weck® Hem-o-lok®) to perform transabdominal traction.

Intracorporeal gastroduodenostomy (T-shaped modified delta-shaped anastomosis procedure)

A. Through a 12-mm port on the left lower side of the abdomen, we resected the duodenum leaving behind an adequate portion. The duodenum was divided in the dorsoventral direction using a 60 mm Endo-GIA stapler, similar to the procedure performed during a cDA. The duodenum was placed vertically, and a linear stapler was angulated to preserve a sufficient portion of the anterosuperior wall of the duodenal bulb (Fig. 2A).

B. We dissected adhesions around the duodenal stump, and additional dissection was performed on a portion of the retroperitoneal attachment to mobilize the duodenum. The stomach was gently pulled toward the duodenum to measure the distance. If the anticipated remnant stomach covered a small portion of the duodenum, it could be deduced that performing an anastomosis later would be easier.

C. A 60 mm Endo-GIA stapler was inserted to divide the stomach by firing this device twice (or thrice) from the side of the greater curvature toward the lesser curvature of the stomach. The initial firing of the stapler was perpendicular to the greater curvature (Fig. 2A).

D. After the stomach had been completely divided, an endopouch (LapBag U-Type) was inserted into the 12-mm port at the umbilicus to place the stomach and the resected LNs. The umbilical incision was extended vertically downward over a length of 2.5~3 cm, and the specimen was removed. The stomach was opened and examined by visual analysis and

Fig. 2. (A) A totally laparoscopic distal gastrectomy (TLDG) with a T-shaped modified delta anastomosis (TDA) procedure. The duodenum is divided in the dorsoventral direction, as is performed for a cDA. The initial firing is observed to be perpendicular to the greater curvature of the stomach, and the stomach is completely divided. (B) A 1-cm orifice is created over the posterior wall of the greater curvature at a distance 2 cm from the staple line of the remnant stomach. The stapler jaw carrying the cartridge is inserted deep into the remnant stomach, and the posterior wall of the stomach is pulled toward the duodenum. (C) The cartridge-free jaw is inserted into the duodenal orifice. (D) Stapling is performed after accurately matching the edges of the 2 orifices. (E) A tagging suture is performed twice, and the completed anastomosis is observed to show a T-shaped appearance where the staple line intersects once.

frozen section analysis to confirm that an adequate proximal resection margin had been obtained. In most cases it was easy to obtain a sufficient resection margin and perform an anastomosis during resection of early gastric cancer located in the distal half of the stomach.

E. After re-inflating the abdominal cavity, the remnant stomach and duodenum were pulled and crossed to check for possible excessive tension during the anastomosis. If the remnant stomach was determined to be smaller than expected and subsequent excessive tension was expected, a totally laparoscopic Billroth II procedure with Braun anastomosis was performed.

F. A 1-cm orifice was created by removing the staples on the anterior edge of the staple line on the duodenal stump. Another 1-cm orifice was created over the posterior wall of the greater curvature at a distance 2 cm from the staple line at the remnant stomach. This process is important to facilitate subsequent stapling. Next, a 45 mm Endo-GIA stapler was inserted into the 12-mm port on the left lower side of the abdomen and inserted and advanced through the duodenal orifice until the thin jaw of the Endo-GIA without a cartridge reached the side of the duodenum. After removing the thin jaw from the duodenum, memorizing the angle of insertion, the thick jaw of the Endo-GIA with the cartridge was inserted deep into the remnant stomach, and the posterior wall of the remnant stomach was pulled toward the duodenum (Fig. 2B). The cartridge-free jaw was carefully inserted into the duodenal orifice, ensuring that the jaw carrying the cartridge was not lost in the remnant stomach (Fig. 2C). Complete insertion of staples was confirmed to prevent stenosis, and stapling was performed after accurately matching the edges of the two orifices (Fig. 2D).

G. The anastomotic site was carefully examined through a common stab incision to confirm that stapling had been appropriately and adequately performed and to check for bleeding. A tagging suture using Vicryl (VICRYL™ Plus 4-0) was performed twice to closely approximate the duodenal and stomach mucosa. Next, staple closure was performed using a 60 mm Endo-GIA stapler with minimal tissue dissection. This procedure eventually resulted in a T-shaped anastomosis with 1 intersecting staple line. (Fig. 2E) In a few patients, a V-Loc (V-Loc™ 90 3-0) was used to laparoscopically perform a continuous running suture in double layers instead of staple closure.

H. After anastomosis was completed, the second portion of the duodenum was compressed with a device, and air was inflated into the stomach through a Levin tube to check if stomach distention could be well maintained and to rule out air leakage.

Patient follow-up

All patients underwent a postoperative follow-up examination at the outpatient clinic once a month over the first 3 months. Information was obtained from patients regarding any observed postoperative weight changes, the amount and frequency of food consumption, satiety or stomachache after meals, and heartburn and reflux symptoms. An upper gastrointestinal (UGI) series was performed 3 months postoperatively to assess food passage and to check for evidence of anas-

Table 1. Patient clinicopathological characteristics

n=40	
Gender (male:female)	25:15 (62.5%:37.5%)
Age (years)	65.23±10.25
BMI* (kg/m ²)	24.98±3.55
Tumor size (cm)	2.25±1.07
Tumor location	
Lower third	28 (70%)
Middle third	12 (30%)
pT stage	
T1a	21 (52.5%)
T1b	17 (42.5%)
T2	2 (5.0%)
T3	0 (0.0%)
pN stage	
N0	35 (87.5%)
N1	5 (12.5%)
N2	0 (0.0%)
N3	0 (0.0%)
pTNM stage	
Ia	35 (87.5%)
Ib	3 (7.5%)
IIa	2 (5.0%)
IIb	0 (0.0%)
ASA [†] classification	
1	5 (12.5%)
2	19 (47.5%)
3	16 (40.0%)

Data are means±standard deviation or numbers (percentages) unless otherwise indicated. *BMI = body mass index, [†]ASA = American Society of Anesthesiologists.

tomotic stenosis. An esophagogastroduodenoscopy (EGD) was performed 1 year postoperatively to evaluate for recurrence, as well as the status of the anastomotic site and the presence of gastroesophageal reflux disease (GERD).

RESULTS

Between February 2016 and May 2017, 40 patients underwent TLDG with TDA, and all patients underwent R0 resection. No patient required conversion from laparoscopic to open distal gastrectomy. Patients who underwent a Billroth II procedure with Braun anastomosis because they were suspected to demonstrate excessive tension at the anastomotic site during surgery excluded from this study.

Of the 40 patients studied, 25 (62.5%) were men and 15 (37.5%) were women. The mean age was 65.23 ± 10.25 years, and the mean BMI was 24.98 ± 3.55 kg/m². The mean tumor size was 2.25 ± 1.07 cm. We observed that the ASA score was 1 in 5 (12.5%), 2 in 19 (47.5%), and 3 in 16 (40%) patients, respectively. Tumor location, pT stage, pN stage and pTNM stage are shown in Table 1.

The intraoperative blood loss was 27.8 ± 33.5 ml. A concomitant cholecystectomy was performed in 9 patients (22.5%), a D1+ dissection in 18 patients (45.0%), and a D2 dissection in 22 patients (55.0%). The number of retrieved LNs was 37.9 ± 12.0 . The proximal resection margin measured 4.69 ± 2.44 cm, and the distal resection margin measured 5.33 ± 2.25 cm. Postoperatively, time until resumption of a soft bland diet was 5.18 ± 0.45 days, and length of hospitalization was 10.60 ± 5.11 days (Table 2).

No postoperative mortality was observed in any patient

Table 2. Perioperative outcomes

	n=40
Blood loss (ml)	27.8 ± 33.5
Combined cholecystectomy (no. of patients, %)	9 (22.5%)
Lymph node dissection	
D1 + α/β	18 (45.0%)
D2	22 (55.0%)
Retrieved lymph node	37.9 ± 12.0
Proximal resection margin (cm)	4.69 ± 2.44
Distal resection margin (cm)	5.33 ± 2.25
SBD* start day	5.18 ± 0.45
Discharge day	10.60 ± 5.11

Data are means $\pm$ standard deviation or numbers (percentages) unless otherwise indicated. *SBD = soft bland diet.

who underwent a laparoscopic distal gastrectomy during the study period, nor was postoperative anastomotic leakage reported. We observed that an anastomotic stricture developed in 1 patient (2.5%), postoperative bleeding was not reported in any patient, and an intra-abdominal abscess was reported in 1 patient (2.5%). Other postoperative complications were: 1 patient showed delayed gastric emptying (2.5%), 2 showed pneumonia (5.0%), 3 showed atelectasis (7.5%), 0 showed ileus, 1 showed dumping symptom (2.5%), 1 showed symptomatic bile reflux (2.5%) and 0 patients showed wound infection. (Table 3) Delayed gastric emptying was defined as the development of signs of gastrostasis detected on abdominal radiography during the process of diet build-up, necessitating fasting due to discomfort after eating. Symptomatic GERD was defined as the development of heartburn, and signs of bile reflux observed on a UGI series or EGD.

The total operative time for a TLDG with TDA was 206.5

Table 3. Postoperative complications

	n=40
Mortality (no. of patients, %)	0
Anastomotic leakage	0
Anastomotic stricture	1 (2.5%)
Post operative bleeding	0
Intra-abdominal abscess	1 (2.5%)
Delayed gastric emptying	1 (2.5%)
Pneumonia	2 (5.0%)
Atelectasis	3 (7.5%)
Ileus	0
Dumping symptom	1 (2.5%)
Symptomatic reflux	1 (2.5%)
Wound infection	0 (0.0%)

Data are numbers (percentages) unless otherwise indicated.

Table 4. Operative data

	n=40
Operative time (min)	206.5 ± 25.4
Anastomosis time (min)	20.9 ± 6.7
Suture	28.1 ± 6.7
Stapling	17.9 ± 3.9
Used cartridges number	4.78 ± 0.66

Data are means $\pm$ standard deviation.

± 25.4 min, and the mean time required for the creation of a TDA was 20.9 ± 6.7 min. The mean time required for creation of the anastomosis in those who underwent suturing was 28.1 ± 6.7 min, and in those who underwent stapling it was 17.9 ± 3.9 min (Table 4). The mean number of cartridges used during the TDA was 4.78 ± 0.66 .

A UGI series performed 3 months postoperatively showed a wide anastomosis, which enabled smooth passage of food (Fig. 3A). Anastomotic sites appeared circular on an EGD examination (Fig. 3B).

DISCUSSION

Lately, a DA is a widely accepted procedure for a TLDG.^{11–14} Recent studies have shown that TLDG with DA offers several advantages over the LADG procedure. Kim et al. have reported that because the stomach is not pulled through a mini-laparotomy during a DA, injuries that can occur secondary to excessive tension during LADG can be avoided, and good visualization of the operative field can be obtained, making DA a favorable option for patients with obesity. Additionally, bleeding can be controlled more effectively than during a circular stapler anastomosis in LADG.²⁵ Song et al. have reported that TLDG is a less invasive procedure than LADG and that it results in faster bowel recovery.¹² A recent meta-analysis that described TLDG and LADG has reported that TLDG with DA is safer and more feasible than LADG, and that it offers the advantage of significantly reduced blood loss, earlier resumption of oral intake, and a shorter postoperative hospitalization period.¹³

However, cDA is associated with a few drawbacks. Kitakami et al. have reported that duodenal ischemia can occur during the preparation process, which involves dissection of the tissues surrounding the posterior wall of the duodenum prior to stapling. Furthermore, the 45 mm stapling process can

induce ischemia as it involves dissection of the feeding vessels supplying the duodenum.¹⁷ Huang et al. have reported that because of an anastomotic intersection where 2 staple lines intersect, it could compromise the blood supply to these sites leading to anastomotic site complications.¹⁸ Furthermore, Park et al. have reported that surgical costs increase due to the use of a larger number of stapler cartridges.²⁶

In order to overcome these limitations, we developed the TDA procedure and assessed the incidence of anastomosis-related complications such as leakage, stenosis, and bleeding associated with this technique. We observed no postoperative bleeding or leakage in any patient, and anastomotic site stenosis occurred in only 1 patient who underwent TLDG with TDA. In this patient, although stapling was performed, the 45 mm staplers had not been completely inserted due to excessive tension between the stomach and duodenum. This patient was transferred to another hospital while he received conservative treatment and was considered a candidate for balloon dilatation. The key take-away from this case was that complete insertion of the 45 mm stapler is extremely important to prevent TDA stenosis. Moreover, it is important to ensure that the mucosal edges are well-approximated during common stab incision closure to achieve minimal tissue dissection.

No major complications requiring immediate postoperative intervention were reported, and the frequency of minor complications such as wound infection ($n=0$), delayed gastric emptying ($n=1$), pneumonia ($n=2$), and atelectasis ($n=3$) was acceptable. The incidence of dumping symptom ($n=1$) and symptomatic bile reflux ($n=1$), which were evaluated during follow-up period, was also acceptable.

We performed a double layer running suture using a V-Loc if during common stab incision closure we detected an inadequate approximation between the stomach and duodenal mucosa. We usually performed the TDA with a running suture in the early period after the introduction of the TDA. However,

Fig. 3. (A) Images of an upper gastrointestinal (UGI) series performed 3 months postoperatively showing a wide anastomosis. (B) Images showing that the anastomotic sites appear circular on esophagogastroduodenoscopic (EGD) examination.

as surgeons gained more experience, closure could be performed using a single 60 mm linear stapler in the later period. TDA was performed more rapidly when a stapler was used instead of a suture (17.9 ± 3.9 min vs. 28.1 ± 6.7 min, respectively). The mean time required for TDA was 20.9 ± 6.7 min, and this procedural time is expected to reduce as frequency of the TDA with stapling increases in the future.

We used a total of 5 cartridges during TLGD with TDA. Because no twisting was observed during the anastomosis operation, the common stab incision did not get twisted, and staplers were inserted into a small incision (1 cm), and closure of the small common stab incision could be achieved using a single 60 mm cartridge. Several studies in which cDA was performed have reported the use of more than 6 cartridges per operation on average.^{25,27} Our method involves the use of fewer stapler cartridges, the cost for the operation could be reduced.

Limitations of our study: 1) Ours was a retrospective study, and we did not compare our results with those of a cDA operation. 2) We could not evaluate the rates of delayed complications such as bile reflux and gastritis because of the short follow-up period. 3) We investigated the incidence of complications based on a subjective assessment of patient-reported outcomes (dumping symptom or GERD). Thus, we could not objectively assess the incidence of complications.

We developed the TDA procedure to overcome the drawbacks associated with cDA. Our technique creates an anastomosis between the anterior duodenal wall and the posterior wall of the stomach without twisting of organs, which therefore reduces the risk of anastomotic leakage and simplifies the procedure. This retrospective study involving patients who underwent TLGD with TDA at our hospital showed that the short-term results including the occurrence of postoperative complications were acceptable. However, further studies and experience are warranted to evaluate the long-term results.

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